Integrated Management Strategy for Risk Reduction of Groundwater Contamination at Tarnowskie Góry Megasite

Janusz Krupanek
Institute for Ecology of Industrial Areas
Katowice, Poland

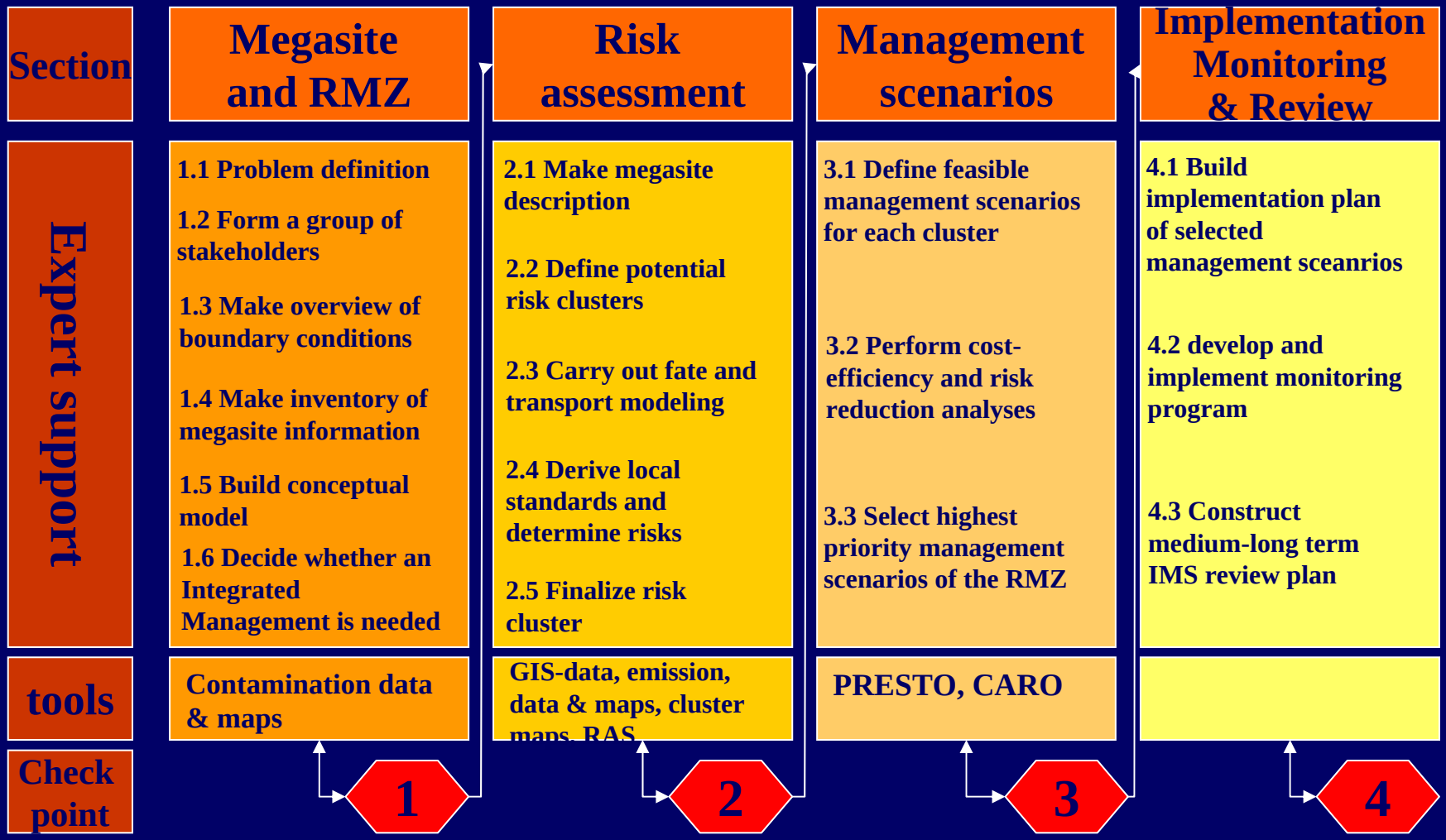
WELCOME Project

Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites. Programme: EESD/RTD 5FP

Coordinator: Huub Rijnaards, TNO, Apeldoorn, The Netherlands

Jerzy Szdzuj, Daniel Słowikowski, Ryszard Janikowski, Marek Korcz
(Institute for Ecology of Industrial Areas, Katowice, Poland)
Grzegorz Malina
(Czestochowa University of Technology, Czestochowa, Poland)

Integrated Management System

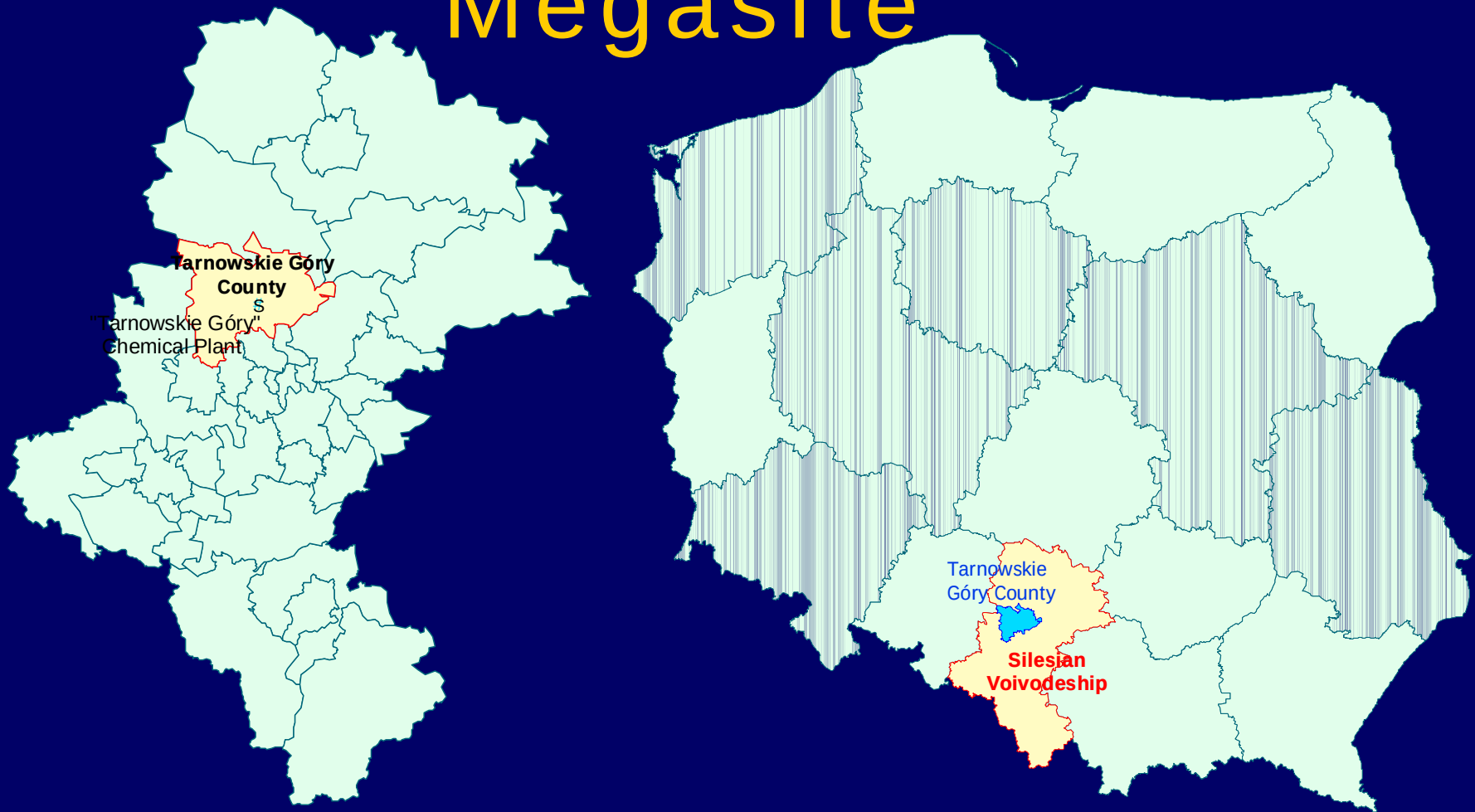


Megasite and Risk Management Zone

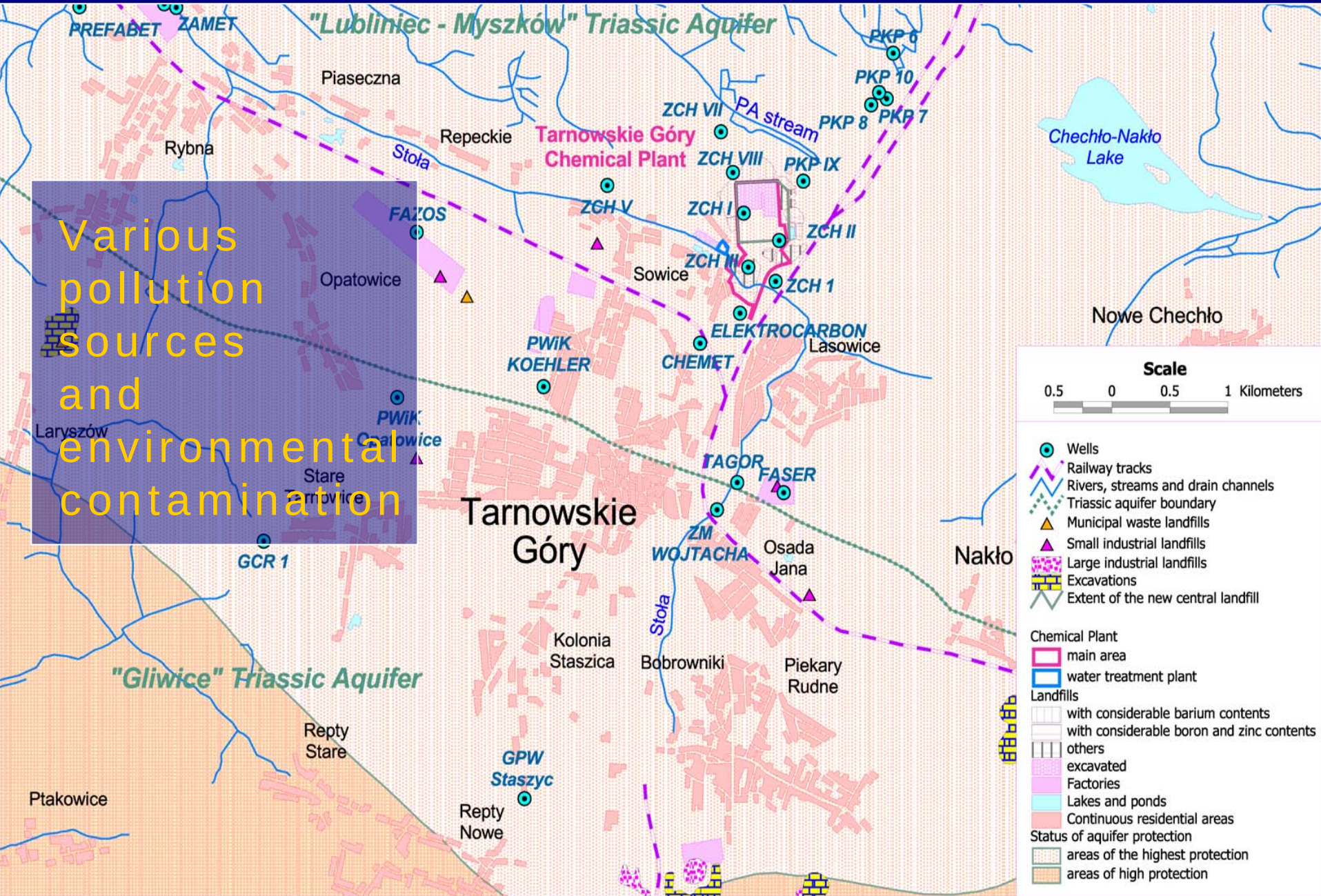
Tarnowskie Góry Megasite

The past industrial activity - beside the unquestionable positives - leaves us with unwanted heritage of environmental (e.g. polluted soil and groundwater), economic and social problems

Geography of the Tarnowskie Góry Megasite



Tarnowskie Góry megasite - overview



HISTORY

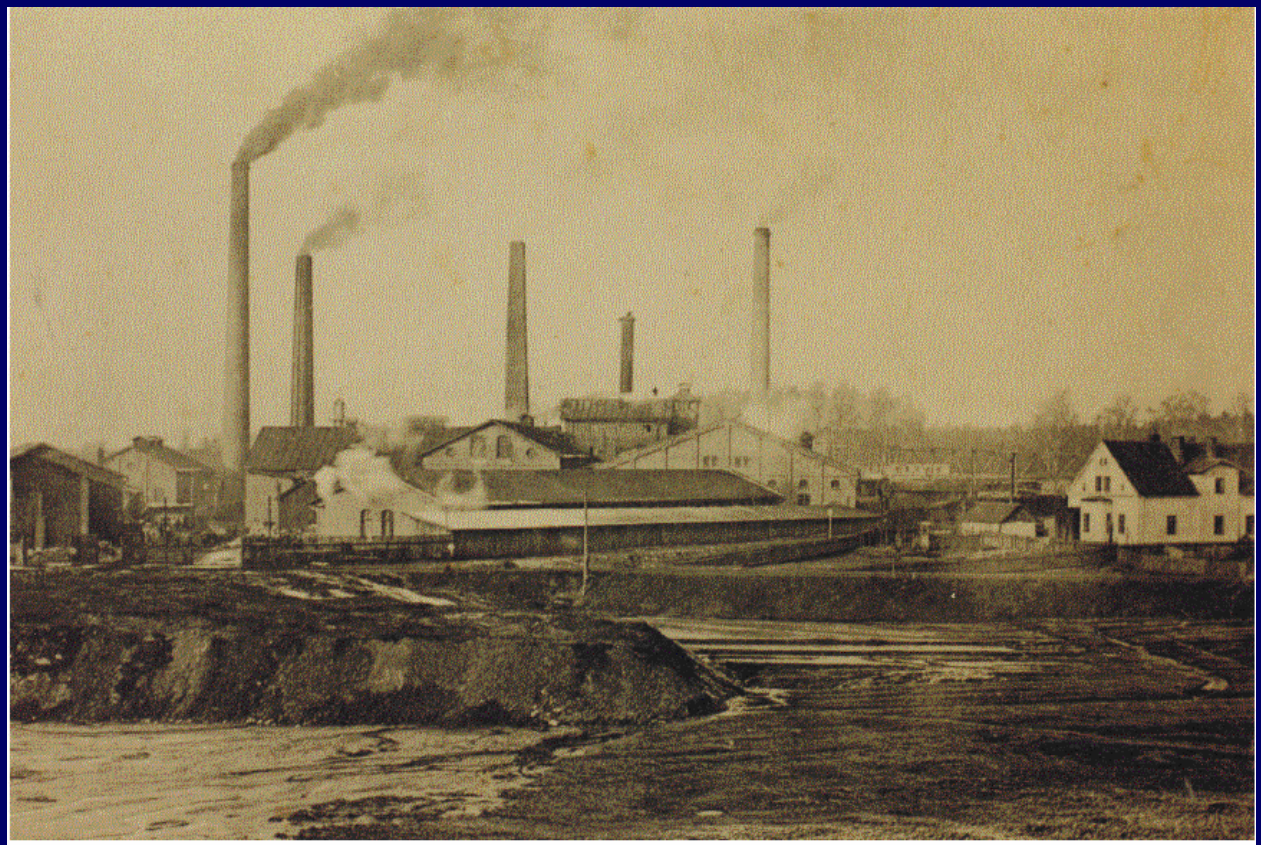
XV-XIX c. – silver, lead and zinc ores extraction

-20 000 shafts
-250 km adits and corridors

HISTORY

XIX c. - Steel and paper production

View of the site from SE, 1892



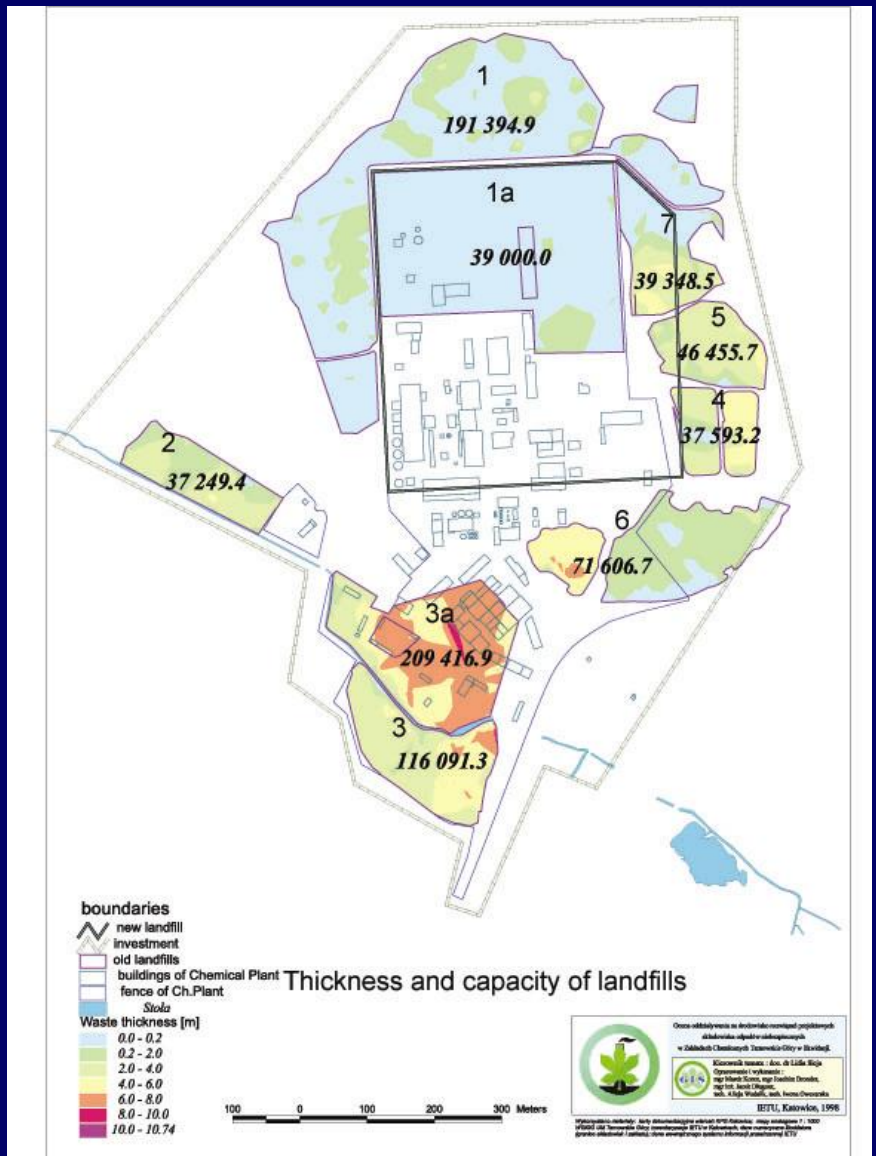
Waste deposits
Changed land structure

HISTORY

1922 – 1995 Chemical Plant „Tarnowskie Góry”– view from SE, 1975

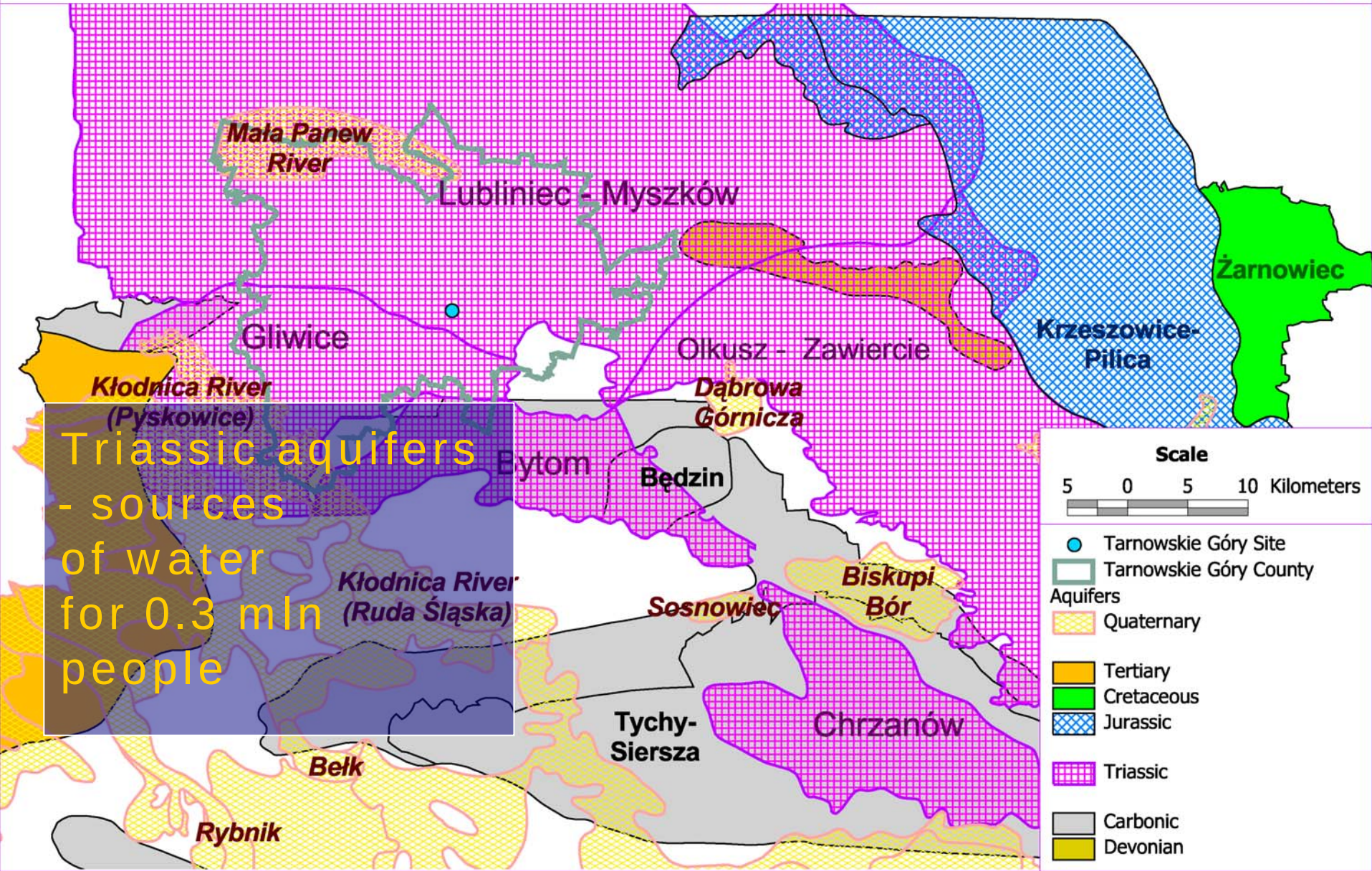
- Production of : sodium dichromate, barium chloride, boric acid, borax, barium nitrate, zinc oxygen, zinc sulphate, sodium perborate, aluminium sulphate, copper sulphate, zinc sulphate and potassium aluminium sulphate, barium salts and lithopone, strontium carbonate, active soot

Chemical Plant – main pollution source



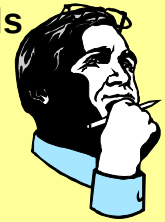
- 1.5 x 10^6 m^3 (2.7x10^6 Mg) waste materials deposited on uncontrolled dumps (26 ha) – total area 34 ha
- The annual leachate load from landfills:
  - B – 6.63 Mg
  - Ba – 80.4 Mg
  - Sr – 5.8 Mg
  - Zn – 1.4 Mg
  - SO_4 – 274.5 Mg

Main Aquifers in the region of Tarnowskie Góry Megasite



Group of stakeholders

Owners/users of wells
(Triassic aquifer)



Local government
(Town Tarnowskie Gory,
County Tarnowskie Gory)

Input information
Megasite manager

Tarnowskie Gory Megasite
round table
stakeholdres meeting

National government
Regulator
(Environmental&sanitary
inspections)

National government
Financial resources
(National budget, National&regional
environmental and water economy funds)

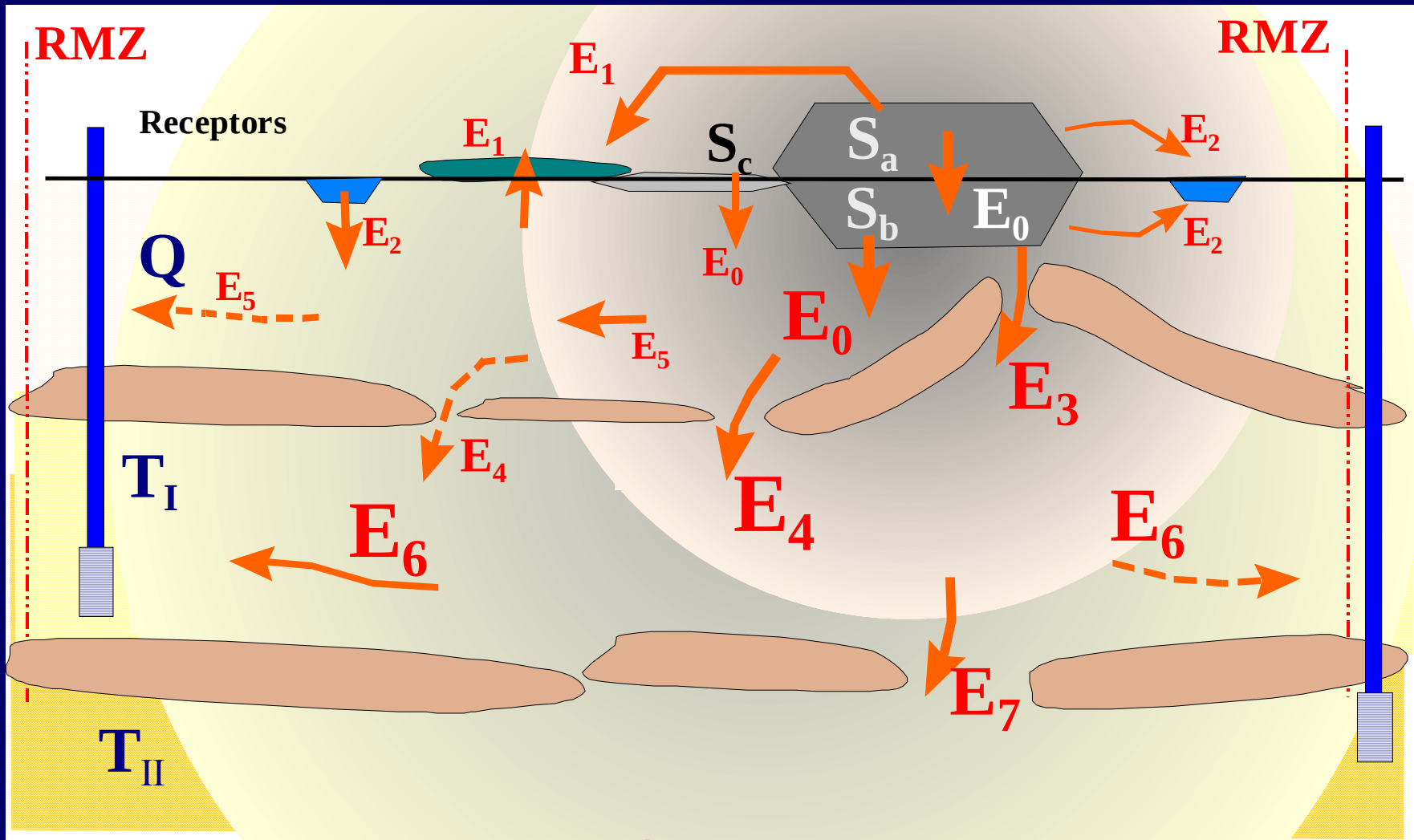
National government
Owner of the site
(Liquidator of Chemical Plant
"Tarnowskie Gory")

Acceptance of integrated managament approach with the focus on groundwater resources as the priority of environmental policy at a local, regional and national scale

Boundary conditions

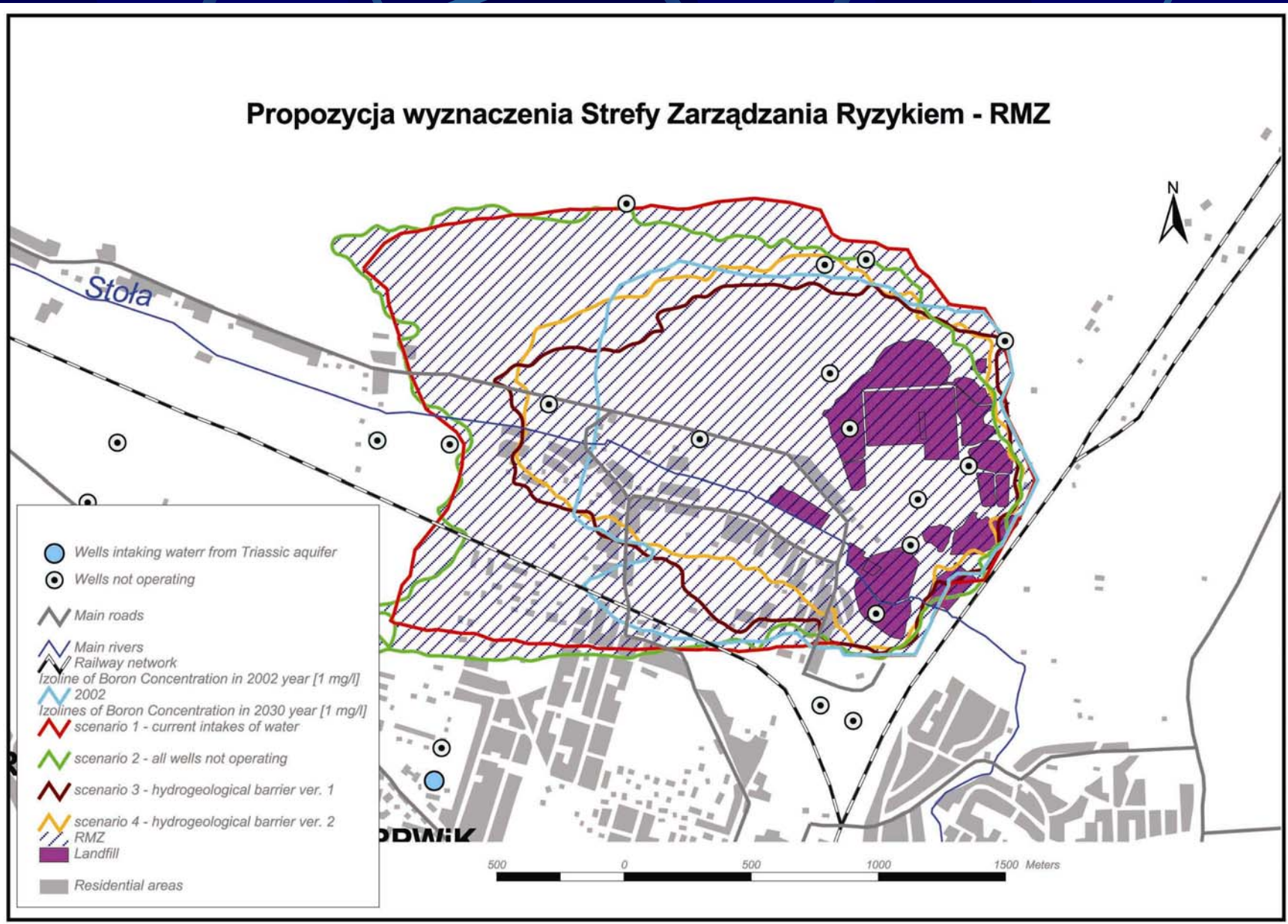
- Economical aspects
  - lack of available funding, slow development, local government budget constrains, infrastructure, administration attitude; lack of revitalization drivers (low prices for land, low investment attractiveness, relative abundant water resources, low level of local consumption)
- Social issues
  - high cost of water, unemployment, rising cost of media for average consumer and the low income families
- Environmental issues
  - legal conditions, groundwater hydrological conditions

Conceptual model

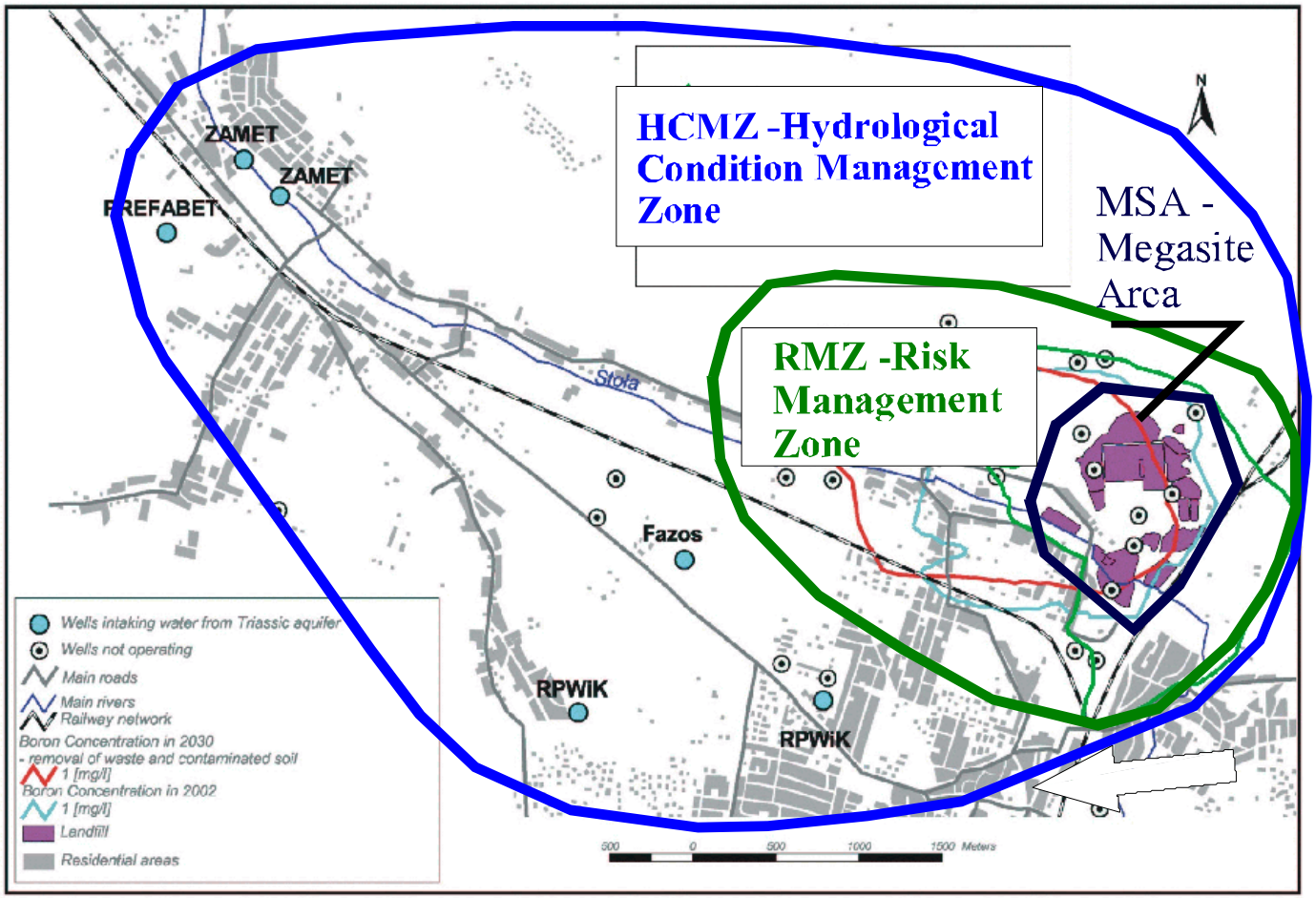


E_0 - deposition in soil, Quaternary
E_1 - health and ecological impacts
E_2- surface waters impact
E_3 - vertical migration - Trriasic
$E_{4,}$ - migration Quaternary -Trriasic
E_5 - migration-Quaternary
$E_{6,}$ - water wells impacts
Q - Quaternary aquifer
T - Trriasic aquifer
S_x - contamination sources
RMZ - Risk Management Zone

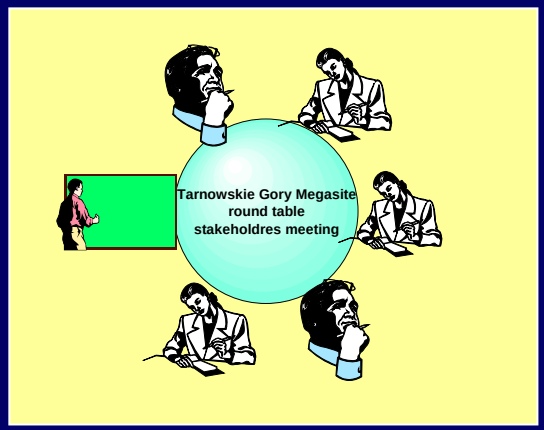
Risk modeling



Management Zones in Tarnowskie Góry megasite



Group of stakeholders



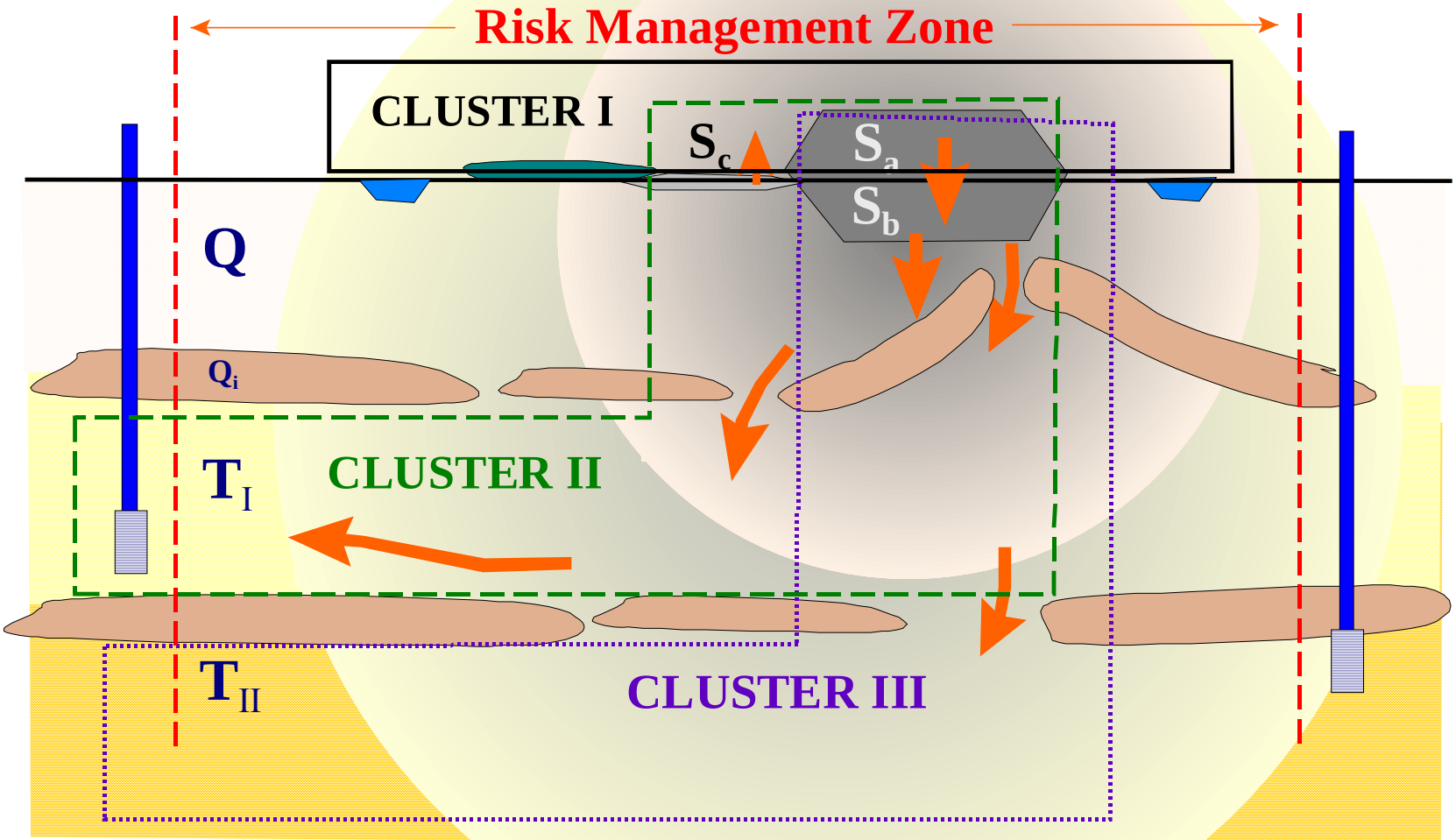
Acceptance of risk based managament approach within the risk management zone and determined boundary conditions

- Health risk (surface contamination)
- Health risk (groundwater contamination)
- Ecological risk (soil, sediments, plant contamination)
- Risk related to water erosion
- Risk related to contaminated sediments

Risk assessment

Tarnowskie Góry Megasite

Risk clusters



Q - Quaternary aquifer

Q_i -Quaternary -isolation layer

T -Triassic aquifer (first & second layer)

S_a - waste deposits of the Chemical Plant Tarnowskie Góry

S_b - contaminated quaternary shallow layer

S_c - contaminanted soil in the vicinity of the chemical plant

Risk evaluation

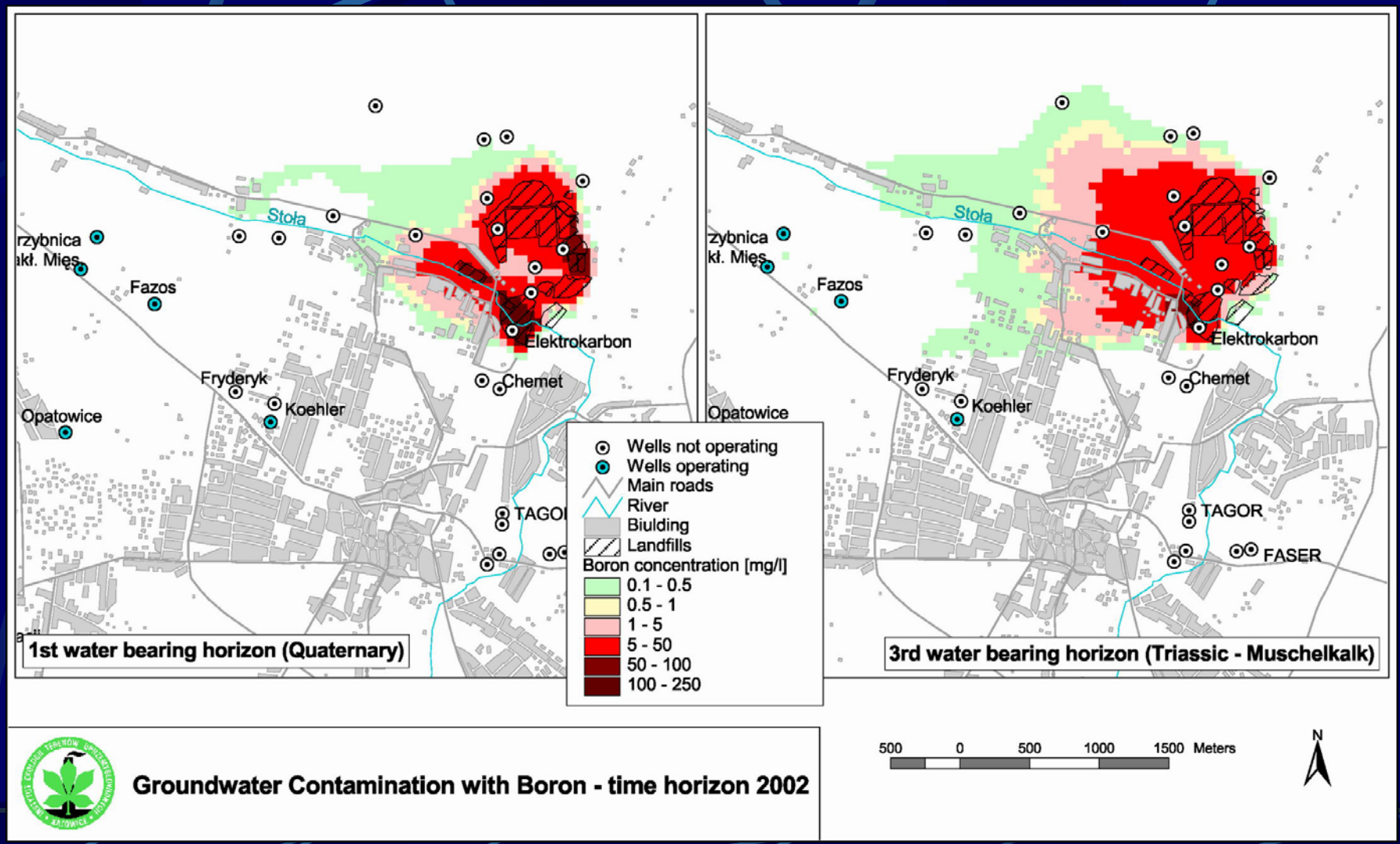
Cluster I	
Health risk (surface)	Medium
Ecological risk (soil, sediments, plants)	Low
Risk related to water erosion	Medium
Risk related to sediments	Low
Cluster II	
Health risk (groundwater wells)	**High**
Cluster III	
Health risk (groundwater wells)	Medium

Priority contaminants

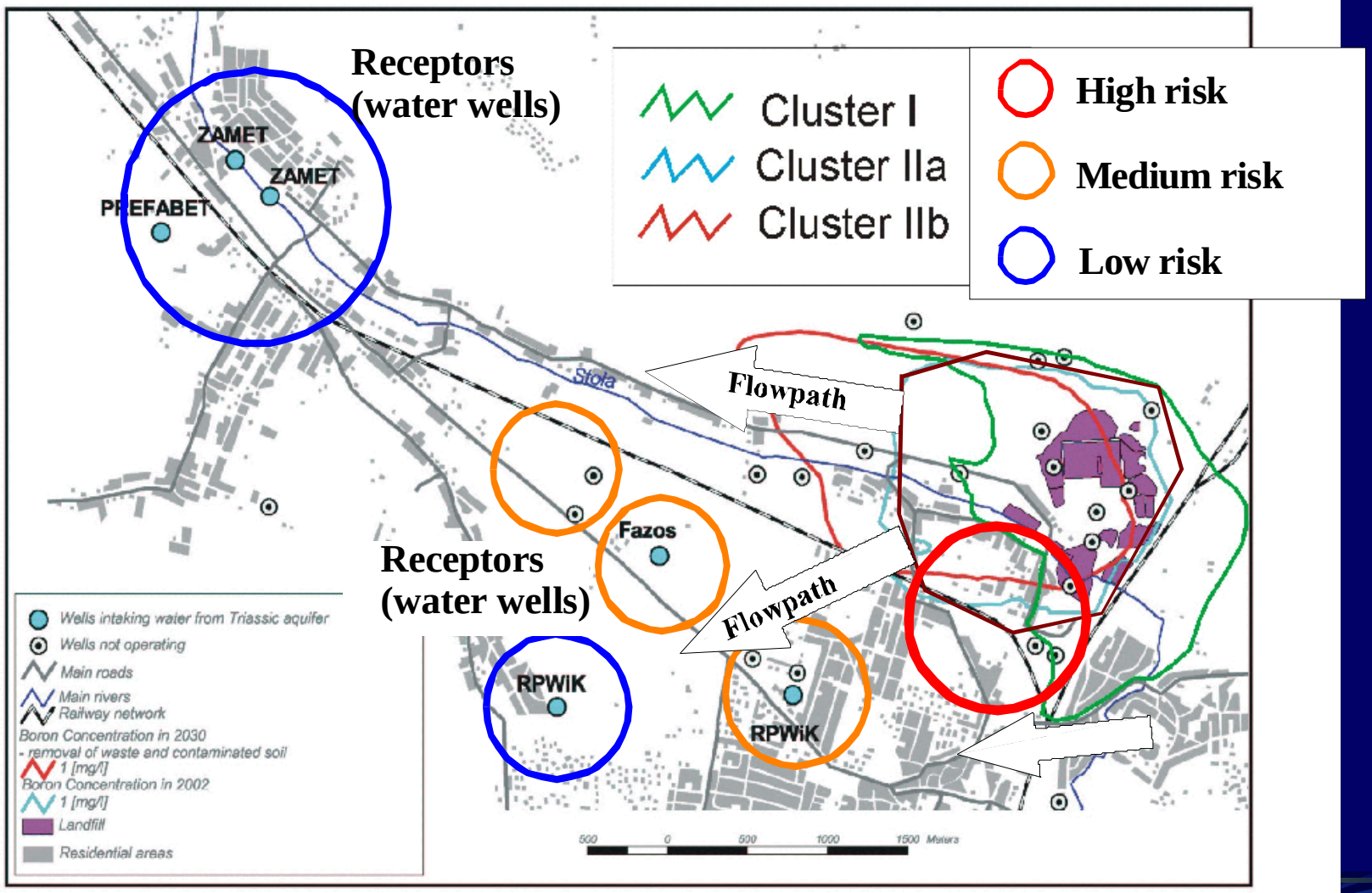
Contaminant	Frequency of occurrence	Natural attenuation potential	Toxicity	Mobility potential	Data availability
Arsenic	Moderate	High	High	Low	Moderate
Barium	High	High	Moderate	Low	Moderate
Boron	High	Low	Moderate	High	Moderate
Cadmium	Moderate	Moderate	High	Low	Moderate
Strontium	High	Low	Low	High	Moderate
Zinc	High	Moderate	Moderate	Low	Moderate

Based on: the interpretation of modelling results and risk assessment and conclusions of the expert meeting, **boron** was selected as the priority contaminant at the Tarnowskie Góry Megasite

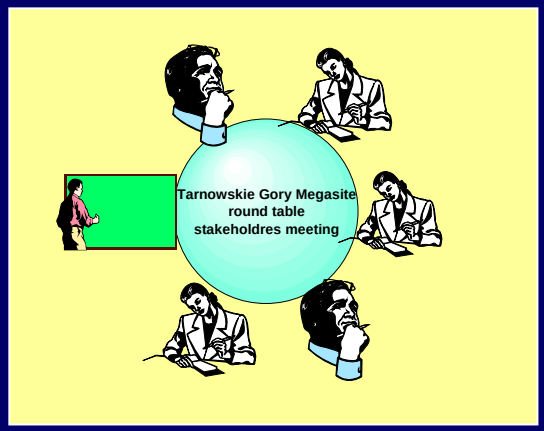
Groundwater contamination with BORON, 2002



Risks and stakeholders interests



Group of stakeholders



Acceptance of risk assumptions and determined local standards at planes of compliance

Boron migration in Triassic aquifer threatening water extraction in the area is a priority

Management scenarios

Tarnowskie Góry Megasite

Management goals for Tarnowskie Góry priorities

- **stabilisation of the contaminants plume – worst case at least no further spread outside the area of risk management zone**
- **stabilisation of the contaminants plume at the actual state (year 2003) trend reversal**
- **clean up of the Triassic aquifer time- frame 2030**

Support different situations by specific tools

Basic scenarios

Source-oriented measures:

- primary sources capping or removal
- contaminants immobilization in soils and Quaternary deposits (secondary source)

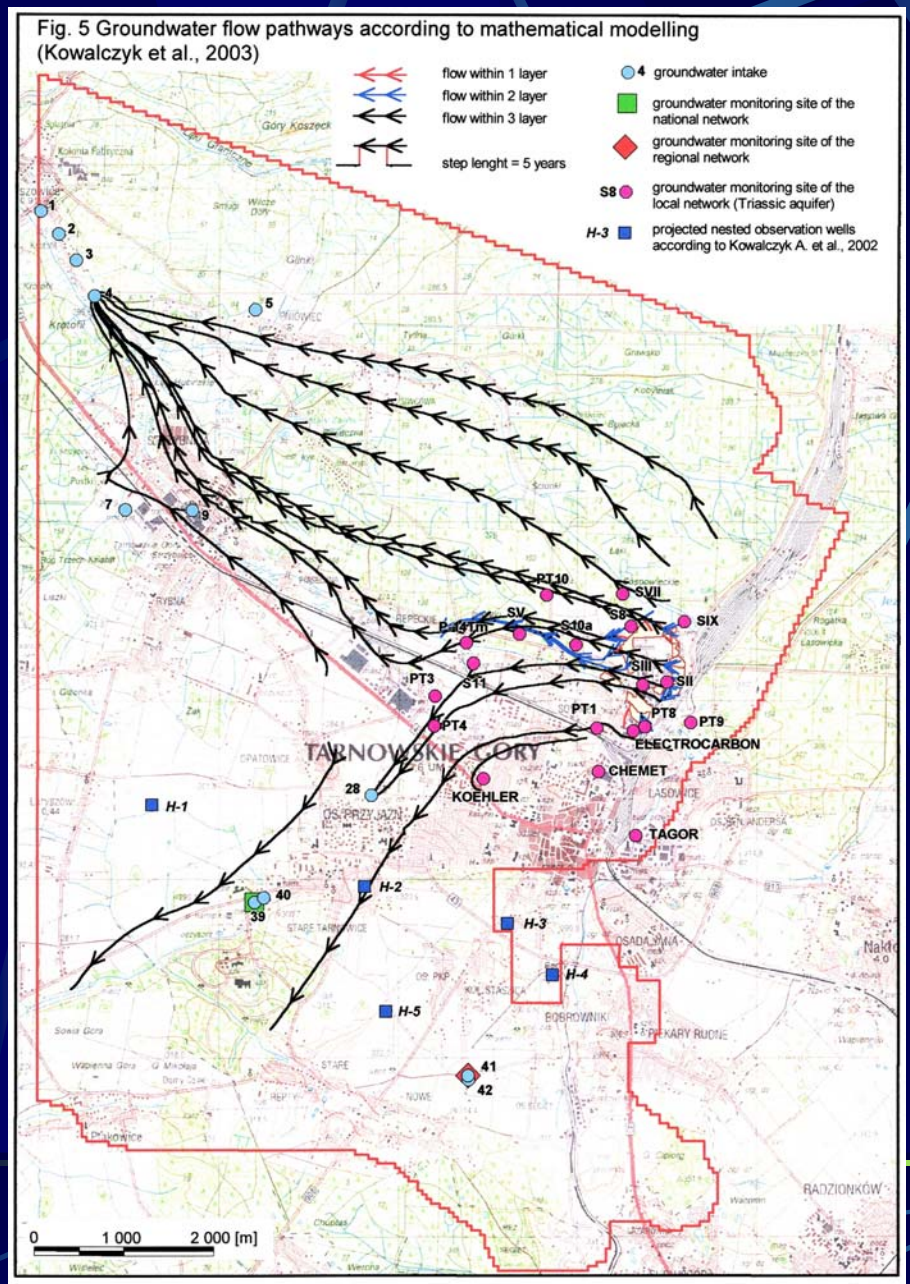
Pathway oriented:

- internal hydrological barrier
- external hydrological barrier

Receptor oriented:

- monitoring,
- water extraction regime at receptors (wells) development as a hydraulic barrier

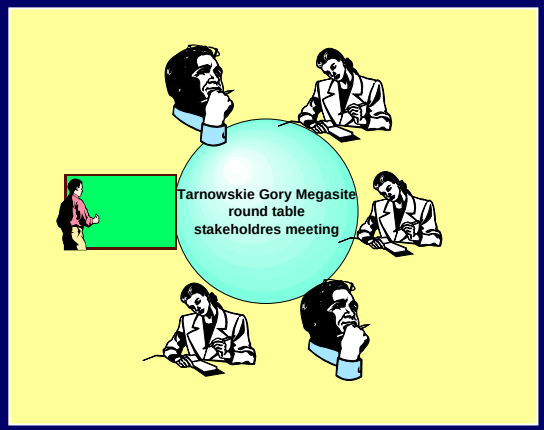
Feasibility study



- Modelling
  - Modflow 96
  - PMPath
  - MT3D
- Technical aspects of implementation
- Land use requirements
- Legal and policy issues

Chemical Plant liquidation plan, 2003

Group of stakeholders



Refining of management goals and acceptance of management options, establishement of local standards and planes of compliance

- **The boron concentration of 0.3 mg/l is accepted as final steering parameter at planes of compliance established for Triassic groundwater wells**
- **Concentration 1 mg of boron /l is reqiured in I level of Triassic aquifer at risk management zones**

Preferred scenarios

- **S 1 – controlled natural attenuation (NA), i.e. source removal + monitoring and control of the hydrological regime**
- **S 2 – active groundwater remediation (AGWR), i.e. source removal + groundwater clean-up + monitoring**
- **S 3 – engineered natural attenuation (NA), i.e. source removal + increased extraction of groundwater (specific and low-risk oriented) within the Risk Management Zone (RMZ) + monitoring**

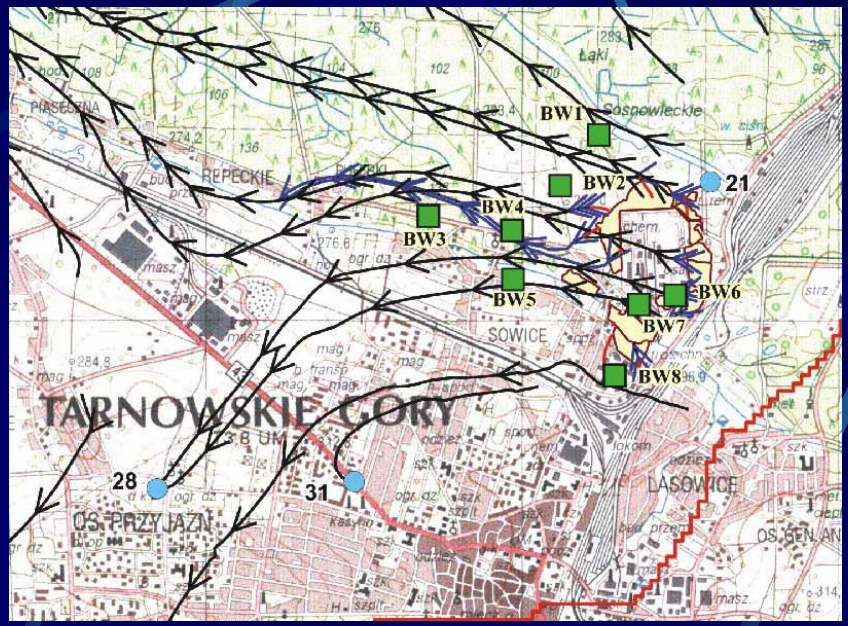
Scenario S1

- **Landfill construction is the main activity**
- **Groudnwater ,onitoring is essentially improved**
- **Relative high risk for selected stakeholders remains – boron plume spread in the Triassic aquifer**

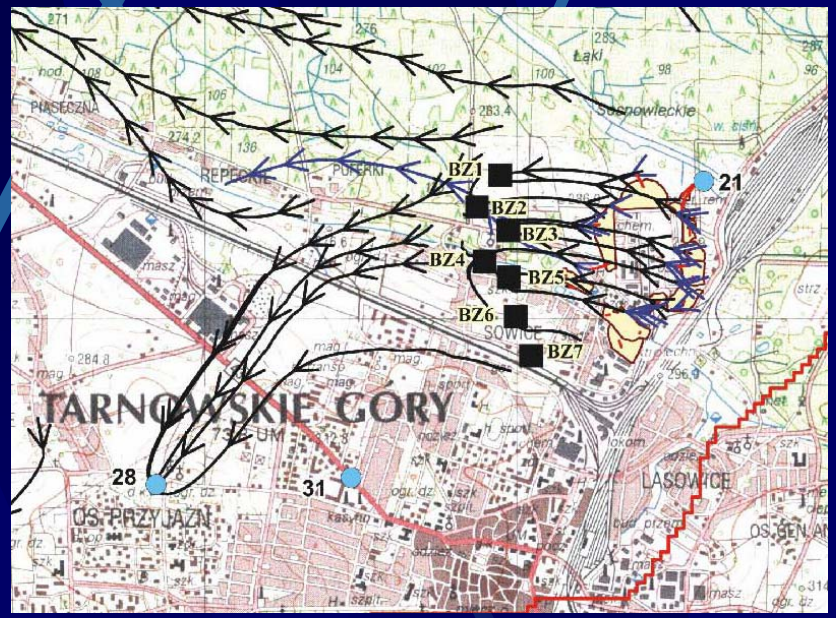
Scenario S2

- **Two technical variants of groundwater clean up**

Internal barrier



External barrier

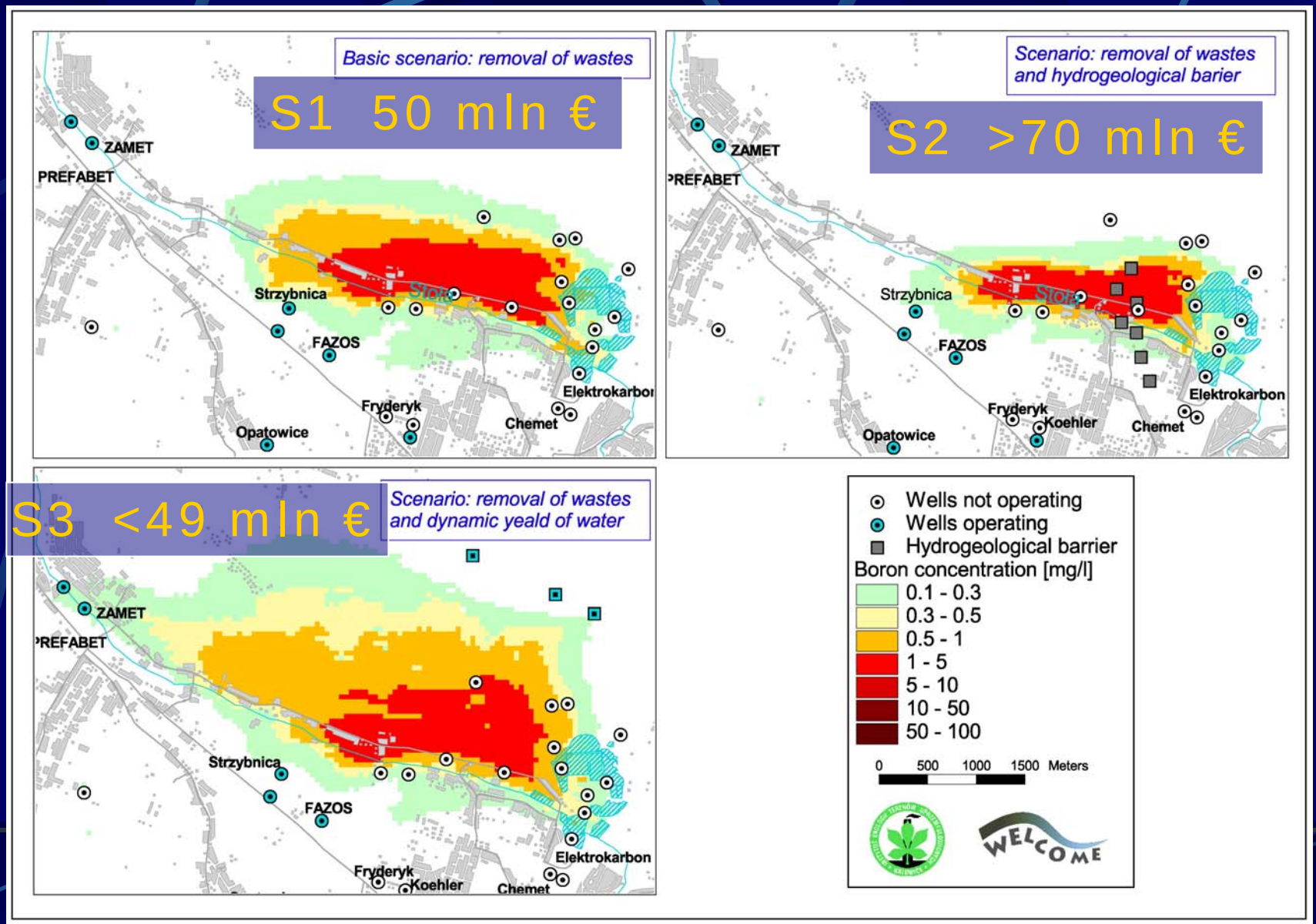


- **Decontamination issue and water utylization issue (700-1200 m3 of contaminated water/day) - high cost**
- **New infrastructure is required (new and existing wells)**

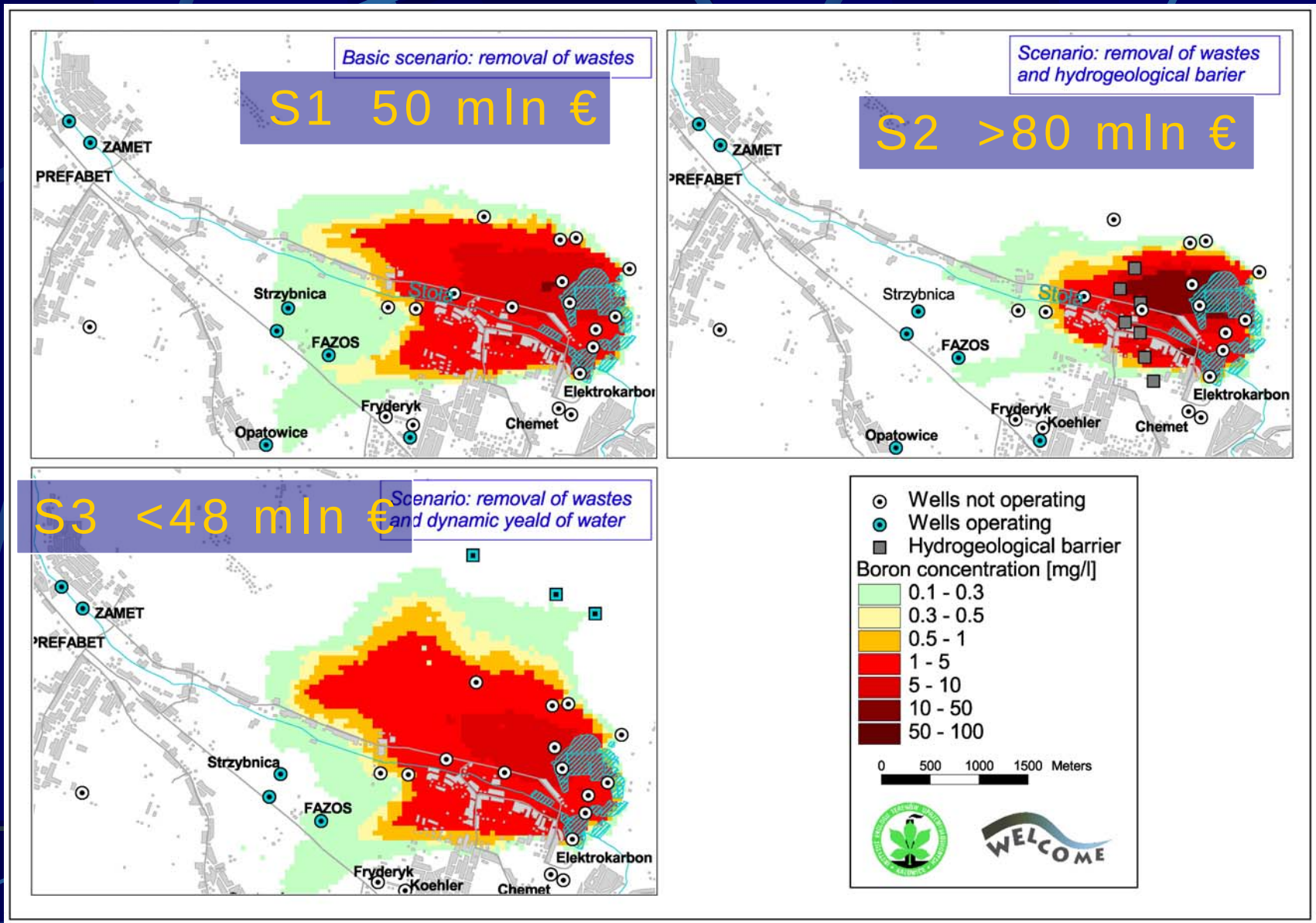
Scenario S3

- Relevant for intensive development of the water extraction system in the area with increased groundwater yield >20 000 m3/d (current yield in the area)
- infrastructure implications (new water wells with high capacity, pipelines should be built)
- Development of new monitoring regime is essential
- Provide safety conditions for existing and potential groundwater well users

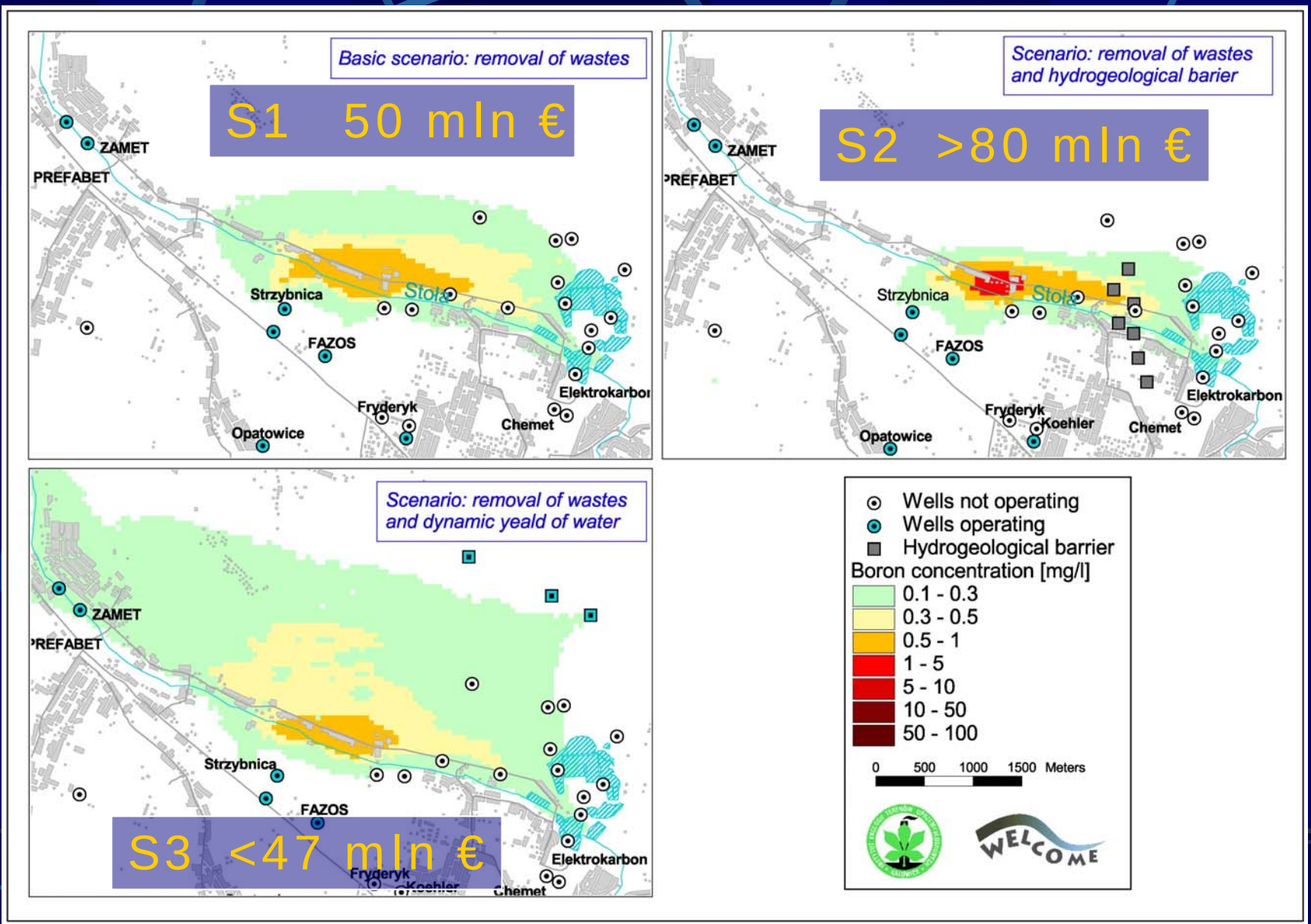
Cost – efficiency
Triassic aquifer contamination – forecast for 2030



Cost – efficiency
Triassic aquifer contamination – forecast for 2075



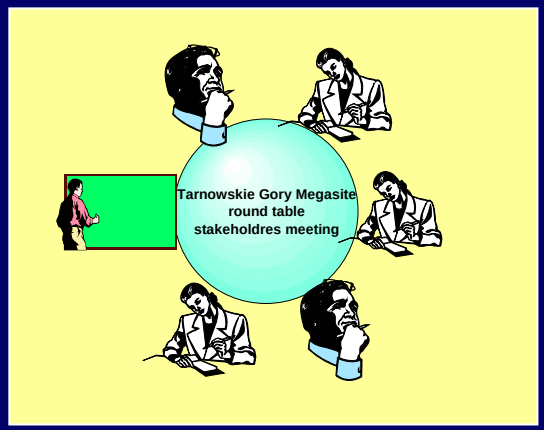
Cost – efficiency
Triassic aquifer contamination – forecast for 2100



Cost-benefit analysis

Issue	S1	S2	S3
Water needs (social, industrial)	-	+	++
Organizational aspects	+	-	-
Environmental issues	-	+	-
Infrastructure implications	+	-	-
Local finance	+	-	-
Local development	-	+	+
Policy and legal aspects	+	+	+

GOS decision on Final IMS



the group of stakeholders have not made the decision on the selection of the final risk management scenario (RMS)

- Scenario S1 is currently being implemented.
- The Scenario S1 and S3 are preferred because of their cost-efficiency and benefits.
- Implementation of the scenario S2 is not excluded.
- The final decision will depend on the following:
  - Access to funds;
  - Elimination of knowledge and technological gaps,
  - Stabilization of environmental regulations

Implementation, Monitoring, Review

Tarnowskie Góry Megasite

Management plan

- establishment of risk management zone (RMZ) in the watershed management plan by the Regional Water Management Board
- Implementation of the monitoring programme with continuous revision and modification
- Further research on boron plume dispersal and cost-efficient clean up solutions
- permanent assessment, verification and management of the risks within the RMZ
- Review process - revisions done by the stakeholders

Organizational scheme

Scenario S1 – controlled NA

- existing organizational structure based on the legal obligations of the local and regional administration and the megasite management organization (the liquidator of chemical plant)

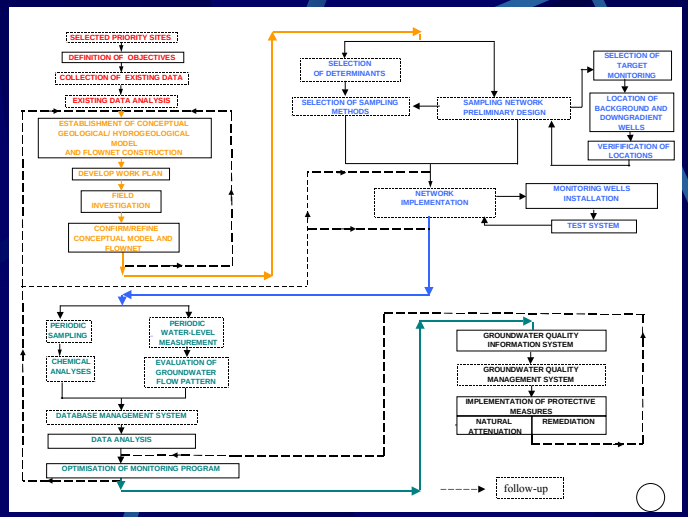
Scenario S2 – active groundwater remediation

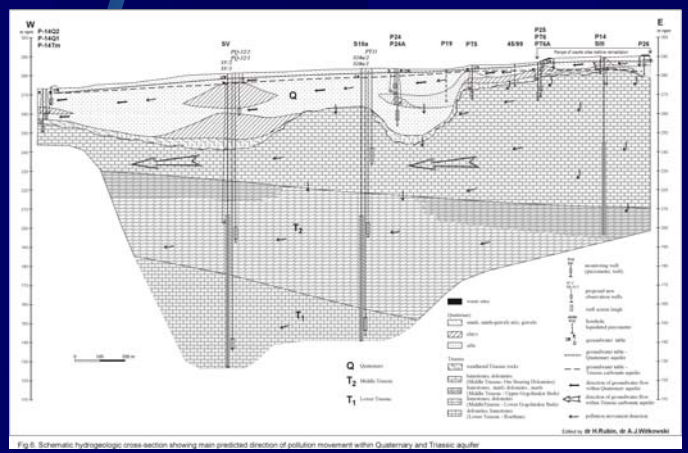
- establishment of a new organization unit within the local and regional administration for implementing this scenario after the chemical plant liquidation program is completed

Scenario S3 – engineered NA

- Engagement of different stakeholders (administration, industry)
- New management structure to intensify the processes of the megasite redevelopment
- Local and regional administration may have a leading position in implementation of this scheme

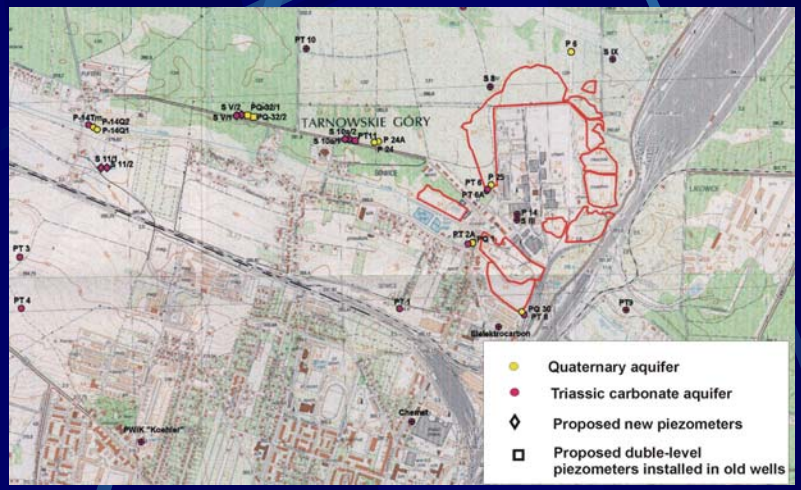
Monitoring Program





- A new organization of a monitoring system for the megasite, is proposed
- Verified sampling protocol, i.e. sampling technique, frequency and parameters to be measured (number and range)

Monitoring Program



- Groundwater quality monitoring of the Triassic aquifers is focused on
  - tracing migration of potential contaminants from the area of dumping sites and quaternary sediments to the operating groundwater intakes
  - performance of the controlled landfill and the secondary sources of contamination (i.e. quaternary sediments).
- Reduction of the monitoring of the Quaternary water-bearing horizons within the area of former dumping sites is proposed

Conclusions

- Integrated Management Strategy for Tarnowskie Góry megasite is a good example of dynamic, interactive, systemic and risk-based management of complex system
- The management of the megasite is an ongoing process of learning with key stakeholders participation

- THANK YOU FOR ATTENTION