WELCOME

WATER, ENVIRONMENT, LANDSCAPE MANAGEMENT AT CONTAMINATED MEGASITES

DEVELOPMENT OF INTEGRATED MANAGEMENT SYSTEM (IMS) FOR PREVENTION AND REDUCTION OF POLLUTION OF WATERBODIES AT CONTAMINATED INDUSTRIAL MEGASITES

WP4.1 GIS DESCRIPTION

PART I

GIS development – site description

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WORKPACKAGE 4

TASK 4.1 – GIS DESCRIPTION

PART I – GIS DEVELOPMENT – SITE DESCRIPTION

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1 INTRODUCTION

Solving the problem of environmental quality management in accord with the principle of sustainable development is one of the key challenges, which the modern civilisation has to face. There are still significant differences in approaching this problem among Member Countries of the European Union. Enlargement of the Union by new countries will make these differences even deeper through adding all the issues that result from the need to ensure equal competitiveness conditions and observing the principle of equal rights of corporate persons.

In order to address the problems of environmental protection and economic development taking account of the future generation needs, the tools supporting environmental decision-making should allow choosing optimal alternatives. Therefore these tools should enable assessing environmental solutions and their economic effects in the aspect of space and time and in variable scales: from micro to macro-scale. Solutions developed on national level are of macro-scale character or regional character from the viewpoint of the European Union. Environmental decisions are most frequently made in scale resulting from natural delimitation of the environment.

This results in the situation that different models are created for each management level and their unification is a sine qua non condition of their integration which definitely leads to an actual optimisation of management decisions in tune with the criteria of sustainable development.

Among environmental models supporting decision making processes, models of individual sites or contaminants predominate. Employing the paradigm of health risk to management allowed implementing environmental contamination standards based on toxicological and ecotoxicological criteria into managerial practice. Despite that fact, environmental models which take advantage of these standards still do not provide for the simultaneity of action of the chemical substances (synergistic, additive or antagonistic action) as each of the substances is usually considered separately in decision-making processes.

In order to change this situation, the up-to-date environmental management models should cover a much higher number of parameters which concern environmental characteristics as well as characteristics of economic effects resulting from the implementation of specific solutions including prevention or reclamation. Foundations of any system of environmental management consist of two major components: a model of the environment which generalisation level depends on the management scale, and costs model. The goal of the WELCOME project is to develop a medium scale problems decision-support system i.e. for problems which concern a site that is characterised by the occurrence of a number of contamination sources of different character, the environmental impact of which significantly influences the quality of life of local communities. In other words, it is a system dedicated to areas of high industrial concentration, referred to as megasites. The three case study areas: port of Rotterdam, Bitterfeld megasite and Tarnowskie Góry megasite, allow stating that an integrated management system is dedicated to areas which surface is equal to a surface of at least one municipality of industrial character or a group of municipalities i.e. several or more hundreds of square kilometres. The developed system cannot serve addressing “point” sites on one hand, while on the other it also does not find application for supporting decisions on regional scale.

Beside application of the principle of health and environmental risk minimisation and cost-effectiveness of outlays, the development of an integrated groundwater management system at megasites is accompanied by an assumption to base the entire system on the geographical information system frequently recognised as an acronym – GIS.

2 GOAL AND SCOPE OF WORK

The goal of this study was to describe the spatial information system of the " Tarnowskie Góry" megasite and carry out its characteristics. The scope of work comprised the following tasks

- Development of a conceptual model of spatial information system including the scope of information resources, characteristics of information sources, survey of potential users;
- Determination of the megasite boundaries along with developing its conceptual model;
- Working out the characteristics of the megasite through an actual development of an information system and creation of information layers combined with elements of the megasite pre-modelling.

3 IMS CONCEPTION VS. POLISH CONDITIONS – MEGASITE DEFINITION

A conceptual model of the Megasite was developed (in a stepwise manner) which integrates different environmental data in a GIS model.

Integrated Management System as risk driven requires GIS as a tool to simulate environmental effects (spatial, temporal) of different management scenarios. This means that GIS model development strategy should take into account the necessity to cooperate with different scenarios and environmental models including models of risk assessment.

The conceptual WELCOME GIS model also must take account of the country –specific environmental management solutions. In Poland, a concept of degraded land surface management has already been worked out. Development of the concept was based on six key premises, which are worth pointing out[1]:

Premise 1 says that the higher the management levels the more generalised information. Also the very system changes its function: from documenting and inventorying at the lowest level to information giving and decisions-supporting on higher levels.

Management of postindustrial areas comprises three foci of the minuteness of details:

- Focus I – elementary– related to documentation of a given property and identification of any of its negative impacts on the environment, scale typical for focus I is equal to or higher than 1:5000 (1:2000, 1:1000, 1:500);
- Focus II – administrative – related to decision-making and spatial planning – scale typical for focus II is 1:10000 (in some cases 1:5000) or lower;
- Focus III– administrative – related to conducting a control of low-level administration works; scale typical for focus III is 1:10000 or lower.

This multi-scaling requires [2] employment of tools capable to construct the system as well as implementing quality assurance requirements into it. GIS tools offer capacities suitable for

[1] Marek Korcz et all, 2000; *Development of the principles of legal and organizational settings ensuring a functional use of degraded areas*; IETU report No 306/DO-GIS/00; Katowice

[2] Map scale is a determinant of an entire set of parameters characterising a cartographic study recognized as „ parameters of scale environment" These parameters are set up by the General Country Surveyor. In case of GIS systems, the problem of scale environment may be reduced through a limited usage of conventional cartographic materials as sources of information .

constructing multi-scale systems. Following appropriate procedures, they enable building up an information system organised in a way providing for a soft switch from one scale into another and control of errors occurring in the course of system creation.

Premise 2 which justifies creating the system as GIS- based is the fact that the input data are frequently diversified and originate from different sources. As such they are subjects of quality control before finally put into the system. In the case of spatial data, only GIS system offers such capacity.

Premise 3 is the need to visualise data in a form of multi-layer map compositions[3].

Premise 4 is the need to monitor the changes in time while **premise 5** is related to the capacity of ensuring access of information to tools for modelling contaminants migration in the environment.

Premise 6 results from the fact that the whole environmental information system in Poland is proposed and developed as GIS tools-based[4].

All the mentioned premises set up the broadest framework of the WELCOME GIS conceptual model.

In view of effective legal regulations, an IMS – supporting information system should operate on two levels: voievodeship and district level and on the level of a municipality and owner of pollutants emitter [5].

On voievodeship level the system should enable controlling the actions of head district authority (starosta) addressing development of reclamation programmes, while on district level (poviat) should support the district authorities in the performance of their statutory tasks set up by Polish environmental law, which include:

- Conducting an initial inventory of properties with a potential contamination and degradation affecting adjacent properties;

[3] A map composition is an equivalent of a conventional map with the only difference that on the contrary to a conventional map a map composition offers the user a capacity of a free modification of the types of information layers comprised in it.

[4] Antares; 2001; Srodowisko 2000 - strategia rozwoju systemu informacyjno-informatycznego resortu srodowiska (Environment 2000 – A strategy of developing an information computer-based system of the environmental sector) , ANTARES, Warszawa

[5] Marek Korcz et all.; 2000; *Development of the principles of legal and organizational settings ensuring a functional use of degraded areas*; IETU report No 306/DO-GIS/00; Katowice

- Confirming the initial diagnosis of a property;
- Development of a list of properties which require reclamation;
- Providing access to information about such properties to the public;
- Identification of persons bearing liability for the degradation;
- Supervision over reclamation works conducted by liable persons or supervision of reclamation works as a superseded investor.

On the level of a municipality/owner the system acquires data from all studies, local monitoring data on properties, their actual functions and those anticipated in spatial plans, applied reclamation measures and results of controls of property condition executed by relevant regulatory bodies including their post-control decisions.

The list of system users is however not limited to the bodies mentioned above.

The first step in GIS conceptualisation is to **identify the subject of management in such a manner as to satisfy future information needs**.

Fuzzy boundaries and definitions should be step-by-step converted into hard deterministic ones. Even the definition of the megasite is initially fuzzy since it assumes that a management body has a good recognition of the situation. This however does not necessarily mean that this body has a good geographical information system.

Megasite is an area where serious contamination was recognised or is suspected. Contamination must be attributable to multisource activities and must result from multicontaminants presence. Additionally, there is no possibility either technical and/or economic available at present to remove contamination in a degree that water quality will meets legal standards.

Tarnowskie Góry Megasite fulfils all the criteria of a megasite defined above, with the only exception that initially its boundaries were not geographically determined.



Fig. 1 Preliminary GIS

Taking into account future information demands it is necessary to create river watersheds models and hydrogeological models. Therefore an assumption was made that the extent of the system should be limited by natural boundaries of impacted groundwater basins and river watersheds.

This assumption is also reflected in the Polish legal regulations addressing water management. They also served as a basis for the Minister of Environment to issue a regulation, which directly links river watersheds and groundwater reservoirs. The spatially interlinked system of river watersheds and groundwater reservoirs is managed by the Regional Board of Water Management (Regionalny Zarzad Gospodarki Wodnej). From the viewpoint of water flow management and water balance, the megasite boundaries should reflect this division. However, the principle of the WELCOME project is management of water quality and as such cannot be limited to management of water balance. Therefore appropriate handling of contamination sources seems to be the priority what means that land surface management should be performed with the use of water quality criteria. This scope of administrative activity has become a responsibility of local authorities of district level. This means legal regulations addressing land surface protection should govern setting up megasite boundaries. While constructing the system, multiple corrections should be taken into account, which exist between the governmental and local administration and the owner of the property

emitting contamination. Water and land are State Treasure owned resources. Land surface including soil belongs to individual owners, local authorities or State Treasure. The state allows using waters and deposits however the state also imposes a number of limitations over their users. In the case of land surface, the user is obliged to observe regulations of environmental protection law, construction law and spatial planning law.

Division of liabilities of individual administrative bodies depends, inter allia, on the expected range of the impact on the environment and potential importance of the resource. Therefore a GIS system used for water management at a megasite has to be supplied with information of administrative character originating from various management levels. The situation becomes additionally complicated by the fact that the control of quality and performance of conditions and limitations imposed on a user by administrative bodies is conducted by Inspection of Environmental Protection and Sanitary Inspection.

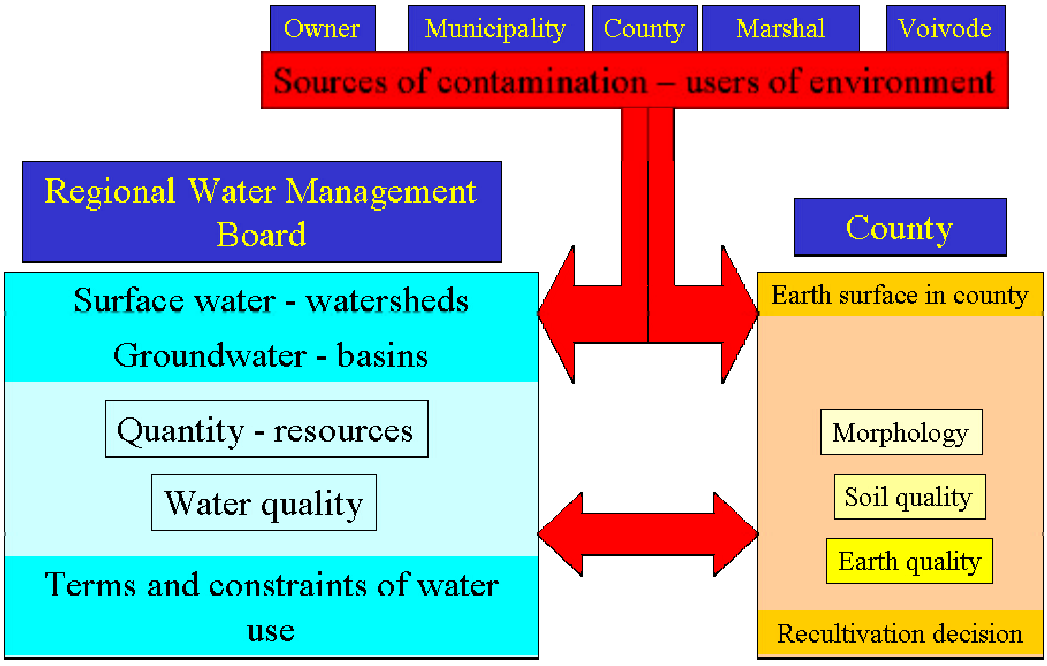


Fig. 2 A general overview of water and land surface management in Poland

Tarnowskie Góry Megasite is an area that impacts water in at least two groundwater basins and at least three main watersheds. The first step in determining the extent of the GIS was integrating information layers on boundaries of administrative units, boundaries of river watersheds and groundwater basins with the system. This allowed identifying spatial relation between these boundaries, evaluating data needs and projecting time constraints. Taking into

account the fact that the legal system in Poland assigns the responsibility for surface quality to poviats and at the same time partially involves this administrative level into water quality management, a decision was made that the basic system extent would be determined by administrative boundaries of Tarnowskie Góry poviat. Presently, there are more than 300 poviat units in Poland, in 163 of which serious land disruption and contamination were recognised. It means that the number of the future end-users of the developed IMS will be at least the same. For the needs of the first steps in GIS development an assumption was made that the extent for basic data collection should be determined by the boundaries of basins and watersheds. Additionally, it was assumed that all data will be "cut" during integration by the basic system extent to obtain basic input data.

The task aimed at determining the megasite boundaries was performed by the project team, however in view of the future IMS functioning as a decision supporting tool this task should be rather assigned to administrative authorities of voievodeship level, while in present development stage of Poland's environmental management system this task should be performed by the Marshal in cooperation with a water management board supervising a given territory.

Based on these assumptions and results of preliminary GIS use, subsequent steps of conceptual model development were realised.

4 INTERIM GIS

Dealing with water-soil pollution related problems it is necessary to take into account at least two scales of observations: a general scale, appropriate for a megasite and a very detailed scale appropriate for particular sites or hot spots. This concept is very much in line with the proposals offered by the national system in which smaller scale refers to recognising a megasite as a whole, while detailed scales are used in case of properties.

Based on IETU team experiences, the scale of 1:50000 was assumed appropriate for the megasite and 1:10000 or more detailed (bigger scales) for smaller sites.

Additionally it has also been assumed that after several years of development the final GIS will become a system using information with an accuracy and a precision that are typical for at least 1:10000 scale and will be compatible with conceptual model of GIS for postindustrial areas management in Poland.

Another problem that had to be tackled was the issue of requested information.

Environmental modelling, especially soil-water models as well as risk identification and assessment require a very comprehensive set of data. Qualitative recognition of migration paths and qualitative evaluation of exposure paths are possible at early stage of work based on preliminary description of the environment. This approach was implemented to develop a conceptual GIS model.

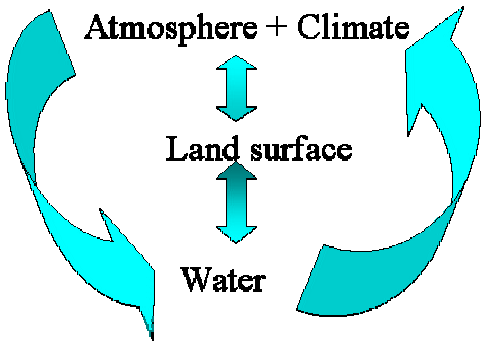


Fig. 3 A general overview of water cycle as a basis for determining the WELCOME GIS information resources

Source + land use ? soil + vegetation ? unconfined aquifer + river and water bodies system? confined aquifer ? wells ? people

Based on such a model several information layers have been developed and included into Megasite GIS.

4.1 EARTH SURFACE

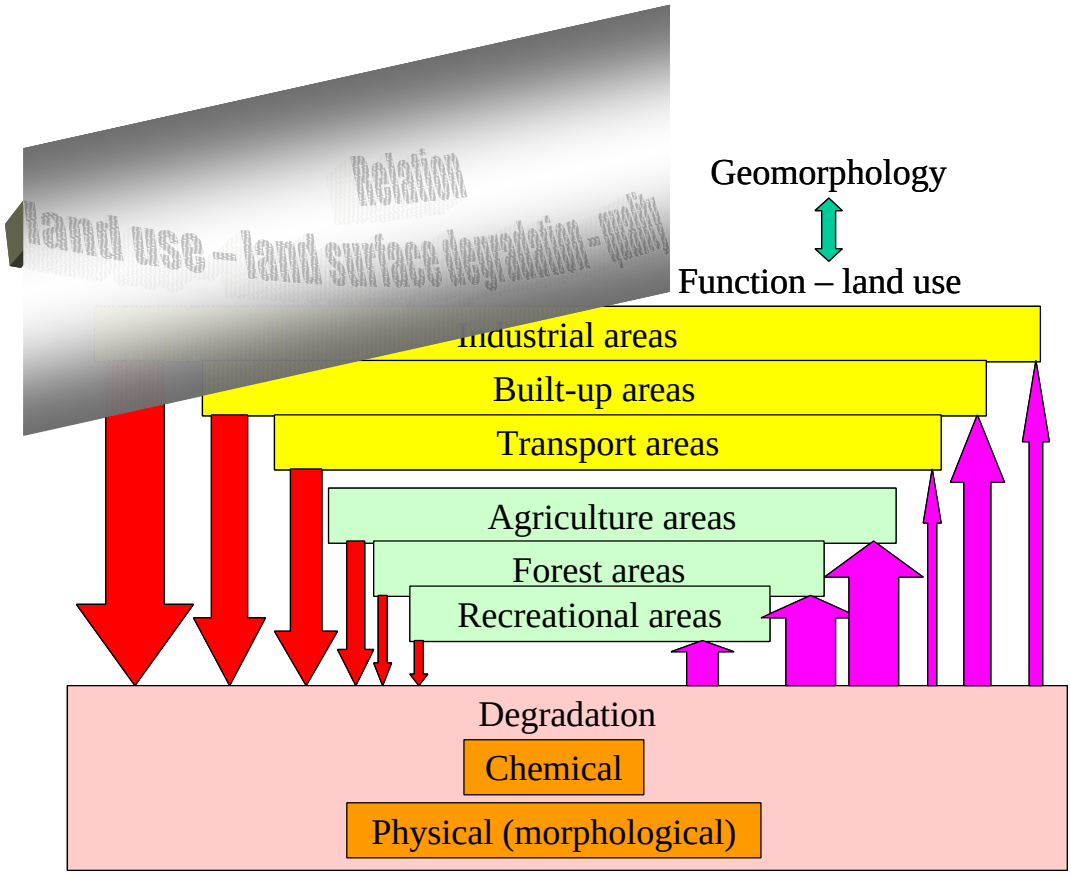


Fig. 4 General relation of land use and land surface degradation

From this point of view map of land use is one of the most important information layers. Each type of land use is linked to separate tables that describe the area in terms of perviousness, or drive the model to the next, more detailed information layer.

Since industrial, service, transportation areas as well as residential areas are meaningful contaminants emission sources, they should be treated with special attention. Therefore it is proposed that compositions of highly detailed maps be generated for these areas. In the case

of the Tarnowskie Góry Megasite, such a composition of maps was developed for the area of the Tarnowskie Góry Chemical Plant in liquidation.

Regardless of the land use maps, the GIS should provide information characterising contamination sources.

Contamination sources can be described as actual or potential. Division of sources into two mentioned categories can be justified by the availability of information. Emissions from actual sources are (or should be) monitored and access to the monitoring data should be ensured on appropriate management level. Characteristics of the potential contamination sources, due to lack of actual data, has to be based on assessments which may undoubtedly be performed within the system. Both types of contamination sources may function as point, linear or polygonal features of the system. It depends on the scale in which the information is provided.

In the case of the Tarnowskie Góry Megasite, for which a sozological[6] map of emitters served as a source of information, emission sources are described as point for sites which surface is smaller than 6,25 ha and as polygonal for sites with surface is larger than 6,25 ha.

Attribute tables should contain datasets allowing for a complete emission description i.e. these tables should contain attributes enabling answering the following questions at any time:

1. Where the source is located?
2. Who is liable for the emission?
3. What the emitter emits ?
4. What is the contaminant emission volume?
5. When and how long the contaminants are emitted?
6. In which form the contaminant enters the environment?

Question 1 is answered by the attributes containing coordinates of the emitter. Question 2 is answered by the attributes describing the source code and name and address of emitter owner linked with them. Question 3 is much more complicated since a single emitter can emit

[6] the term sozology proposed by polish scientist -W.Goetel (1965); sozology is a science dealing with the problems of nature protection, protection of natural resources and sustainability of their use.

several substances of various environmental hazard characteristic. Additionally, the emission itself may vary in time. Therefore the database should contain a table containing at least the following fields

- Emitters identity code;
- Name of the emitted substance;
- Units in which the emission is described;
- Emission volume;
- Time of emitter operation during day;
- Time of emitter operation in individual week days;
- Time of emitter operation in individual months.

The emitter should be characterised by determining the date when the emission started and when it was over, technical parameters of the emitter including specification of the form of emitted substance (liquid, gas, particulate matter, solid matter, sediment) along with identity code of contamination receiver.

For most of contamination emitters present at the Tarnowskie Góry Megasite these requirements are not met and need supplementing. For WELCOME project needs emission values are provided as assessed values.

Regardless of original emitters at degraded areas, secondary emitters also should be taken account of. At the Tarnowskie Góry Megasite, the heavy metal contaminated soil can be recognised as secondary emitter. Information layers allowing assessing the share of secondary emitters in global emission have been categorised into the group of potential emitters since the emission volumes be provided as assessed values regardless of the GIS development stage.

A layer describing land surface in a generalised risk model determines also general functions of this surface. This information is then used for creating scenarios of a megasite use and determining, by a more or less complicated modelling, the environmental effects of changing the functions of individual objects - components of the megasite. Land use scenarios are encompassed in detailed spatial plans. In Poland, these plans are developed on local level i.e. by municipalities. Spatial plans are worked out in scales of 1:5000 or 1:10000, depending on

the size of the administrative unit. This means that the data from municipalities within one poviat can be easily incorporated into the Megasite GIS system.

Verification of effects resulting from the land use change will take place at poviat level and as a proposal will be addressed to a municipality responsible for a given site. The information layer of the Tarnowskie Góry town's physical plan was incorporated into the WELCOME GIS from the Tarnowskie Góry town GIS system

The following elements of land surface play the key role in the risk model:

- vegetation cover;
- building development;
- roads;
- soil.

These elements are assigned the function of emitters and/or receptors in the model.

Mutual spatial and qualitative relations of these elements shape the routes of contaminant migration correlated with the topography of land surface.

This situation requires supplementing the GIS by appropriate information layers.

Land surface topography was chosen as base layer since it is an element controlling a number of input parameters (fields of precipitation, temperature and wind) as well as parameters determining the directions of water flow. Minuteness of details should be different for a megasite and for individual features. Since the variability of this layer will be rather small, the land surface topography layer may be assumed as developed outside the system. Altitude models of areas are created in some countries by civil services and are available to all users of the environment free of charge. In Poland, access to this information layer is subject to fees and is offered either by commercial companies (scale: 1:50000) or by land survey and cartography administration of voievodeship level. In the case of the Tarnowskie Góry Megasite this layer has been worked out in two scales 1:50000 (megasite) and 1:1000 (the Chemical Plant).as own studies of the Institute for Ecology of Industrial Areas.

Supporting layers (slope and exposition) need to be generated from the developed land surface topography layer using GIS tools. These supporting layers will be used in subsequent

steps of GIS building to describe and characterise the sub-watersheds and riverbeds or to verify their characteristics.

Information on building development and roads serves to calculate the indices of impermeable surfaces share in individual land use units or directly in hydrogeological units.

Information on vegetation cover is incorporated into the system in a step-by-step basis: beginning from the most generalised information contained in a land use map up to data determining distribution of species in the vegetation cover. These data allow verifying the precision of water balance elements modelling in individual hydrogeological units (interception, vaporisation, surface runoff, and inhibition of contaminant flow)

The vegetation cover of the Tarnowskie Góry Megasite was described in a general way (forests: deciduous, mixed, coniferous, high vegetation of urban green areas and orchards, grass vegetation of meadows, grasslands, low vegetation urban green areas, vegetation cover of arable lands). A more specific vegetation maps are not routinely generated by civil or local administration services. This means that should a land surface management model require respectively more specific data on vegetation cover, local authorities (starosta) will have to order such an information layer generated either as a product of aerial photographs analysis or field studies conducted by botanists.

Another element which presence in the system results from the need of serving environmental models (but also some other models as well) is the layer describing megasite soils.

Exclusively from the environmental viewpoint, this layer is responsible for providing data on soil units occurring at the site along with their grain size composition, water-bearing capacity, hydraulic parameters and qualitative composition. One information layer may describe several beds in soil profile.

The following sources of information may be used for constructing the soil information layer:

- Maps of arable land soils, scale 1:5000;
- Forest management maps, scale 1:5000;

- Generalised soil maps, scales: 1: 10000 up to 1:100000.

A compilation of these information layers allows developing a map of area ecological structure, which serves for building a map of hydrological units – the key model component.

There are a number of alternatives to acquire information necessary to describe the hydrogeological units.

For the purposes of the Tarnowskie Góry Megasite, a soil map in the scale of 1:100000 developed by the Institute of Crops, Fertilisation and Soil Sciences was used as a source of soil information. This map combined with a land use map served to determine the boundaries of soil units of the top soil layer i.e. layer I (to the depth of 50 cm) The surface between soil units is covered by impermeable or poorly permeable areas (building, roads, parking lots). Soil units are described using the name species and type. Soil layer II i.e. below the depth of 50 cm up to 100 cm is assumed continuous, regardless of the land use.

Data contained in these information layers are converted into continuous layers using procedures worked out by IETU. The continuous layers are described in terms of soil grain size composition and organic matter content. As next step, soil hydraulic parameters are calculated using Saxton equations. In this way a set of information allowing modelling of water behaviour in soil and conditioning occurrence and volume of ground outflow is generated and put into the system.

The general scheme of water circulation shows that data characterising climatic parameters and atmospheric pollution are also important elements of GIS.

4.2 CLIMATE

Basic climatic data necessary for modelling water circulation at a megasite comprise:

- location of the measurement stations;
- climatic characteristics(characteristics of statistical distributions of temperatures, atmospheric precipitation and winds from a multi-year period for monthly and daily periods);
- series of temperature measurements data – monthly and daily means;
- series of measurements data on anemometric relations –monthly and daily means;
- series of atmospheric precipitation measurements data - monthly and daily means.

This set of data is generated by meteorological services. The megasite GIS may comprise one or several point measurement stations. Data originating from these sources have to be converted from point to surface data taking also account of variability in time. This task may be operated by a weather generator module incorporated into the system. Depending on the needs, the generator may determine the field of precipitation, temperature and wind for specified, set-up time sequences.

Conventional land surface management models use either means from a multi-year period or annual means of desired parameters. More updated solutions enable calculating daily means while advanced models calculate hourly characteristics what obviously improves the quality of the final modelling results.

Means from a multi-year period obtained from the Swierklaniec meteorological station were used in the Tarnowskie Góry Megasite mode. It is postulated to undertake efforts to develop a model based on daily means.

4.3 SURFACE WATER

A GIS system should also provide data relevant for modelling surface waters. Basic information originating from external sources (river network, water reservoirs, gauging stations, bottom sediments sampling points) must be converted into typical GIS layers containing parameters useful and necessary in modelling the flow and chemistry of surface waters.

This group of information layers comprises a layer describing river networks, spring points and outlet points. Individual river sections should be assigned a unique identity number, determined riverbed parameters such as slope, coordinate from the beginning of the section and from its end, characteristics of the bed shape and material of which it is made. Outlet points should contain information on water flow rate in time unit. The river network should be compatible with the geomorphologic model.

This postulate is being accomplished through incorporating a set of geomorphologic data from the altitude model into the system and employing GIS tools dedicated to agreeing both characteristics: the geomorphologic characteristics and the characteristics of the network of rivers and water reservoirs

4.4 GROUNDWATER

The final set of data encompassed by the GIS is a set describing the geology and hydrogeology of a megasite.

The Fig. 5 presents the most important information layers identified at the stage of source data integration and creating the base model layers. The layer of lithological units contains parameters, which characterise the medium of water transfer. This layer is of critical importance and has been developed based on a geological map and data originating from boreholes, wells and piezometers.

In the Tarnowskie Góry Megasite model, the entire medium has been described as a very generalised three-layer model. Layer I is a typical porous medium built of Quaternary deposits of diversified characteristics (thickness, grain size composition). Layer I is restricted by land surface and the roof of the confining layer. The system describes it in terms of lithological type of the medium and its thickness. Layer II - confining layer is built of clayey and dusty formations of Upper Triassic or Tertiary clayey formations. Similarly to layer I, it is described in terms of lithological type of the medium and its thickness. Layer III is a fissured-karstic medium built of carbonate Middle and Low Triassic formations.

Layers describing geological profiles are point layers. Each of them informs about the number of lithological types determined in the profile, depth of a lithological type change, depth of drilled and stabilised water tables. It also provides some general data of the borehole i.e.: location coordinates (X, Y, Z), borehole name and identity code, date when the borehole was made.

The faults layer was generated as linear, with information on the fault slope direction and its character. This layer is necessary to determine spatial relations of the lithological types and limitations of water flow on fault surfaces..

Taking advantage of the above mentioned information layers, the system allows for a separate generation of structural surfaces characterising roofs and bottoms of individual media recognised in a megasite model.

The Tarnowskie Góry Megasite model comprises a roof of a porous Quaternary medium (this roof corresponds to land surface within the area of Quaternary formations occurrence), roof of an impermeable layer and roof of carbonate Triassic formations. Moreover, the system is equipped with layers providing data on electric conductivity coefficient, which is an input information to the model before its calibration.

The described set of layers is accompanied by tables and supporting files containing default information allowing for conducting preliminary modelling. During calibration, values contained in these supporting materials undergo changes within set-up, permissible ranges.

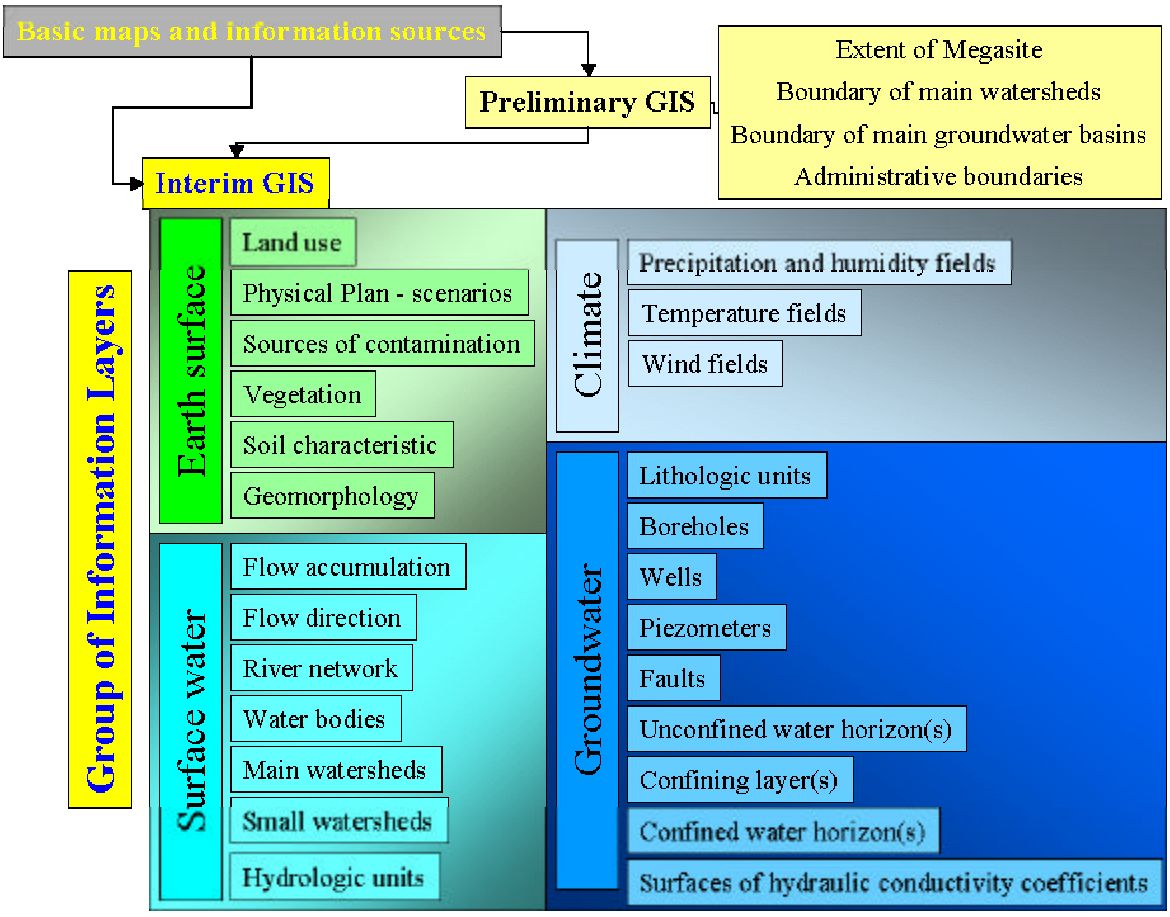


Fig. 5 General scheme of WELCOME GIS development

Next step in a megasite GIS development is to conduct a modelling which enables determining the rate of water flow and its direction, performance of water balance that takes account of atmospheric precipitation as well as water inflow and outflow at the megasite due to result of side-flows and waters originating from artificial inflows. After calibration based on measurement data from gauging stations and data on water table surface in wells and piezometers, the developed model serves as a basis for modelling contaminant migration.

The principle of risk, which is one of the key principles of land surface and water quality management, requires however supplementing the system by subsequent information layers.

The most important layer to be incorporated is the one, which characterises the population number, duration of a stay at a given place as well as such parameters as average body weight, average water consumption, average air use. This layer should determine the links, which exist between the waters, characterised by the GIS and consumers.

Before supplied to the consumers, waters from wells in industrialised areas are first treated and then redistributed in space what disturbs the natural spatial links. Therefore the system should also contain data on water supply network, water treatment stations and pipelines transporting waters from wells to the treatment stations. Such information allows restoring the relation between water contamination and human exposure. A similar phenomenon is observed in the case of exposure to secondary emission from land surface. Determining the number of people exposed to specific environmental conditions is possible when some assumptions are made. People spend a defined number of hours in the place of their residence. This creates an opportunity to determine the spatial relation between the number of exposed people and potential environmental conditions. This relation is obviously disturbed by the fact that an indoor exposure characteristic differs from the outdoor exposure. However, there is a significant number of hours which people spend travelling, at their workplaces and schools. While the exposure character at each of these places can be possibly defined, a relatively precise determination of the residents number of a specific area staying in a given workplace is rather difficult

This element may cause errors of several tens of percent assessing population risk what means that only determination of an individual risk is feasible.

In its final stage of the development, the GIS should allow generating maps of individual health risk assessment, resulting from various scenarios of land use. Since the task of IMS construction requires combining the analysis of risk elimination costs with an effect measured by the level of risk reduction, it is necessary to categorise the entire megasite from the viewpoint of application of various remediation scenarios and implementation of identical water cleanup technologies.

Performance of an environmental classification analysis from this point of view requires introduction of further additional sets of data into the system. A map of natural attenuation capacities of the environment is an example of the necessary additional information layer.

Each developed information layer is described by a set of metainformation.

5 GIS DEVELOPMENT

The critical steps in this development effort include:

1) acquisition of all pertinent data relative to the study area;

2) accurate integration of the data into a spatial model; and

3) assessment and identification of these environmental indicators that are the most useful for modelling of environment and predicting the behaviour of contaminants in surface and groundwater. In evaluating the study area, potential sources and types of data necessary to form the GIS database were identified. Data were evaluated with respect to their potential usefulness, cost, and availability within project time constraints. Data types deemed necessary include: administrative, potential and actual sources of contamination, topographic, vegetation, pedologic, geologic, hydrogeologic maps; borehole location and related hydrologic information such as well yield, water level, water quality, aquifer test data (hydraulic conductivity, transmissivity, porosity, etc.); and synthesised information addressing local and regional hydrogeologic investigations.

Typical scheme of the development work includes:

- existing data collection for determined extents;
- evaluation of data;
- updating, modification of data;
- collection of new data.

Data collection efforts were generally divided between two types of information:

1) maps and related data available from the state administration;

2) reports, maps and related data that form the part of Main Groundwater Basins technical documentation;

5.1 MAPS

5.1.1 Topographic maps

Topographic maps are produced in Poland by cartographic and geodesy survey under Cartographic Act.

Maps are produced according to guidelines and detailed instructions approved by the Main Country Land Surveyor.

The following maps are available:

- Basic maps of scale 1:500 and 1:1000;
- Detailed maps 1:2500, 1:5000, 1:10000;
- Survey maps 1:25000, 1:50000, 1:100000.

Map users should remember that spatial data (maps and databases) are produced in different coordinate systems. Beside older archives that are connected with local coordinate systems and state coordinate system dated before II World War (the later based on Bessel ellipsoid), the most frequent coordinate systems used are as follows:

- State Coordinate System 1965 (Polish acronym - PUW65);
- State Coordinate System 1942 (Polish acronym - PUW42);
- State Coordinate System 1992 (Polish acronym - PUW92);
- State Coordinate System 2000.

PUW92 is a system of coordinates currently effective in Poland t (maps scale from 1:10000 and less detailed) as well as PUW2000 (of scale bigger than 1:10000). Since only recently there was a change of relevant regulations, a significant portion of materials including those offered by state surveys is related with older systems. For example: cartographic materials produced by Tarnowskie Góry Town Hall or generated for the needs of the Chemical Plant liquidator are in Cartesian coordinates PUW65.

This requires processing of data into appropriate system of coordinates on a case-by-case basis.

The differences among coordinate systems result not only from different projection applications but also from ellipsoid changing.

Both PUW 65 and PUW42 are based on Krassovsky ellipsoid with main point located in Pulkovo. That is the reason that the PUW42 is frequently described as Pulkovo42 in literature with number dependent on related zone.

Recalculation of coordinates from this system into PUW92 is relatively simple. Similar situation is for materials in PUW65 zone5. But recalculation of other zones of this system into PUW92 is a much more complicated process as the solution of this problem, which would bring really satisfactory results, actually does not exists.

The table below presents selected parameters of PUW92.

Table 1 The parameters of PUW92

Parameter	Value
Ellipsoid	GRS80 (for cartographic purposes also WGS84)
Projection	Transverse Mercator (Gauss Kruger)
Units	Meters
Central meridian	19:00:00
Reference latitude	00:00:00
Scale factor m	0.9993
False easting	500000
False northing	4 500 000

5.1.2 Sozological Map of Poland[7]

Selected sheets of the Sozological Map of Poland of 1:50 000 scale were obtained as a set of information layers. The sozological map is one of the best information sources about the use of environment in Poland.

The sozological map consists of a number of information layers comprising most of sozological aspects. The intentions of the map authors are lucid: the map is aimed to compile

[7] Praca zbiorowa (ed. Główny Geodeta Kraju); 1997; *Wytyczne techniczne K-3.6 „System informacji o terenie. Mapa sozologiczna Polski skala 1:50000, w formie analogowej i numerycznej”*; GUGiK; Warszawa

environmental information sufficient for planning new economic, municipal as well as recreational objects at all levels of management.

The map was generated as a product of a conventional vectorisation (analogue) of a map in the scale of 1:50000. The authors assumed the map as a typical GIS product of vector character. At the current stage of development, the scope of information encompassed in the entire sozological map as well as in the land surface form layer is not sufficient to support decision- making processes neither on district (poviat) nor voievodeship level.

The development of this map was initiated in late 90's.The map was produced using the state coordinate system PUW42 and based on analysis of aerial photographs combined with central level information resources. The map is available as paper form and as a set of information layers and databases in MapInfo format as well as ArcView formats.

The scale of the map is 1:50000 what results in the fact that the enclosed information is not sufficiently accurate. Therefore, beside systemic data, data from land survey need to be simultaneously entered.

There are several information layers containing information on emission sources: point emitters (actual emissions to waters and air, and potential emitters –landfills, cemeteries, wastewater treatment plants) and polygonal emitters (large features which are actual or potential contamination sources, e.g.: open workings, mining areas).

Division of land surface forms into point and polygonal results from the division of features into two categories using the criterion of the surface size. The value of the assumed criterion was 6,25 ha, and it allowed to recognise large features which boundaries can be projected in the map scale as polygonal forms and smaller features e.g.: 250 x 250 m, which are represented as points. This division seems justified for analogue maps and visualisation purposes. However, for systemic needs the system should be developed in a way enabling representing all objects as polygonal features, not to mention maintaining common fields in attribute sets. The only common attribute specified in that database is the type of industry for the purposes of which a given landfill site or working was created. In the case of actual point emitters – the attribute determines if the emitter is of industrial or municipal character. Other attribute data (except for systemic) are not contained in the database.

The system of a sozological map contains information useful at various levels of land surface reclamation analysis. Nevertheless all of them are of index character or incomplete metadata. The authors assumed an ongoing development of the map and continuous input of relevant data with an ultimate goal to transform the map into an actual spatial information system on the environment.

The following are they key weak points of the sozological map:

- Lack of a basic element necessary for automating environmental data analysis. The map is not equipped with a digital altitude layer i.e.: a numerical altitude model as a base numerical model of the area;
- Incompleteness of hydrographic network database. Analysis of hydrographic data showed that the resource of information on watercourses contained in the database is not only sufficient but incorrect in topological sense as well. This proves that a digital sozological map has to be equipped with a module of hydrographic data quality (correctness) analysis so as to signalise potential errors at each system level.

5.1.3 Hydrological Map of Poland (HMP) and HYDRO Bank

The map covers the entire territory of Poland. It is constructed in cartographic projection "1942". The first sheets of HMP were prepared in 1989. Since 1996, the map is systematically constructed in Polish, in accordance with the approved instruction. The completion of the map is expected in 2005. The HMP is financed by the National Fund of Environmental Protection and Water Management.

The aim of the map is a synthetic presentation of the hydrogeological conditions, useful aquifers and characterisation of groundwater resources, their dynamics, quality and hazards. The map also provides local administration with necessary information on groundwater and helps programming hydrogeological investigations carried for territorial planning purposes.

HMP database content:

- SURFACE WATER: classes of stagnant water quality; classes of river water quality in sections of groundwater risks: water gauges (in the documentation map); European watershed; watershed; confluence;
- WATER-BEARING CAPACITY; description of the hydrogeological unit; extent of the hydrogeological unit; useful aquifer (UA): thickness, transmissivity, depth; potential discharge of a well;

- QUALITY OF GROUNDWATER: fresh and mineral waters appearance; classes of groundwater quality; exceed indicator of water quality in UA;
- HYDRODYNAMICS: hydroizohypses; direction of water flow in UA; depression cone; reprisal cone;
- GROUNDWATER INTAKE: spring, classes of water quality in springs; dug well, classes of water quality in dug well; hydrogeological borehole; classes of water quality in borehole; medicinal water intake; hydrogeological borehole without sampling; gallery; shaft; collector well; intake drain; hydrogeological test borehole; PGI points of groundwater stationary observations; points of groundwater sampling for map preparation purposes; groundwater intake from many boreholes; groundwater intake from many boreholes - infiltration type; mining area of medicinal and mineral waters;
- HAZARDS: risk degree (5 categories); waste disposals of solid materials; sewage discharges; communal sewage discharges; industrial sewage discharges; emission of dusts and gases; storage of liquid fuels; sewage treatment; chemical plant, metallurgic plant, agriculture - food or other industry; mining depository, mining heaps with description;
- OTHERS: mining area of mineral deposits; faults; impermeable wall; regional documentation - its extent; hydrogeological cross-section; national border.

5.1.4 Detailed Geological Map of Poland scale of 1:50 000

A Detailed Geological Map of Poland (DGMP))is a covered lithological-stratigraphic map that also takes into account the origin and facies of the sediments as well as tectonics and thickness relations. It reflects the surface geological structure of the area, with vertical stratigraphic and lithological profiles; it also defines possible mineral potential, and presents hydrogeological and engineering-geological conditions. Additionally, the map contains basic information on dynamic geology, geomorphology, palaeogeography, environmental geology, etc.

The Detailed Geological Map of Poland is currently developed by the Polish Geological Institute, with the help of geological enterprises and companies, universities, Polish Academy of Science, 42 organisations in total.

The co-ordinator and main executor of DGMP is the Polish Geological Institute (PGI). Co-ordination of DGMP is one of the PGI statutory obligations. Co-ordination system includes DGMP Chief Co-ordinator (situated in PGI), 18 Regional Co-ordinators and 6 Co-ordinators, responsible for selected scientific problems, editing and digitising. They supervise full map cycle, from the initial programme to the final map, which is accepted by the Commission of Cartographic Works, representing the Ministry of Environment.

The completion of the first DGMP edition is expected in 2005.

Content of DGMP:

- deposits of grass cover; loess decalcification zones; old river beds; swamps, swamp ores; bog ores and cones areas boundaries; slope debris and talus; alluvial cones; alluvial - talus cones; talus cones; talus accumulation rocks; accumulation blocks and block fields etc.; accumulation of the moraine boulders; erratic boulders; erratic boulders F>1,5 m; accumulation of erratic boulders; accumulations of local boulders; exotics; quartzite blocks; basaltic blocks; wood;
- erosion cuts; earth cracks; collapse sinks; collapse sink boundaries; sinkholes; caves; anthropogenic forms; anthropogenic scars;
- landslide and rock-fall scars; landslides boundaries; wide landslide zones;
- groundwater effluences and seepages; vaucluse springs; spring with the gas chemical symbol, letter sign of mineral; artesian wells; mineral water exploitation shaft;
- selected documentation points; geological boundaries; geological cross-section; bedding; strike of beds and dip of different geological planes; hieroglyphs position; synclines and anticlines; faults; slice and weakness zones; thrusts boundaries; boundaries of tectonic units; glacial tectonic disturbances; periglacial structures;
- fossil flora finding; floral detritus; localities of fossil soil;
- directions of sediment transport; pillow structures; amygdaloidal structures; metamorphism zones; quartzitization; linear elongation of minerals or mineral aggregates; contact metamorphism; zones of hornfels texture; absolute age dating;
- mineralisation; boundaries of hydrothermal and pneumatolytic alterations; kaolinization; mineral appearance; mineralisation zones; natural gas appearances; crude oil seepages;
- magnetic profile; seismic sounding traverses; geoelectric profiles; geoelectric sounding traverses; electro -resistivity differential profile;
- selected boreholes; exploration mine galleries; mine shafts - active; mine shafts - inactive; open cast mines; selected important quarries; natural gas exploitation shafts; crude oil exploitation shafts;
- prehistoric findings; ancient castles;

The Detail Geological Map of Poland is produced in PUW42.

Some of the sheets are available as vector maps while some others as raster or paper maps. Each sheet of this map was developed separately what resulted in typical geometrical errors that can be removed during edge matching process as well as in disagreement of particular

features classification (lithological classes and stratigraphic units). To eliminate this type of disagreement, co-operation with geology experts was required. Finally some of the data had to be generalised.

Base map data layers in the GIS were appropriately coded with as many descriptive attributes as could be derived from the base maps. For future coding the guide edited by the Polish Geological Institute will be used.

Monitoring of environment in Poland is executed by different state organisations as well as, based on an administrative decision, by industrial units or municipal units responsible for suspected or actual contamination.

5.2 MONITORING DATA

Data compiled in the framework of the Sate Environmental Monitoring (PMS) serve as a primary source of data on the state of the environment. The goal of the National Environmental Monitoring is to acquire, store and process environmental data and provide access to them. The goals of the State Monitoring are accomplished based on Action Plan approved by the Minister of Environmental Protection, Natural Resources and Forestry. In 1999, tasks were performed accordingly to the „National Environmental Monitoring programme for the years 1998 – 2002".

As the General Environmental Protection Inspection report says (GIOS, Warszawa 2000) realisation of the PMS tasks in 1999 was focused on environmental quality studies and was a continuation of the research performed within:

- the national framework which primary aim is to monitor main environmental components taking account of international obligations resulting from agreements and conventions signed by Poland, and to evaluate the effectiveness of environmental protection aimed efforts undertaken in national scale;
- regional frameworks which primary aim is to monitor main environmental components within the voievodeship areas (voievodeship networks) or combined areas of several voievodeships (intervoievodeship networks) to evaluate the effectiveness of environmental protection aimed efforts undertaken on voievodeship and intervoievodeship scale;
- Local networks which primary aim is to monitor selected environmental components, which are in focus due to local conditions;

In 1999 data was acquired and collected in the following sub-systems:

Air quality monitoring ;

Surface waters monitoring;

Groundwaters monitoring;

Soil monitoring;

Wastes monitoring;

Noise monitoring;

Ionising radiation monitoring;

Forests monitoring;

Integrated environmental monitoring.

Voievodeship Environmental Protection Inspections store the data from the monitoring of environmental condition in the following databases:

- SAZP-W – air pollution database;
- JAWO – rivers monitoring database;
- JEZIORA – lakes monitoring database;
- OPH – noise monitoring database;
- SIGOP-W – hazardous waste monitoring database.

HYDRO Bank is a database storing information about hydrogeological boreholes, wells and springs of drinking, mineral and thermal water. HYDRO Bank database includes: basic information about item location, litho-stratigraphic information, chemical analysis of water, pumping tests results, etc. This database also includes hydrogeological reports about more than 126 000 hydrogeological items already drilled in Poland. Full dataset (covering the whole Poland) is stored in **Central Hydrogeological HYDRO Database (CBDH)** at the Polish Geological Institute (PGI) in Warsaw.

Based on research data, information on the state of individual environmental components is periodically generated. It is published in an editorial series „Biblioteka Monitoringu

Srodowiska". This information is forwarded to local and governmental administration bodies to support decision-making processes. It also ensures setting up strategies of economic and spatial development most appropriate both for the country and for individual regions. The developed environmental information also finds application in evaluating the progress in accomplishing the goals set up in environmental action plans.

Criteria for the assessment of the state of environment comprise immision standards provided by Polish legal regulations. Such standards were set up for the assessment of air and rivers condition and for noise nuisance. Other PMS subsystems use specific PMS- dedicated guidelines developed based on long-term studies and observations to determine the quality of individual environmental components.

Tasks of the National Environmental Monitoring are coordinated by the State Inspector of Environmental Protection.

A significant portion of environmental quality studies is conducted by research and development units and academia as target-specific projects ordered by the State Inspector of Environmental Protection. These projects are financed from budgetary sources of the Inspection and by the National Fund of Environmental Protection and Water Management. These projects contribute to the development of the following subsystems:

- **Monitoring of groundwaters, national network – research performed by the State Geological Institute;**
- monitoring of the Baltic Sea - research performed by the Gdynia Division of the Institute of Meteorology and Water Management;
- **monitoring of soil chemistry - national network—research performed by the Institute of Crops, Fertilisation and Soil Sciences in Pulawy;**
- monitoring of ionising radiation – national network –research is performed by the central Laboratory of Radiological Protection in Warsaw;
- monitoring of forests – national network – research is performed by the Research Institute of Forestry in Warsaw;
- Integrated Environmental Monitoring - national network - research performed by various research and development units and academia under the coordination of the Poznan University.

The other research work the National Environmental Monitoring is performed by the Voievodeship Environmental Protection Inspections. In 1999, they realised the following tasks:

In “environmental protection” field:

- Research and assessment of air quality (national, regional and local networks);
- **Research of the atmospheric precipitation chemistry (national network);**
- **Research and assessment of water quality in rivers (national, regional and local networks);**
- **Research and assessment of water quality in dam reservoirs (regional network);**
- **Research and assessment of ordinary groundwaters (regional and local networks);**
- **Soil chemistry research (regional and local networks);**
- Measurements of transportation noise intensity (regional network);

In ”emission” field:

- Quantitative and qualitative determinations of emissions volume discharged to the environment by emission sources – **wastes monitoring** (**SIGOP-W database**);
- Determinations of noise transmitted to the environment (OPH database);
- Measurements of air pollution emissions;
- **Control measurements of the quality of discharged wastewaters.**

In the “assessment and prognosis” field – development of reports, communicates and information. These studies contain a combined analysis of data comprised in the fields: “environment” and “emission” as well as results from studies performed by units cooperating within the PMS framework such as: Voievodeship Sanitary and Epidemiological Stations, soil-chemistry stations, research and development units and academia. The studies present the current state of the environment along with the policies and trends resulting from the performed measurement campaigns.

In 1999, measurement campaigns within the PMS were performed according to an operational plan set up for the national network by the State Inspector of Environmental Protection and

voievodeship plans (regional networks) also approved by the State Inspector of Environmental Protection upon acceptance of the voivodes.

Data from the monitoring stations are formally available to any person on a commercial basis, or on non-profit basis (only technical cost of data collection, store and sharing) to persons having a legal interest. Only some of data are available to the public, mainly as meta-information, excluding measurement data from monitoring station. When publicly available, these data are generally outdated.

Monitoring of agricultural areas contamination is conducted by the Institute of Crops, Fertilisation and Soil Sciences in Pulawy for the State Inspection of Environmental Protection . The Institute in Pulawy is a state institute from the group of research and development units affiliated with the Ministry of Agriculture. Institute for Ecology of Industrial Areas is involved to the same group of scientific units but is affiliated at Ministry of Environment). Results of monitoring are available only as printed reports with generalised maps each year.

Monitoring of underground water (only waters of main aquifers qualified as resources of water for use) is conducted by Polish Geological Institute (a state institute from the group of research and development units affiliated with the Ministry of Environment) for the State Inspection of Environmental Protection .

Monitoring of surface waters is conducted by their services of the State Inspection of Environmental Protection or by the Institute of Hydrology and Meteorology (state institute from the group of research and development units affiliated at Ministry of Environment) for the State Inspection of by the services of the Ministry of Health (State Sanitary and Epidemiological Inspections).

Monitoring of air is conducted by services of the State Inspection of Environmental Protection and by the State Sanitary and Epidemiological Inspection.

Additionally, based on an administrative decision issued by the State Inspection of Environmental Protection, industrial and municipal plants are obliged to develop local monitoring, data of which are only available directly to the State Inspection.

Organisations contacted for data search to accomplish WELCOME project needs included: Polish Geological Survey (Polish Geological Institute Archive, Voivodeship Geological Archive, Bank of Hydrogeological Data), the Silesian Voivodeship Survey Department,

Regional Water Management Board in Wroclaw and in Gliwice, the State Water Management Institute – Katowice Branch, Ministry of Environment and many others. Copies of topographic and geologic maps were obtained along with reports and any available well logs. Data sources identified as available , especially geological, hydrogeological and topographical data, frequently required agency permission for their retrieval.

5.3 DATA INTEGRATION

The GIS is developed using Arc/INFO and ArcView software. The GIS utilises Arc/INFO's georelational data model in which all spatial data are vectorized and referenced to a common Cartesian coordinate system. Each point is recorded as a single location; lines are recorded as a series of ordered x,y coordinates; and polygonal features are recorded as a series of x,y coordinates defining line segments that enclose an area. The GIS includes fully relational database capabilities, in which each spatial feature captured (point, line, or polygon) can be linked to a virtually limitless number of descriptive attributes. Each data type becomes a distinct 'layer' of information in the GIS, though each presents a unique set of automation and integration challenges. Material obtained in different formats required strong efforts from the GIS team to integrate into GIS.

5.3.1 Recalculation of coordinate systems

Polish State Datum 1992 (PUW 92) was selected as coordinate system for WELCOME project.

While coordinates are the thread that tie all data together within a GIS, many “GISs” do not have coordinate system and datum transformation routines other than crude rubber sheeting techniques. Thus, it is critical that coordinates be transferred to the same coordinate system and datum before insertion into the GIS. The average shift of coordinates only resulting from ellipsoid change is in case of Poland on level of 135m and more.

Using the instruction issued by the General Country Land Surveyor[8] an extension of the ArcView software was worked out which enables automating the transfer of maps developed in .shp form to the reference coordinate system.

Another method that can be used for cartographic purposes with worsen yet still comparative accuracy is the Molodensky Method.

5.3.2 Base Maps

Topographic maps

The project study area has been subdivided for reference into a series of 15-min. quadrangles. Corner tics of these quadrangles serve as registration control points for all base maps automation. The database was designed using a PUW92coordinate system and structured at the first stage of WELCOME GIS development around a 1:50 000 scale base map series produced by the Polish Survey Department.

The 1:50 000 map series provides a source of important base map data, including surface hydrography, transportation features, and built-up areas locations along with the names of small settlements and resorts. The source maps were available as raster and on paper media.

The Institute for Ecology of Industrial Areas has developed an internal spatial information system that is composed of several information layers. These information layers were one of the main information sources for the preliminary GIS.

Topographic maps obtained as rectified and registered rasters from the Vovodeship Cartography and Survey Centre with permission of the Marshal Office were used as background maps. Screen vectorizing was used to update existing information layers.

Topographic data constitute the key element in determining water table elevations and, subsequently, the development of potentiometric maps. The topographic contours of 1:50000 scale were integrated into the GIS and used to derive a digital elevation model from which

[8] Kadaj Roman; 2001; *Wytyczne techniczne G-1.10 – Formuly odwzorowawcze i parametry ukladów wspólrzednych (Technical Guidelines G 1.10,- Projection formulas and parameters of coordinate systems)* Glówny Geodeta Kraju, GUGiK, wyd.2 zmienione, Warszawa

more accurate elevations can be determined for any well location, permitting refinement of the potentiometric surface map.

The Geological map required nearly full technological processing pathway. The obtained rasters were registered in PUW42.

Monitoring data and technical documentation of groundwater basins

Separate methods were used for monitoring data as well as technical documentation of the Main Groundwater Basins as well as geological data from the central geological archives.

Materials obtained in paper form were scanned. Descriptive materials and tables were vectorized using dedicated OCR software. The workload used for the accomplishment of these tasks was extremely high and related to quality assurance and verification of a number values. Table data were consolidated into unified data files using calculation sheets and afterwards transformed into a database. These materials however had no spatial references but only a reference to an identity code on the map. This reference was used to correlate table data with a specific location determined based on vectorized maps.

The maps were scanned in small sections since their technical condition reflected significant surface deformations what could result in occurrence of serious errors in case the maps were scanned on a large-scale scanner.

Scanned maps sections were entered into the system using all registered and rectified raster and vector maps. For maps of 1:50000 and 1:25000 scales, root mean square (RMS) error did not exceed 25 m. Material was registered and rectified using ArcView 8.2 functions. Only Helmert transformation was applied. The registered and rectified materials were used to retrieve location of boreholes and wells in flat coordinates used in the system. Vectorized maps were coded according to information provided in them. The generated databases in which flat coordinates were accompanied by an identity code on a map were correlated with tables linked to a specific map.

Then the information originating from various documentation sources was compared using both; location on a map and values of descriptive attributes. The developed database concerning water intakes was finally verified against the BANK Hydro data

Well Locations

Understanding the spatial distribution of the existing wells is obviously an important initial step in developing a hydrogeological model of any site. Furthermore, without accurate location (and elevation) data for these wells, the borehole data collected during drilling (described below) are useless.

Once primary data had been collected and reviewed, it was necessary to accurately verify a significant number of well locations essential for the GIS model to correct location and borehole characteristics. Three factors created large uncertainties in borehole locations:

1) Borehole locations on drill logs were identified only based on old topographic maps;

2) Coordinates of some boreholes could be determined only from general maps of 1:50000 scale;

3) There were differences among hydrological documents concerning location of the same boreholes;

4) Some of boreholes drilling logs were very old and without elevation data.

These factors combined with cost constraints and accuracy requirements dictated the use of sub 20m GPS receivers to accurately survey borehole positions. Errors of measurement in dominant part of cases were below 5m.

Because borehole elevations combined with water level data are critical for creating accurate potentiometric maps, additional steps were taken to improve elevation measurements. As GPS determined altitudes are generally limited to 3 m, elevations were determined by extracting the z value for given x and y locations on DEM and compared with detail topographic maps.

Prior to the GPS survey, a preliminary well location data layer was developed, using spatial tools offered by GIS. The preliminary well location data layer gave project hydrologists a provisional set of data from which to develop early working hypotheses. Upon completion of the GPS survey, the well locations were rectified and the development of the working groundwater model became more clearly focused.

Well logs

Hydrogeological data in the form of database are accessible from state archive – HYDRO Bank. Numerical hydrogeological and geological maps are generated as a part of a program realised by Polish Geological Institute. Many of these well logs contained extensive information including hydrogeologic descriptions and characteristics of rock units encountered during drilling, as well as well construction information describing the casing, screening, and development history of the well. In addition, the reports contained water chemistry and well yield data vital for the successful characterisation of groundwater flow in the study area. Data entry templates were created for more an efficient entry of large quantities of existing well log information. Finally, several separate well log data files were created, each containing from eight to forty separate descriptive attributes.

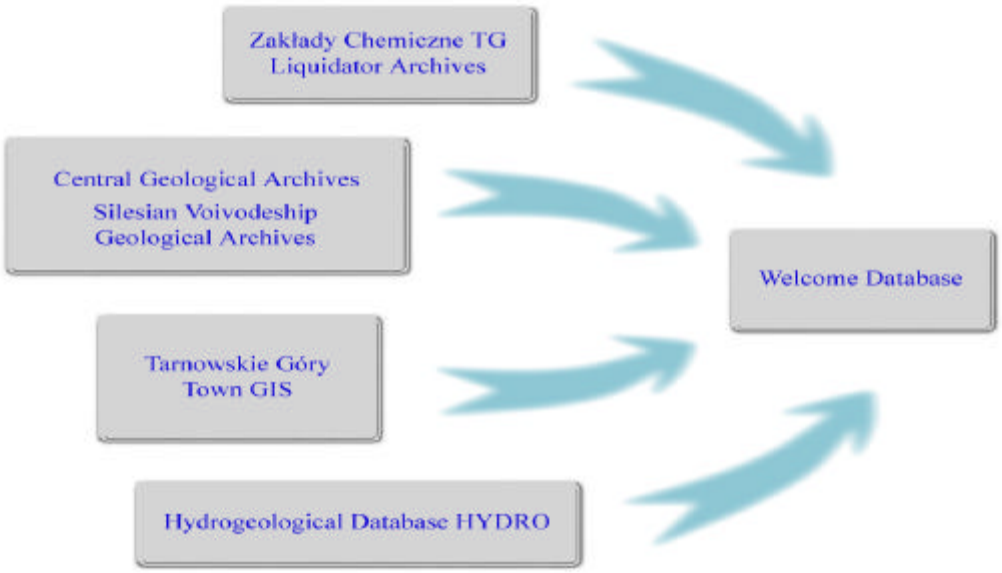


Fig. 6 Well logs data sources

In the GIS, all well log files were linked relationally to the well location attribute table, so that any combination of well construction, lithologic, geochemical, or hydrogeologic characteristics, for any number of wells, could be quickly viewed in spatial context.

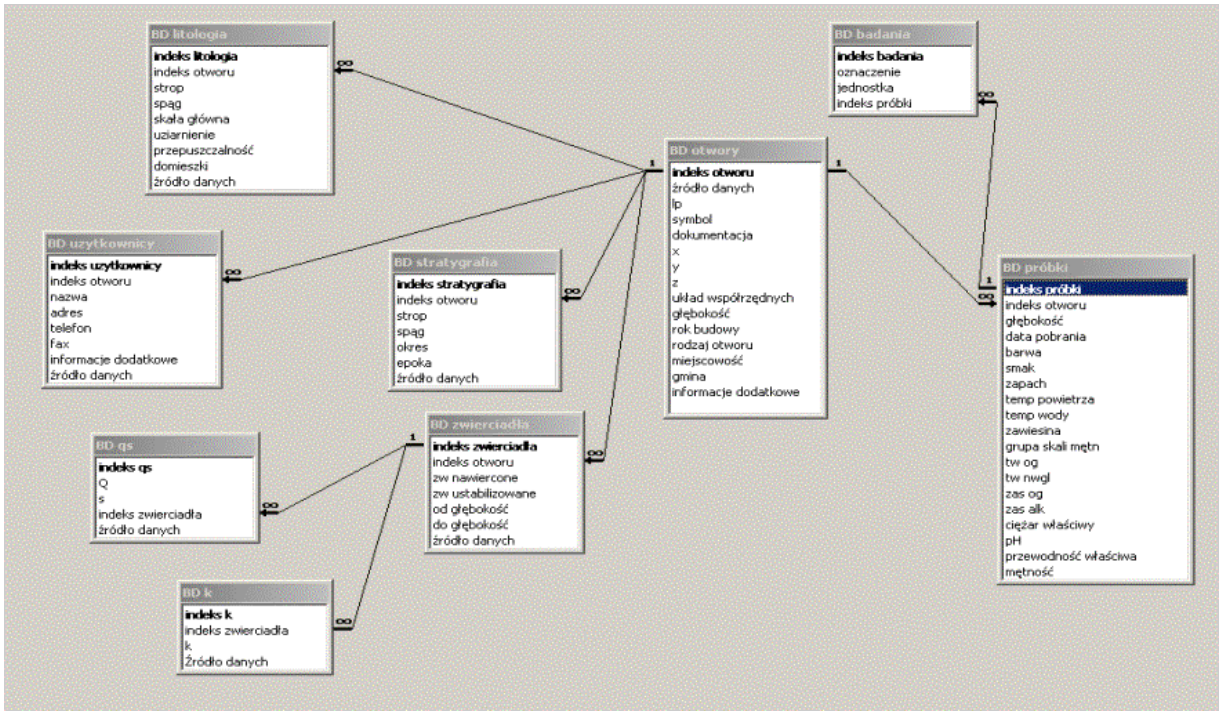


Fig. 7 Structure and relation of hydrogeological databases

River network

The hydrographic map contained in the sozological map required re-processing.

The information resource of the sozological map refers to the axis of watercourses. The database contains information on the name of a watercourse, if existing, its identity code and section lengths and other attributes describing the riverbed

Analysis of this information resource showed that the graphic part of the database has not been updated as for vector orientation. Orientation of the watercourses should be from the outlet to the spring since such orientation enables an easy use of this information and its automatic interpretation. Gaps in the field “watercourse name” for some rivers were another failure of the resource, so was the lack of watercourse connections in outlet sections. This problem could occur during format transformation or could be a vectorization error not eliminated during verification stage. Other identified failures concerned lack of the uniqueness of watercourse names and consequently lack of a unique identity code. All the identified problems enforced the need to analyse the topology of the entire resource. A preliminary, arbitrary division of watercourses into basins was carried out what reduced the sizes of files and made analysis of individual basins simpler. Documentation of hydrographic division of Poland’s rivers served as a division basis.

Three order I basins were recognised – the Odra River basin – assigned no. 1, the Vistula River basin assigned no. 2 and the Danube (Vague) River basin – assigned no 4.

Order II and III basins were determined using coding according to the hydrographic atlas of Poland.

Each basin was analysed by ArcView software (using own AVENUE scripts). The analysis was performed only for larger watercourses, i.e. courses identifiable by name in the system. Step I of the analysis concerned determining the outlets and springs. The outlet sections (actual or final sections of watercourses determined by the edge of the map sheet) were coded with one uniform code while a separate code was assigned to spring sections.

Step 2 of the analysis was focused on topological correctness and allowed identifying the sections of incorrect orientation or unlinked sections. Improper orientation was turned in the case of watercourses with orientation error, in cases where section links were missing, relevant sections were drawn adding the name attribute to appropriate field. An automatic correction was also made using a numerical area model (the outlet point is usually located at higher altitude than the spring point). Topology correction of watercourses not encompassed in the model was performed using topographic and hydrographic maps.

As a final product, a topologically correct map of watercourses was generated which is equipped with a complete name attribute at the entire length.

This map served as a basis for developing an automatic procedure of river profiles analysis and determination of sub-watersheds. The numerical area model was used to perform automatic analysis of river profiles. Errors occurring due to failure in matching the model to the rivers layer were eliminated automatically.

Map of sub-watersheds

Methodology of an expedited watershed determination is based on the following key indicators:

1. Derivatives of area properties (flow directions, flow accumulation etc.) remain constant if NMT is unchanged, and are not a watershed delimitation function for a random point but rather for the NMT. As such they do not have to (and should not) be correlated with operations of individual watersheds determination.

2. The key property of the watershed boundary is that it defines the area from which the water flows to the watershed outlet in a precise and unique way. Any point located outside this area does not participate in the flow towards the outlet point i.e. it is not a subject of interest when solving problems addressing a given watershed area.

The method of an expedited watershed determination consists of two preliminary steps and some techniques to utilise the pre-processed data

Step 1 – determining the derivatives of NMT properties

Basic derivative properties of the area (flow direction and accumulation grids based on altitude grid) are calculated and stored, so that they are ready available when needed for defining individual watersheds. This means that these operations need to be performed only once for a given NMT (if the NMT is changed – they obviously need to be repeated). This also allows for their simultaneous calculation on various computers while the final watershed delimitation should be performed by one workstation. Since calculation of the derivatives of area properties belongs to the most intensive calculation operations, it should be made using appropriately efficient, preferably dedicated computers. When the calculations are ready, the data can be transmitted to other computers, on which calculation operations that are less intensive but require more interaction will be performed.

To analyse the area of the Slaskie Voievodeship, IETU had two NMT models available. They were made based on various analogue materials and on various reference systems. The available materials however, did not cover the entire area of the voievodeship. Both models were integrated and PUW92 was assumed as the coordinate system. IETU generated a model of the northern part of the voievodeship in 92 system. The older model comprising the former Katowice Voievodeship was developed in PUW65 s5 system. The material was stored as a grid 10m-resolution map. Using an own developed module for transforming geographical coordinates to land survey data for various ellipsoids and projections, the entire model of the Katowice Voievodeship was recalculated into PUW92 coordinates. Both maps were combined using grid function. The disagreement value was assessed on the level of several to 40 m in belts were models overlapped (width of a sheet of a topographic map in PUW92 system and scale of 1:50000).

Simultaneously, an update of input data for the central part of the voievodeship was ongoing. A database comprising coordinates of land-survey points represented on the topographic maps (approx. 100-150 points per sheet), point type identifications (land –survey, altitude, hydrographic) and the altitude in m a.s.l. created. All input data of the Katowice Voievodeship altitude model were recalculated into PUW92.

Step 2 – Calculating the profiles of main rivers (i.e. with a unique identity code).

Node points of the topologically correct river network were used for determining the altitudes of the model. These values were verified against hydrographical point data present on the topographic maps and by an assumption that a node point located closer to the outlet should be lower than the node point located closer to the spring.

The next steps were focused on the development of complete altitude river profiles. The number of vertices in individual river sections was condensed, however not exceeding the distance of 20 m. The worked out algorithm allows determining the altitude of a top point based on data from the altitude model and altitudes correlated with node points so that subsequent altitude value downstream cannot be higher than at the preceding point.

River profiles were determined by a set of node and top points. Transformed into a grid format of resolution identical with NMT, individual grid cells of the altitude model could be replaced by cells of the calculated river profiles.

Step 3 – Calculating sub-watersheds

An operation of levelling local depressions using ArcView algorithm was performed on the integrated model of the northern and central part of the Slaskie Voievodeship with watershed profiles built- in. Then the model was used for generating maps of NMT derivatives i.e. maps of flow directions using algorithm 8D[9] and creating a map of flow accumulation volume.

[9] ESRI. (1997), *Watershed Delineator Application - User's Manual*, Environmental Systems Research Institute, Redlands, CA. The name 8D means 8 directions. Each grid cell is assigned a code of one of the 8 directions, in which water may outflow from the cell. This way of coding covers the entire area. Its further analysis allows counting the cells which are correlated by the same flow direction. In this way a grid of outflow accumulation is determined

Next, the boundaries of sub-watersheds were calculated. Selecting the value of boundary accumulation i.e. boundary value of a surface which is a sub-watershed, turned out to be a critical element of this operation: an extremely low value leads to generating an excessive number of units while a too high value – integrates watershed of key rivers in the hydrographical network. It is suggested to consider development of a method for a dynamic determination of boundary accumulation value, which would take into account area diversity, length of river sections, watershed surface and other factors. The grid map of sub-watersheds was converted into .shp. Sub-watersheds are encompassed in watersheds of higher order. Watershed boundaries determined arbitrarily were compared with boundaries generated automatically and integrated into a map of the Slaskie Voievodeship watersheds.

Map of building development

The map of building development constitutes the second, extremely important from the viewpoint of the future land use as a source of information for risk assessment and analysis, layer in the system.

As it has already been mentioned, in the present form of the sozological map building development is projected as polygonal features of high generalisation level. Results of the studies conveyed by the authors of this report[10] proved that such generalisation level does not allow utilising this layer as a reliable source of information to create a map of population distribution. The generated spatial distributions are too flat i.e. areas of intensive building development are underestimated while areas of dispersed development are overestimated. The authors have developed a methodology for generating maps of population distribution. According to this methodology this error may be reduced when differences in the density of building development are taken into account. Information on this density is provided by topographic maps in the scale of 1:50000. Unfortunately this is not the best source of information since the lowest number of errors occurs in the case of maps based on address maps which are directly linked to building cadastre. However, considering the value of errors

[10] Korcz M.; 1994; *Address map: A basic tool for biological and health monitoring*; [in] Proceedings ”GIS in Ecological Studies and Environmental Management – Warszawa, Poland 26-28 September 1994; GRID; also Korcz M., Bronder J., Slowikowski D., Dlugosz J.; 2001; *Analiza zebranych informacji o narazeniu ludnosci metodami GIS*; raport IETU; Katowice and Slowikowski D., Korcz M.; 2001; *Przestrzenny rozklad ryzyka zdrowotnego wynikajacego z emisji zanieczyszczen z zakladów przemyslowych na terenie województwa lódzkiego*, Inzynieria i Ochrona Srodowiska T4, 2001, Wydawnictwo Politechniki Czestochowskiej

permitted in risk analysis it can be assumed that a map of building development in the scale of 1:50000 is a sufficient source of information for creating population distribution maps. An algorithm of preliminary analysis was proposed in this study. It did not contain health risk assessment module. Instead, a ranking of features from the viewpoint of the distance from the building development was incorporated into the algorithm.

Several steps were implemented to generate the building development map as a vector map through screen vectorisation of features described on the map as consolidated building developments. Features signed as industrial buildings were excluded from vectorisation. Features signed as point building developments were created through making colour extracts of each map sheet. These extracts were then retrieved as black and white images. Concentrations of points less than four pixels were regarded as fuzz and removed from the images. After adding .tfw file, the image was saved in .shp format. Using the method of selecting features already present on the vector maps of condensed development and selecting features of surface below $100m^2$, redundant polygons were removed. Individual layers were afterwards simplified by transforming each feature into a rectangle, preserving its original surface size. Next, each map sheet was reviewed and redundant features, which were not signed as buildings, were removed. Such errors occurred on some map sheets in the contours of highways, road junctions and in the vicinity of bridges and viaducts signatures The review of layers allowed eliminating erroneous information on the building development as well as supplementing necessary data when they could not be acquired through image filtration. Complex and oversimplified features were corrected. Features rotated against the map and differences in surfaces of the buildings were left uncorrected. From the viewpoint of the role, which the building development layer is to play in the system, the acquired state of data verification was considered satisfactory. Further works on the building development layer were concentrated on coding the building development types to generate a map of population distribution.

5.4 GIS DATA INTEGRATION – SUMMARY AND CONCLUSION

GIS data integration activities are an ongoing effort. Base map, well location, topographic, field observations have been fully automated and integrated into the GIS. The information source differentiation as well as different data formats required a high workload to combine rationally data into one, spatially coherent system. Data vectorised from paper sources

requested additional quality assurance steps to minimise spatial errors introduced during digitising. Only well location data, acquired via GPS survey by our team have been linked via the GIS' relational database to the hydrologic data acquired without additional effort. Once integrated, various data can be displayed, merged, and analysed in spatial and georelational context with one another. All data is managed within a coherent spatial reference frame and can be used for developing scenarios and models.

GIS database development and data integration in an Accession Country such as Poland represents a variety of unique challenges. These challenges have become apparent at the early stages of data acquisition and had a significant effect on the project progress. Uncertainty regarding the availability and specific format of numerous data resulted in significant delays in database development activities. Conflicting reports regarding the available format and quality of data slowed down project development and ultimately resulted in manual digitising of selected futures from paper source maps.

In building a GIS database for comprehensive analysis, all avenues of data collection should be pursued including literature surveys, public and private organisations, and computer networks. The utility of GPS and GIS allowed their use by many non-surveyors and others not intimately familiar with geodetic and geographic control. It is critical that GPS and GIS operators be completely aware of the geo-referencing systems, datums, and elevation surfaces used during collection and transformation of positional information so as not to mix incompatible coordinates.

6 LIST OF INFORMATION LAYERS

A list of developed and integrated in the system information layers along with their description and map compositions is in Annex 1 to this part of the report.

I Extent of the coverage: Megasite Site			II Type of GIS coverages and databases: **P**reliminary / **I**nterim / **F**inal	III Group of the coverage: **E**arth surface, **S**urface waters **G**roundwaters, **A**uxiliary
I	**II**	**III**	**Name of information layer (coverage)**	**Card**
M	P	E	Geographical regions	Card no. 1
M	P	E	Geomorphologic regions	Card no. 2
M	P	A	Map decoder	Card no. 3
M	P	EWG	Borders of municipalities	Card no. 4
M	P	EWG	River basin	Card no. 5
M	P	G	Boundaries of the Carboniferous aquifer	Card no. 6
M	P	G	Boundaries of the Triassic aquifer	Card no. 7
M	P	G	Boundaries of the Quaternary aquifer	Card no. 8
M	P	G	Aquifers protection status	Card no. 9
M	P	EWG	Extent of the Megasite	Card no. 10
M	P	A	2 km grid in the Megasite extent	Card no. 11
M	P	G	Map of Fridrich Grube 1871	Card no. 12
M	P	G	Former excavation shafts (including medieval ones)	Card no. 13
M	P	G	Former adits and drifts (including medieval ones)	Card no. 14
M	I	E	Digital elevation model (altitude)	Card no. 15
M	I	E	Slope of the surface	Card no. 16
M	I	E	Aspect of the surface	Card no. 17
M	I	W	Flow direction	Card no. 18
M	I	W	Flow accumulation	Card no. 19
M	I	E	Surface area – real areas of grid cells	Card no. 20
M	I	W	River basin small	Card no. 21
M	I	W	River basin large	Card no. 22
M	I	E	Land use of the Megasite - NATLAN	Card no. 23
M	I	E	Land use of the Megasite	Card no. 24
M	I	E	Urban plan of Tarnowskie Góry Municipality	Card no. 25
M	I	E	Soil	Card no. 26
M	I	G	Geology	Card no. 27
M	I	G	Faults within Triassic formation	Card no. 28
M	I	E	Residential area of the Megasite	Card no. 29
M	I	E	Industrial plants	Card no. 30
M	I	E	Large excavations (greater than 1ha)	Card no. 31
M	I	E	Small excavations (less than 1ha)	Card no. 32
M	I	E	Large industrial landfills	Card no. 33
M	I	E	Small industrial landfills	Card no. 34
M	I	E	Small municipal landfills	Card no. 35
M	I	E	Petrol stations	Card no. 36
M	I	E	Resource storages	Card no. 37
M	I	E	Waste water treatment plants	Card no. 38
M	I	E	Sewage discharge points	Card no. 39
M	I	E	Cemeteries	Card no. 40
M	I	G	Wells and boreholes of the HYDRO database	Card no. 41
M	I	G	Ground water conductivity	Card no. 42
M	I	G	Ground water barium concentration	Card no. 43
M	I	G	Ground water zinc concentration	Card no. 44

M	I	W	River network within the Megasite extent	Card no. 45
M	I	W	Water bodies within the Megasite extent	Card no. 46
M	I	E	Road network	Card no. 47
M	I	E	Railway network	Card no. 48
M	I	E	Settlements	Card no. 49
M	I	E	Tarnowskie Góry Chemical Plant	Card no. 50
S	P	A	Extent of the site	Card no. 51
S	P	A	Topographic map of TGCP	Card no. 52
S	P	EWG	Tarnowskie Góry Chemical Plant boundaries	Card no. 53
S	P	EWG	Landfills of the TGCP	Card no. 54
S	P	EWG	Boundary of the central landfill and investment area of the TGCP	Card no. 55
S	I	E	Topsoil characteristics in the vicinity of TGCP	Card no. 56
S	I	E	Results from soil sampling in April 19th 2002	Card no. 57
S	I	E	Results from soil sampling in May 17th 2002	Card no. 58
S	I	E	Results from soil sampling in May 28th 2002	Card no. 59
S	I	E	Results from soil sampling in summer 2002	Card no. 60
S	I	E	Results from plant sampling in June and July 2002	Card no. 61
S	I	W	Results from surface water sampling in year 2002	Card no. 62
S	I	G	Results from GW sampling in the first quarter of year 2002	Card no. 63
S	I	E	Digital Elevation Model of the site	Card no. 64
M	F	E	Sand contents in surface layer (0-50cm)	Card no. 65
M	F	E	Clay contents in surface layer (0-50cm)	Card no. 66
M	F	E	Hydraulic conductivity at saturation of surface layer (0-50cm), units - 10-6m/s	Card no. 67
M	F	E	Saturation of surface layer (0-50cm)	Card no. 68
M	F	E	Bulk density of surface layer (0-50cm)	Card no. 69
M	F	E	Field Capacity of surface layer (0-50cm)	Card no. 70
M	F	E	Permanent wilting point of surface layer (0-50cm)	Card no. 71
M	F	E	Plant available water of surface layer (0-50cm)	Card no. 72
M	F	E	Sand contents in subsurface layer (50-100cm)	Card no. 73
M	F	E	Clay contents in subsurface layer (50-100cm)	Card no. 74
M	F	E	Hydraulic Conductivity at saturation of subsurface layer (50-100cm), units - 10-6m/s	Card no. 75
M	F	E	Saturation of subsurface layer (50-100cm)	Card no. 76
M	F	E	Bulk density of subsurface layer (50-100cm)	Card no. 77
M	F	E	Field Capacity of subsurface layer (50-100cm)	Card no. 78
M	F	E	Permanent wilting point of subsurface layer (50-100cm)	Card no. 79
M	F	E	Plant available water of subsurface layer (50-100cm)	Card no. 80
M	F	E	Cadmium concentration in topsoil	Card no. 81
M	F	E	Lead concentration in topsoil	Card no. 82
M	F	E	Zinc concentration in topsoil	Card no. 83
S	F	G	Interpolated barium concentration in Quaternary water bearing horizon	Card no. 84
S	F	G	Interpolated barium concentration in Triassic water bearing horizon	Card no. 85
S	F	G	Interpolated boron concentration in Quaternary water bearing horizon	Card no. 86
S	F	G	Interpolated boron concentration in Triassic water bearing horizon	Card no. 87
S	F	G	Interpolated strontium concentration in Quaternary water bearing horizon	Card no. 88
S	F	G	Interpolated strontium concentration in Triassic water bearing horizon	Card no. 89
S	F	G	Interpolated concentration of dissolved substances in Quaternary water bearing horizon	Card no. 90
S	F	G	Interpolated concentration of dissolved substances in Triassic water bearing horizon	Card no. 91
S	F	G	Interpolated concentration of chlorides in Quaternary water bearing horizon	Card no. 92
S	F	G	Interpolated concentration of chlorides in Triassic water bearing horizon	Card no. 93
S	F	G	Interpolated concentration of sulphates in Quaternary water bearing horizon	Card no. 94
S	F	G	Interpolated concentration of sulphates in Triassic water bearing horizon	Card no. 95
M	F	EWG	Number of residents in 1 ha square	Card no. 96

7 MEGASITE DESCRIPTION

7.1 MEGASITE LOCATION

The Tarnowskie Góry Megasite, a heavy-metal contaminated area, is located in the Silesian Voivodeship in the southern part of Poland (Fig. 8).

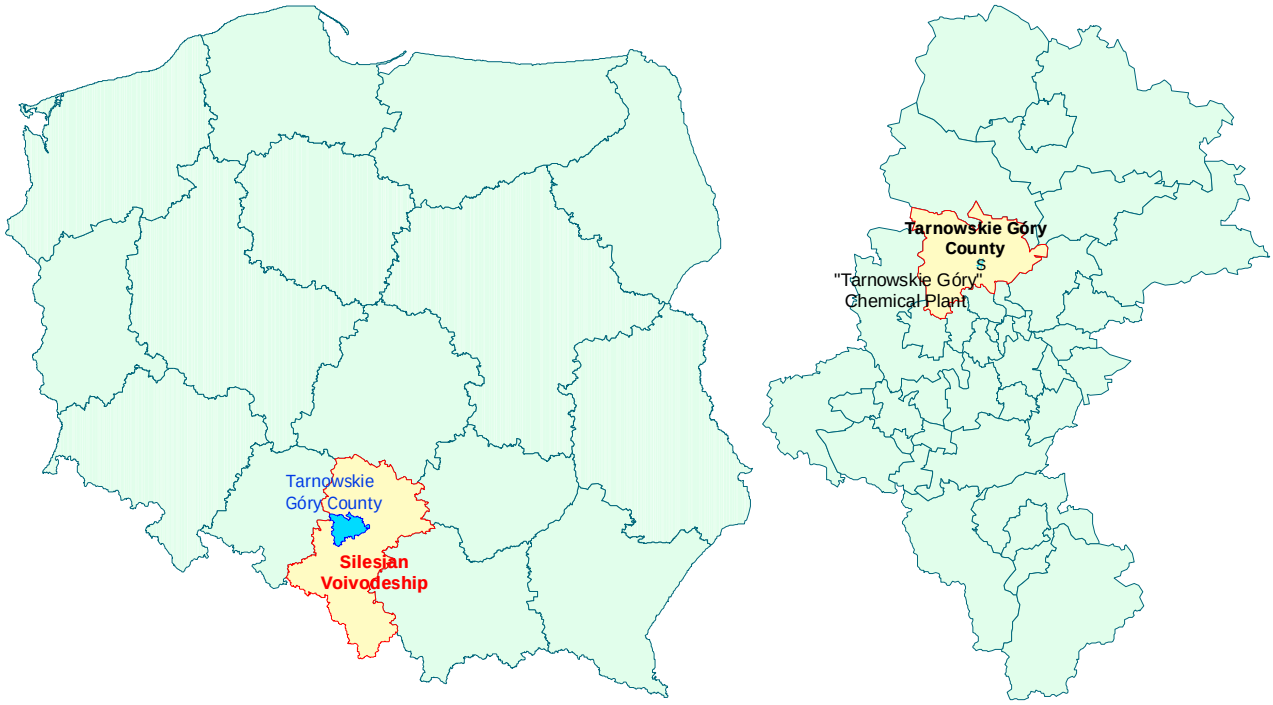


Fig. 8. Administrative division of Poland and Silesian Voivodeship

The extent of the Tarnowskie Góry Megasite was determined by boundaries of Tarnowskie Góry District (Poviat), boundaries of useful Triassic aquifers and watersheds of the area. Due to practical aspect of environmental management and development of the Integrated Management System (IMS), a decision was made to set up the boundary of the district (poviat) as the megasite boundary.

The former “Tarnowskie Góry” Chemical Plant, also called Tarnowskie Góry Site, is located in the centre of the Megasite. The abandoned plant belongs to Poland’s most serious sources of soil and ground water contamination. The risk posed by this site along with waste stored there for ages justifies the governmental decision to liquidate the plant and recognize its as the top priority of land management in Poland.

Geographically, the area of the Megasite is a part of the Katowice Upland, Opole Plain and Tarnowskie Góry Bump. For centuries, the Tarnowskie Góry area was well known for extraction of silver, zinc and lead ores, whereas the Katowice Upland is the region of hard coal extraction and metallurgy accompanied by relevant supportive industries.

The largest part of the area belongs to the Mala Panew River watershed, a right tributary of the Odra River. Southern part of the area belongs to the Klodnica River watershed, also a right tributary of Odra. The main river of the Tarnowskie Góry Site is the Stola River which has its spring within the town boundaries, south from Chemical Plant. The Stola River is a left tributary of Mala Panew.

The “Tarnowskie Gory" Chemical Plant is located in the central part of the Megasite, in Sowice - a district of Tarnowskie Góry Municipality. A more detailed map of site neighbourhood is presented below (Fig. 9).

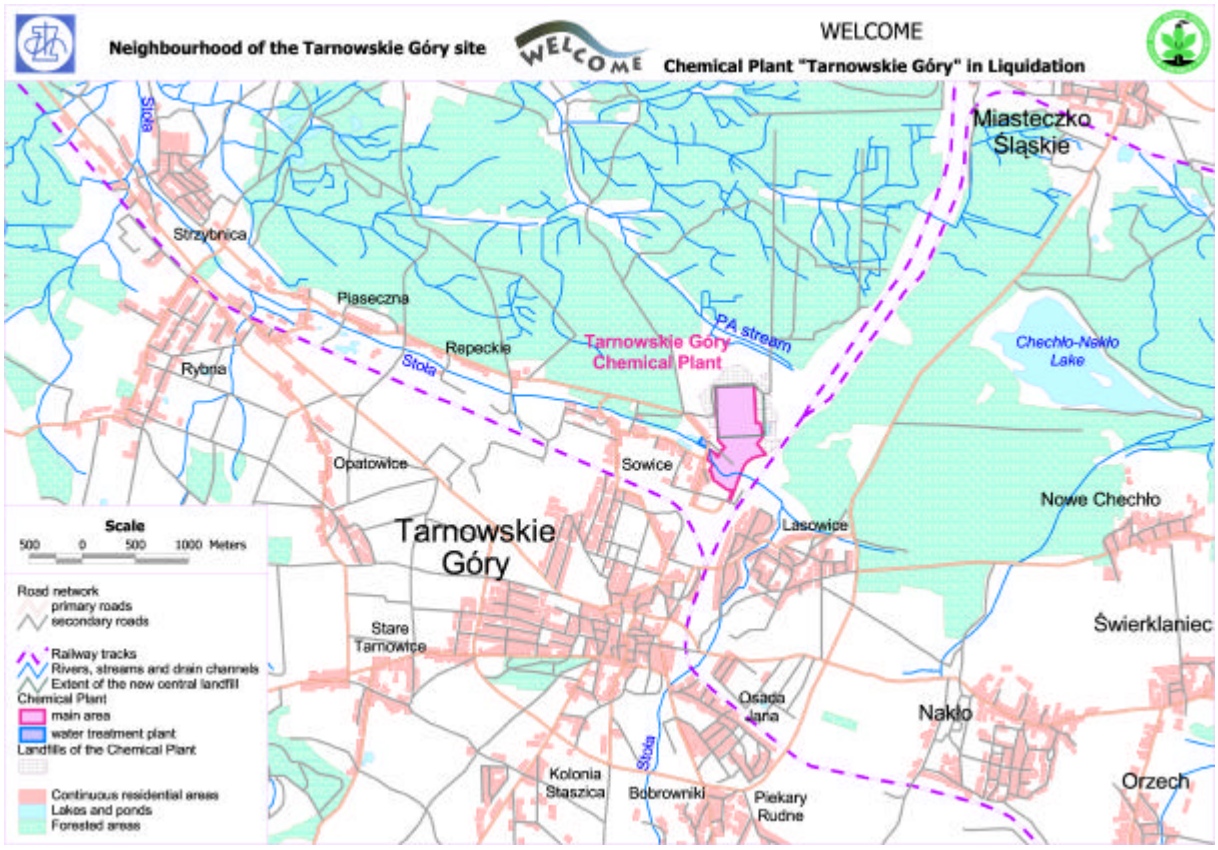


Fig. 9. Neighborhood of the “Tarnowskie Góry” Chemical Plant Hotspot

A semi-natural type of land-use i.e. forests and arable land, dominates in the area of the Megasite. The share of water impermeable surfaces in the total Megasite surface is relatively small and refers primarily to the area of the Tarnowskie Góry town. The structure of vegetation species present at the site will thus decide about the precipitation field and water flows.

Table 2 Structure of the Megasite landuse

No.	Type of land use	percentage
1	Airports	0,245
2	Broad-leaved forest	3,529
3	Complex cultivation patterns	9,265
4	Coniferous forest	31,453
5	Construction sites	0,073
6	Continuous urban fabric	0,260
7	Discontinuous urban fabric	8,332
8	Dump sites	0,478
9	Fruit trees and berry plantations	0,443
10	Green urban areas	0,899
11	Industrial or commercial units	1,730
12	Inland marshes	0,165
13	Land principally occupied by agriculture	2,145
14	Mineral extraction sites	0,272
15	Mixed forest	6,193
16	Moors and heath land	1,083
17	Non-irrigated arable land	25,806
18	Pastures	5,136
19	Port Areas	0,038
20	Road and rail networks and associated land	0,270
21	Sport and leisure facilities	0,276
22	Transitional woodland-scrub	1,192
23	Water bodies	0,717

Table 3 Megasite soil textural classes structure

No.	Soil textural group	percentage
1	Not classified	50,394
2	alluvial soils	2,732
3	loamy soils	15,052
4	clayey soils	0,185
5	sandy soils	22,728

No.	Soil textural group	percentage
6	silty soils	0,620
7	rocks	0,003
8	gravelly soils	0,107
9	rendzinas	6,556
10	skeletal soils	0,014
11	peaty soils	1,609

7.2 CLIMATE

Climatic conditions at the Megasite are typical for this part of Poland. Average atmospheric wet precipitation is about 707mm and it varies from 531 mm for dry years to 935 mm for wet years. Precipitation in summer half-year is 467mm, for winter half-year: 240 mm. The number of days with precipitation higher than 0.1mm is 140-160 in the year. Evapotranspiration during year is 520mm; 400mm in summer half year and 120mm in winter half-year.

Average temperature of air is 7.5^{o}C, with average for winter period –1^{o}C and 14^{o}C for summer period. Predominant wind directions are from NW in summer and SW in winter. Wind velocity in winter is about 20% higher than in summer. Meteorological conditions are presented based on measurements data from the Swierklaniec monitoring station, located 6km from the Tarnowskie Góry Chemical Plant.

Selected data from this station are presented below[11].

[11] Leszek Osródka; Charakterystka klimatologiczna województwa katowickiego; raport Instytutu Meteorologii I Gospodarki Wodnej;Katowice

Table 4 Extremes of daily thermal characteristics (°C)

Station: SWIERKLANIEC Period: 1961—1990

No.		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Season X-III	Season IV-IX	Year	
1.	Temperature N	-24.7	-20.5	-15.7	-2.5	0.6	4.6	10.0	9.7	2.6	-2.6	-11.8	-20.1	-24.7	-2.5	-24.7	1985
	mean daily . X	7.8	12.2	14.9	19,4	23.4	28.2	26.2	26.0	22.6	18.5	15.0	12.5	18.5	28.2	28.2	1963
2.	Temperature N	-37.2	-29.0	-24.0	-8.0	-3.9	-0.6	4.1	1.1	-4.9	-8.7	-19.1	-25.9	-37.2	-8.0	-37.2	1987
	minimum X	5.5	9.7	10.7	13.2	16.6	19.9	19.9	19.4	17.4	14.3	11.2	8.6	14.3	19.9	19.9	1986
3.	Temperature N	-20.0	-15.9	-10.0	-0.5	3.1	8.0	12.2	11.4	8.0	-0.3	-6.7	-15.2	-20.0	-0.5	-20.0	1987
	maximum X	13.3	17.8	22.6	28.3	31.0	33.5	34.1	34.0	30.8	25.6	20.1	16.7	25.6	34.1	34.1	1988
4.	Temperature N	-31.6	-28.4	-22.3	-6.0	-1.0	4.1	8.3	7.2	-3.6	-8.2	-18.1	-25.4	-31.6	-6.0	-31.6	1987
	hour: 6 GMT X	8.2	11.7	11.4	16.4	21.5	24.2	24.3	23.2	21.0	15.4	13.8	13.3	15.4	24.3	24.3	1963
5.	Temperature N	-20.2	-16,7	-11.1	-2.4	1.1	6.8	10.4	10.7	5.1	-1,5	-7.0	-16.0	-20.2	-2.4	-20.2	1987
	hour 12 GMT X	13.1	16.1	21.8	26.8	30.1	32.7	32.9	32.5	30.1	25.1	19.2	16.0	25.1	32.9	32.9	1988
6.	Temperature N	-23.5	-22.1	-16.6	-2.3	0.5	1.4	8.4	7.7	0.5	-2,1	-15.8	-21.8	-23.5	-2.3	-23.5	1985
	hour: 18 GMT X	10.8	13.6	16.7	22.4	25.4	28.7	28.6	28.8	24.7	20.1	16.4	11.1	20.1	28.8	28.8	1971
7.	Temperature N	-28.8	-21.0	-20.0	-5.8	-1.3	1.6	1.3	3.2	-1.7	-6.2	-13.6	-21.0	-28.8	-5.8	-28.8	1987
	hour 0 GMT X	9.4	11.8	12.5	15.8	18.3	*27.7*	25.4	22.5	20.5	17.1	12.7	10.8	17.1	27.7	27.7	1986

Absolute minimum: -37.2 date 8 I 1987

Absolute maximum: 34.1 date 24 VII 1988

*/ N – the lowest value of the multi-year period

X – the highest value of the multi-year period

Table 5 Number of ground-freeze, frosty, extremely frosty, hot and extremely hot days

Station : SWIERKLANIEC Period: 1961 — 1990

No.			Month												Season		YEAR	
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	X-III	IV- IX		
1	ground freeze Tmin < 0.0 C Tmax > 0.0 C	S	12	13	15	7	1	0,0			0.5	5	10	12	66	9	75	
		N	4	1	6	1	-	-			-	-	4	1	48	3	57	1987
		X	23	21	22	13	9	1			3	15	18	20	89	18	99	1986
2	frosty Tmax < 0.0 C	S	13	9	3	0.1						0	2	10	38	0.1	38	
		N	-	-	-	-						-	-	1	6	-	6	1974
		X	27	27	13	1						1	10	29	71	1	72	1963
3	Extr. frosty Tmin < -10.0 C	S	8	5	2								0.5	5	20		20	
		N	-	-	-								-	-	-		-	
		X	23	16	14								4	13	52		52	1963
4	hot Tmax >25.0 C	S				0.5	3	7	9	9	2	0.2			0.2	30	31	
		N				-	-	1	-	3	-	-			-	11	11	1980
		X				6	10	14	19	17	7	1			1	56	56	1983
5	Extr. hot Tmax >30.0 C	S					0.1	0.5	1	1	0					3	3	
		N					-	-	-	-	-					-	-	
		X					1	3	6	6	1					12	12	1963

Autumn ground-freeze	S - 10.X	N - 14 IX 1973
Spring ground-freeze	S - 4.V	X - 3 VI 1963
Maximum sequence of frosty days	35 days 8 I 1963 - 11 II 1963	
Maximum sequence of extremely frosty days	19 days 3 I 1985 - 21 I 1985	
Maximum sequence of hot days	16 days 24 VII 1971 - 8 VIII 1971	
Maximum sequence of extremely hot days	4 days 23 VII 1963 - 26 VII 1963	

*/ S-mean value, mean data in a multi-year period
N the lowest value, the earliest date in a multi-year period
X the highest value, the latest date in the multi-year period
"-" no phenomenon occurrence in the investigated period

Table 6 Mean air temperatures (° C) in period: 1981 - 1990

No			Month												Season		Year	
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	X-III	IV- IX		
1	Temperature Mean-day.	S	-2.3	-1.5	3	7.8	13,7	15.5	17.5	17.1	13.3	9	2.9	-0.1	1.9	14.2	8	
		N	-10.4	-8.5	-2.7	5.1	11.1	13.7	15	15.1	11.1	8.1	-0.3	-3.2	-0.2	13.4	6.7	1985
		X	2.7	4.6	6.5	9.9	15.1	16.8	19.2	18.2	15.3	10.2	5	2.7	4	15.3	9.1	1989
2	Temperature minimum	S	-5.5	-4.8	-0.9	2.6	7.6	10.4	11.7	11.4	9	4.9	-0.1	-2.8	-1.5	8.8	3.6	
		N	-15.1	-13	-6.7	0.7	5.6	9.5	10.2	10.1	8	3.2	-3.3	-6.8	-3.7	7.8	2.5	1987
		X	0.4	0.7	1.9	4.8	9.4	12.1	12.8	12.5	10.1	6.8	2.2	0.5	0.4	9.6	4.6	1989
3	Temperature maximum	S	0.7	2	7.6	13.5	19.3	20.6	23.2	23	18.5	13.9	6.1	2.2	5.5	19.7	12.7	
		N	-6.2	-4.4	1.1	10.9	16.7	17.9	20.3	20.2	14.8	12.1	2.9	-0.3	3.3	18.6	11.1	1987
		X	4.9	9.3	11.6	15.9	20.8	22.3	25.4	24.8	22.6	15	9	5	7.9	21.5	14.4	1982
4	Temperature hour 6 GMT	S	-3.5	-3.5	0.6	5	11.6	13.9	15.6	14.5	10.7	6.3	1.5	-1	0.1	11.9	6	
		N	-11.8	-11.6	-5.4	2.6	9.1	12.4	13.2	12.7	9.5	4.9	-1.3	-3.9	-2	11.3	4.7	1987
		X	2	2.4	4.1	6.9	12.7	15.4	17	15.3	11.6	8.1	4	1.9	2.2	12.6	7.1	1989
5	Temperature hour 12 GMT	S	-0.5	0.8	6	11.3	17.5	18.7	21.1	21.3	16.9	12.9	5	1.3	4.3	17.8	11	
		N	-8.7	-5.3	0.1	8.2	13.6	16.3	18	18.4	13.7	11.2	1.6	-1.6	2.1	16.7	9.5	1987
		X	4.2	7.7	9.8	13.6	18.8	20.1	23	23.2	21.1	13.9	7.9	4	6.6	19.4	12.2	1989
6	Temperature hour 18 GMT	S	-2.1	-0.8	4.1	9.7	15.7	17.3	19.8	18.9	14.4	9.6	3	0	2.3	16	9.1	
		N	-10.2	-7.5	-1.4	7	13.4	14.9	17.3	16.6	11.2	8.6	-0.2	-3.2	0.1	15.3	7.8	1985
		X	2.8	5.3	7.7	11.9	17.3	19.2	22.4	20.2	17.2	11.1	5.4	2.6	4.5	17.7	10.2	1983
7	Temperature hour 0 GMT	S	-3	-2.5	1.2	5	9.8	12.2	13.7	13.6	11	7.2	2.1	-0.6	0.8	10.9	5.8	
		N	-10.8	-9.8	-4.3	2.4	8.2	11.2	11.5	12.5	9.9	6.3	-1.2	-4.3	-1.3	10.3	4.6	1985
		X	2.3	3.1	4.3	7.6	11.7	13.6	15.5	14.6	12.1	8.6	4.4	2.2	2.9	11.7	7	1989

*/ S - multiyear period mean
N – the lowest value in the multiyear period
X – the highest value in the multiyear period

Table 7 Extremes of daily thermal characteristics (°C) in period: 1981 - 1990

No			Month											Season			Year	
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	X-III	IV-IX		
1	Mean day temperature	N	-24.7	-20.5	-14.2	-2.5	1.2	8.6	10.4	9.9	6.2	-2.6	-11.7	-13.6	-24.7	-2.5	-24.7	1985
		X	7.8	12.2	14.9	16.8	23.1	25.5	26.2	24.6	21.5	18.5	11.3	12.3	18.5	26.2	26.2	1988
2	Minimum temperature	N	-37.2	-29	-20	-8	-1.1	1.3	4.5	1.1	-0.9	-8.7	-19.1	-21	-37.2	-8	-37.2	1987
		X	5.5	9.7	10.7	13.2	16.6	19.9	19.9	18.1	17.4	14.3	9.5	8.6	14.3	19.9	19.9	1986
3	Maximum temperature	N	-20	-15.9	-8.9	0.5	3.1	10.9	12.6	11.4	9.1	1	-5	-8.8	-20	0,5	-20	1987
		X	11.8	17.8	21.4	26.6	31	32	34.1	32.7	29.6	25.4	17.1	16.7	25.4	34.1	34.1	1988
4	Temperature at 6 hour GMT	N	-31.6	-28.4	-19.6	-6	0.5	7.2	9	7.2	0.3	-8.2	-18.1	-16.4	-31.6	-6	-31.6	1987
		X	8.2	11.7	11.4	15.7	21.5	22.3	23.8	21.9	18.9	15.4	12.9	13.3	15.4	23.8	23.8	1988
5	Temperature at12 hour GMT	N	-20.2	-16.7	-10.1	-1.7	1.1	8.2	11.5	10.9	8.5	0.5	-7	-9.5	-20.2	-1.7	-20.2	1987
		X	11.8	16.1	19.9	25.6	30.1	30.4	32.9	31.2	27.7	25.1	16.4	16	25.1	32.9	32.9	1988
6	Temperature at18 hour GMT	N	-23.5	-20.3	-13.9	-2.3	2.8	5.1	10.9	10.1	6.3	-1.4	-11.4	-14.9	-23.5	-2.3	-23.5	1985
		X	10.8	13.6	16.7	22	25.4	28.7	28.6	28.8	24.7	19.5	14.7	11.1	19.5	28.8	28.8	1989
7	Temperature at 0 hour GMT	N	-28.8	-21	-17.7	-4.8	0.4	3.4	1.3	3.2	0.6	-6.2	-12	-20.9	-28.8	-4.8	-28.8	1987
		X	9.4	11.8	12.5	15.1	18.3	27.7	24.6	20.9	20.5	17.1	11	10.8	17.1	27.7	27.7	1986

Absolute minimum; -37.2 date 8 I 1987
Absolute maximum: 34.1 date 24 VII 1988
*/ N – the lowest value in multiyear period
X – the highest value in multiyear period

Table 8 Average air temperature (°C) in period: 1961 - 1990

Station: SWIERKLANIEC Period: 1961 — 1990

No			Month												Season		Year	
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	X-III	IV-IX		
1.	Daily mean temperature	S	-3.0	-1.4	2.4	7.6	12.9	15.9	17.2	16.7	13.0	8.5	3.3	-0.8	1.5	13.9	7.7	
		N	-10.7	-8.5	-2.7	5.1	9.8	13.7	15.0	14.6	10.7	5.5	-0.3	-7.0	-1.4	12.3	6.5	1980
		X	2.8	4.6	6.5	11,1	15.1	18.5	19.3	18.5	15,8	12.2	7.1	2.9	4.0	15.3	9.1	1989
2.	Minimum temperature	S	-6.4	-4.8	-1.5	2.7	7.1	10.5	11.7	11.4	8,4	4.4	0.5	-3.5	-1.8	8.6	3.4	
		N	-15.7	-13.2	-6.7	0.7	3.9	8.8	10.2	8.9	6,1	1.6	-4.2	-9.9	-5.4	7.8	2.0	1963
		X	0.5	0.7	1.9	4.8	9.4	12.8	13.7	13.3	10.6	7.9	3.9	0.9	0.4	9.8	4.9	1974
3.	Maximum temperature	S	-0.1	2.1	6.8	12.9	18.4	21.2	22.6	22.5	18.5	13.4	6.3	1.6	5.1	19.4	12.3	
		N	-6.9	-4.4	0.9	10.2	14.9	17.9	19.9	20.2	14.8	8.7	2.9	-4.5	2.3	17.5	10.9	1980
		X	5.3	9.3	11.6	17.4	20.9	24.3	25.7	25.5	22.6	17.5	10.8	5.5	7.9	21.5	14.4	1982
4.	Temperature at 6 hour GMT	S	-4.2	-3.3	-0.1	5.1	11.0	14.4	15.4	14.4	10.5	6.0	2.1	-1.7	-0.2	11.8	5.8	
		N	-11.8	-11.6	-5.4	2.6	8.5	12.4	13.2	12.5	8.4	2.6	-1.7	-8.2	-3.2	10.6	4.7	1987
		X	2.0	2.4	4.1	8.0	13.3	17.2	17.4	16.3	13.0	9.7	6.0	2.0	2.2	12.8	7.1	1989
5.	Temperature at 12 hour GMT	S	-1.2	0.9	5.4	11.2	16.6	19.4	20.8	20.9	17.1	12.3	5.2	0.5	3.9	17.7	10.8	
		N	-8.7	-5.3	-0.1	8,2	13.2	16.3	17.7	18.4	13.7	7.6	1.6	-5.4	1.1	15.5	9.1	1980
		X	4.6	7.7	9.8	15,9	19.5	22.4	24.4	23.6	21.4	16.4	9.6	4.0	6.6	19.5	12.2	1989
6.	Temperature at18 hour GMT	S	-3.1	-1.1	3.0	8.3	13.7	16.6	18.1	17.3	13.2	8.5	3.2	-0.9	1.6	14.6	8.1	
		N	-11.5	-8.6	-2.4	5.7	9.6	13.5	14.6	14.1	10.4	5.7	-0.7	-7.2	-1.9	12.1	6.0	1965
		X	2.8	5.3	7.7	11.9	17.3	19.6	22.4	20.2	17.2	11.4	6.4	2,8	4.5	17.7	10.2	1983
7.	Temperature at 0 hour GMT	S	-3.2	-2.1	1.2	4.6	9.3	12.2	13.6	13.4	10.6	6.5	2.2	-0.5	0.7	10.6	5.6	
		N	-10.8	-9.8	-4.3	2.4	5.9	11.0	11.5	11.1	8.6	4.0	-1.2	-4.3	-1.3	9.4	4.6	1980
		X	2.3	3.1	4.3	7.6	11.7	14.7	15.5	15.1	12.5	8.6	4.4	2.6	2.9	11.7	7.0	1989

*/ S – mean from multi-year period
N – the lowest value in the multi-year period
X – the highest value in the multi-year period

Table 9 Air temperature values of determined probability of occurrence in period: 1961 - 1990

No			Month											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Median	S	-1.8	-0.6	2.5	7.4	12.9	15.9	17.1	16.5	12.9	8.5	3.5	-0.3
		N	0.7	-3.2	-0.6	2.6	7.2	10.4	11.7	11.4	8.8	4.7	0.6	-2.3
		X	0.7	2.1	6.4	12.8	18.4	21.2	22.6	22.3	18.2	12.9	6	1.7
2	Predicted value	S	-2.9	-1.4	2.4	7.6	12.9	15.9	17.2	16.7	13	8.5	3.3	-0.8
		N	-6.2	-4.8	-1.5	2.7	7.1	10.5	11.7	11.4	8.4	4.4	0.5	-3.5
		X	0	2.1	6.8	12.9	18.4	21.2	22.6	22.5	18.5	13.4	6.3	-3.5
3	Standard deviation	S	5.6	5	4.8	4.1	3.9	3.7	3.2	3.1	3.5	3.9	4.2	4.9
		N	6.9	6.2	4.9	3.6	3.6	3.3	2.8	3	3.5	4	4.3	5.7
		X	4.9	4.8	5.8	5.4	4.9	4.6	4.3	4.3	4.5	4.9	4.8	4.6
4	Once in a 10year period	S	-18.2	-15.1	-9.4	-3.4	2.5	6.2	8.5	8.6	4.4	-1	-7.3	-14.1
		N	-24.9	-21.8	-14.1	-6.9	-2.4	1.8	4.1	3.3	-0.6	-5.8	-10.7	-19
		X	-13.2	-10.9	-7.6	-1.6	5.1	8.7	10.9	11.2	7	1.5	-5.6	-10.7
5	Once in a 5 year period	S	-16.8	-13.9	-8.3	-2.4	3.4	7.1	9.3	9.3	5.2	-0.2	-6.3	-12.9
		N	-23.2	-20.2	-13	-6.1	-1.6	2.5	4.8	4	0.2	-4.9	-9.7	-17.6
		X	-13.2	-9.7	-6.3	-0.3	6.3	9.8	12	12.3	8	2.5	-4.5	-9.6
6	Every year	S	-13.2	-10.7	-5.6	0.1	5.8	9.4	11.3	11.2	7.2	2	-3.9	-9.8
		N	-18.9	-16.3	-10	-3.8	0.6	4.6	6.5	5.9	2.3	-2.5	-7.1	-14
		X	-8.9	6.7	-2.9	3.1	9.4	12.7	14.7	14.9	10.7	5.3	-1.7	-6.7
7	Every year throughout	S	-2.9	-1.4	2.4	7.6	12.9	15.9	17.2	16.7	13	8.5	3.3	-0.8
		N	-6.2	-4.8	-1.5	2.7	7.1	10.5	11.7	11.4	8.4	4.4	0.5	-3.5
		X	0	2.1	6.8	12.9	18.4	21.2	22.6	22.5	18.5	13.4	6.3	1.7
8	Nearly all days	S	7.4	7.9	10.4	15	19.9	22.5	23.1	22.1	18.8	14.9	10.5	8.1
		N	6.4	6.7	7	9.1	13.5	16.4	16.9	16.8	14.5	11.4	8.1	7
		X	9	11	16.5	22.7	17.4	29.6	30.5	30.1	26.3	21.4	14.4	10.1
9	Once in a 10year it will be warmer	S	12.3	12.3	14.2	18.6	23.2	25.6	25.9	24.7	21.6	17.9	14	12.4
		N	12.4	12.2	11.1	12.2	23.2	19.2	19.4	19.4	17.5	14.7	11.8	12
		X	13.3	15.2	21.2	27.4	31.7	33.6	34.3	33.7	30	25.3	18.3	14.1

*/ S – Mean temperature (°C)
N – Minimum temperature (°C)
X – Maximum temperature (°C)

Table 10 Water vapour pressure (hPa) in period: 1961 - 1990

No.			Months												Seasons		YEAR	
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-III	IV- IX		
1	Mean pressure [hPa]	S	4.7	4.9	5.9	7.3	10.9	13.3	14.6	14.6	12	9	6.6	5.5	6.1	12.1	9.1	
		N	2.9	2.6	4.1	6	8.7	10.7	12.8	12.6	10.7	7.1	4.9	4.4				
		X	6.5	6.3	7.3	9.4	13.4	15.9	17.1	16.4	14.1	10.3	7.7	6.8	6.7	13.3	9.9	1983
2	Periodical pressure extremes	S																
		N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1961
		X	14.4	40.9	13.5	17.4	21.4	23.4	24.4	25.9	27.8	18.4	13.1	11.2	40.9	27.8	40.9	1985
3	Number of days with pressure >=18hPa	S						0.2	0.7	0.6						1.5	1.5	
		N																
		X						2	4	5						8	8.0	1971

* / S – multi-year period mean
N – the lowest value in the multi-year period
X – the highest mean in the multi-year period

Table 11 Relative air humidity (%) in period: 1961 – 1990

No.			Month												Season		YEAR	
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	X-III	IV-IX		
1	Mean humidity [%]	S	84	81	74	70	68	71	70	73	78	79	83	85	81	71	76	
		N	78	71	66	60	57	58	63	65	72	71	77	79	76	67	71	1986
		X	89	90	82	79	76	77	84	83	W	88	89	91	85	78	82	1980
2	Humidity at 12 hour GMT [%]	S	79	74	62	56	55	60	59	58	64	66	76	81	73	59	66	
		N	74	63	45	43	42	44	50	44	54	51	63	72	64	52	57	1986
		X	85	83	72	68	69	67	77	70	74	78	85	88	79	67	73	1980
3	Minimum periodical humidity [%]	S																
		N	17	16	15	16	16	19	16	21	27	16	27	26	15	16	15	1972
		X																
4	Number of days with humidity >=80% at 12 hour GMT	S	11	8	4	4	3	3	3	3	4	5	9	13	50	21	71	
		N	0	0	0	0	0	0	0	0	0	0	0	0	48	21	79	1989
		X	23	19	14	11	11	9	14	12	12	16	22	26	99	49	135	1980
5	Number of days with humidity <40% at 12 hour GMT	S	0	1	3	5	5	2	2	3	1	2	0	0	5	18	23	
		N	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	1983
		X	2	4	12	16	16	17	13	12	10	12	3	3	18	69	83	1986

Absolute humidity minimum 15.0 date 14 III 1972

*/ S – multi-year period mean

N – the lowest value in the multi-year period

X – the highest value in the multi-year period

Table 12 Statistics of winds and atmospheric equilibrium according to Dagandaud

Years: 1961-1990 winter season (15.X-25.IV) station: Swierklaniec Calm air calculated as v=1m/s

V m/s	KR	Wind sectors												
		NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	N	Total
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	19	16	6	18	16	1	22	17	4	15	7	141
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	22	184	144	49	208	136	35	332	248	37	235	138	1768
	5	5	38	62	19	116	84	14	178	105	20	98	39	778
	6	10	100	115	26	164	88	6	193	134	20	117	64	1037
	total	**37**	**341**	**337**	**100**	**506**	**324**	**56**	**725**	**504**	**81**	**465**	**248**	**3724**
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	9	19	2	17	12	1	11	5	1	4	0	82
	3	10	33	51	21	59	39	12	82	44	14	31	16	412
	4	64	320	253	69	291	180	59	675	414	120	529	192	3166
	5	5	56	69	16	122	92	21	312	148	29	114	52	1036
	6	9	59	81	20	98	81	20	181	71	20	77	37	754
	total	**89**	**477**	**473**	**128**	**587**	**404**	**113**	**1261**	**682**	**184**	**755**	**297**	**5450**
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	6	12	3	8	3	4	11	5	1	6	3	63
	3	1	23	28	3	27	23	9	68	45	11	25	12	275
	4	21	105	92	16	80	72	27	344	280	60	273	89	1459
	5	5	25	18	4	33	33	15	128	73	17	53	6	410
	6	1	15	18	5	24	28	6	91	57	5	26	7	283
	total	**29**	**174**	**168**	**31**	**172**	**159**	**61**	**642**	**460**	**94**	**383**	**117**	**2490**
4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	4	29	29	19	13	23	17	114	58	15	41	23	385
	4	24	84	82	21	53	126	77	659	467	99	382	89	2163
	5	0	8	13	1	14	21	11	96	45	7	24	6	246
	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	**28**	**121**	**124**	**41**	**80**	**170**	**105**	**869**	**570**	**121**	**447**	**118**	**2794**
5	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	1	9	15	4	8	13	6	80	42	11	19	5	213
	4	7	39	31	6	23	51	24	297	239	45	157	29	948
	5	0	0	10	1	8	6	2	41	26	6	15	2	117
	total	**8**	**48**	**56**	**11**	**39**	**70**	**32**	**418**	**307**	**62**	**191**	**36**	**1278**
6	3	1	0	1	0	0	3	0	4	3	0	1	0	13
	4	4	11	14	6	7	21	19	140	122	62	78	12	496
	total	**5**	**11**	**15**	**6**	**7**	**24**	**19**	**144**	**125**	**62**	**79**	**12**	**509**
7	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	1	11	14	1	7	25	8	135	176	28	120	12	538
	total	**1**	**11**	**14**	**1**	**7**	**25**	**8**	**135**	**176**	**28**	**120**	**12**	**538**
8	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	3	1	0	1	9	34	28	33	18	2	129
	total	**0**	**0**	**3**	**1**	**0**	**1**	**9**	**34**	**28**	**33**	**18**	**2**	**129**
9	4	0	0	2	0	0	8	1	51	51	18	50	3	184
	total	**0**	**0**	**2**	**0**	**0**	**8**	**1**	**51**	**51**	**18**	**50**	**3**	**184**
10	4	0	0	0	1	0	1	2	12	14	12	13	1	56
	total	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**12**	**14**	**12**	**13**	**1**	**56**
11	4	0	0	0	1	4	4	5	48	58	27	30	0	177
	total	**0**	**0**	**0**	**1**	**4**	**4**	**5**	**48**	**58**	**27**	**30**	**0**	**177**
Total		**197**	**1183**	**1192**	**321**	**1402**	**1190**	**411**	**4339**	**2975**	**722**	**2551**	**846**	**17329**

Table 13 Statistics of winds and atmospheric equilibrium according to Dagandaud

Period: 1961-1990 Station: Swierklaniec Calm air calculated as v=1m/s

V m/s	KR	Wind Sectors												
		NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	N	Total
1	1	2	0	12	3	6	5	0	17	11	5	17	3	81
	2	25	154	105	33	88	58	6	150	168	41	203	82	1113
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	39	321	223	70	296	196	53	494	502	99	604	245	3142
	5	15	102	106	30	176	123	24	297	230	52	241	85	1481
	6	33	270	259	46	269	168	14	394	308	81	381	166	2389
	total	**114**	**847**	**705**	**182**	**835**	**550**	**97**	**1352**	**1219**	**278**	**1446**	**581**	**8206**
2	1	3	17	18	4	16	12	1	11	17	6	6	4	115
	2	12	80	67	29	73	41	14	97	60	27	88	32	620
	3	31	168	129	55	147	106	31	223	194	79	263	120	1546
	4	91	508	348	99	395	246	72	962	705	233	1080	383	5122
	5	15	100	116	25	178	149	32	484	269	70	276	95	1809
	6	17	124	132	31	167	111	33	291	131	48	154	68	1307
	Total	**169**	**997**	**810**	**243**	**976**	**665**	**183**	**2068**	**1376**	**463**	**1867**	**702**	**10519**
3	1	2	7	11	2	8	4	0	9	9	5	10	3	70
	2	10	28	31	12	24	25	10	55	72	23	58	30	378
	3	9	58	60	13	50	42	19	138	156	41	138	53	777
	4	29	139	114	19	103	101	34	444	455	121	508	149	2216
	5	6	33	24	7	48	53	19	194	137	34	114	15	684
	6	3	20	25	8	55	57	10	129	75	15	43	16	456
	Total	**59**	**285**	**265**	**61**	**288**	**282**	**92**	**969**	**904**	**239**	**871**	**266**	**4581**
4	2	2	8	10	4	3	4	3	16	18	3	7	4	82
	3	20	84	80	34	49	65	44	269	248	108	298	82	1381
	4	31	116	99	25	81	161	92	821	697	226	686	124	3159
	5	1	9	23	2	25	27	14	125	60	18	34	12	350
	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	**54**	**217**	**212**	**65**	**158**	**257**	**153**	**1231**	**1023**	**355**	**1025**	**222**	**4972**
5	2	0	1	3	2	1	0	2	8	4	1	4	3	29
	3	2	22	30	8	19	31	14	177	155	45	105	17	625
	4	8	48	34	6	32	66	29	384	375	99	309	49	1439
	5	0	0	13	2	9	10	2	55	30	10	21	2	154
	Total	**10**	**71**	**80**	**18**	**61**	**107**	**47**	**624**	**564**	**155**	**439**	**71**	**2247**
6	3	1	0	3	1	3	4	4	16	13	14	17	0	76
	4	6	11	15	7	8	31	23	181	171	127	146	14	740
	Total	**7**	**11**	**18**	**8**	**11**	**35**	**27**	**197**	**184**	**141**	**163**	**14**	**816**
7	3	0	0	0	0	0	0	0	2	0	1	2	2	7
	4	1	14	16	1	9	28	11	169	246	42	191	15	743
	Total	**1**	**14**	**16**	**1**	**9**	**28**	**11**	**171**	**246**	**43**	**193**	**17**	**750**
8	3	0	0	0	0	0	0	0	0	2	1	0	0	3
	4	1	1	4	1	0	1	9	43	40	60	26	3	189
	Total	**1**	**1**	**4**	**1**	**0**	**1**	**9**	**43**	**42**	**61**	**26**	**3**	**192**
9	4	0	0	4	0	1	10	1	64	65	28	75	3	251
	Total	**0**	**0**	**4**	**0**	**1**	**10**	**1**	**64**	**65**	**28**	**75**	**3**	**251**
10	4	0	0	0	1	0	1	2	16	21	18	17	1	77
	Total	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**16**	**21**	**18**	**17**	**1**	**77**
11	4	0	0	0	1	4	5	5	51	66	31	37	0	200
	Total	**0**	**0**	**0**	**1**	**4**	**5**	**5**	**51**	**66**	**31**	**37**	**0**	**200**
Total		**415**	**2443**	**2114**	**581**	**2343**	**1941**	**627**	**6786**	**5710**	**1812**	**6159**	**1880**	**32811**

7.3 HISTORY

The area of the Tarnowskie Góry Megasite has been industrially active for centuries. Already in the 14th century, and according to some sources as early as in the 12th century, silver and lead ores were excavated there.

First documented written sources on mining in Bytom area date back to the hours of Pope Innocent II. In documents dated 1247, some references on ore exploitation in Repty can be found. Production of silver from these ores ranks this region among the oldest European mining centres, older than Freiberg, Tyrol or Kutna Hora. Until 13th century, the main product of the mining activity was silver. On the turn of this century and throughout 14th century the basic product recovered from these ores was lead.

In the 12th and 14th century mines of galena (lead glance) operated at such settlements as Repty, Piekary Polskie (Rudne), Bobrowniki, Sucha Góra, Stolarzowice, Zbroslawice, Ptakowice, Dabrówka Wielka and in Szarlej (Abt, 1957). Shafts were rather narrow and small at that time, usually with a diameter of about 1m (Hubner, 1899) and closely located to each other within a distance of several meters.



Fig. 10 Medieval mining

Walls of shafts were covered with timber. The main tools of ore exploitation were hammers and picks. Occasionally, ores were crushed with fire. The network of underground galleries was so entangled that very often miners did not move further because they were afraid of getting lost. The height of corridors was usually 0,8m, only in several cases it reached 2m; whereas the width was usually 0,7 – 1,5m. Very often short corridors extended up to 10m around the shaft. Due to some problems with water flooding only places with favourable extraction conditions were mined. This is the reason for and intensive development of mining in the vicinity of such locations as Sucha Góra and Srebrna Góra near Segiet. The lower located, flooded shafts were operated only during short dry periods. On the turn of the 15th century mining of deposits decreased due to the exhaustion of the shallow ore deposits. An incidental discovery of new galena deposits in 1526 initiated the most intensive development of mining in the northern part of the Bytom Area (within the Tarnowskie Góry region).Each year tens of new shafts were built. In 1533-1536 their number increased more than ten times, reaching the number of one thousand in one year. The boom of mining works falls in the period of 1556-1559 when 2500 new shafts were built. The number of miners was more than 1000. In subsequent years the number of excavated shafts decreased to hundreds per year. The average output was 600-800 Mg of lead per year and in the period of the highest development - up to 3000 Mg. In the years of the highest production the output of silver from these ores was from 600 kg to 1000 kg. At the beginning of the 17th century the production of silver decreased to 200 kg. Summarizing, within the period of 1528-1628 more than 20 000 shafts were operated in the Tarnowskie Góry region. The mining activities concentrated around Tarnowskie Góry, in towns and settlements such as: Liszcze, Blaszyna (8 thousands shafts), in Repty (3600 shafts), Lasowice and Sowice (3000 shafts) and Bobrowniki (1000 shafts).

Mining based on new technology of flooded deposits extraction was developed in the middle of the 16th century. At the very beginning water was scooped with buckets and leather bags, then with the so called “paternoster” device (a prototype of pumping device with timber pipes and bags acting as pistons), and finally - with pumps. Since these ways of deposit dewatering were very expensive, methods of gravitational dewatering were introduced.

Construction of groundwater adits began with an open section on the surface by the river to which the water was to be discharged. Next section of the adit was constructed as an underground drift. In this way the adit reached the deposit. In Tarnowskie Góry Land water adits were excavated since the second half of the 16th century, but some sources indicate

earlier date (Abt, 1957). This author suggests that the adit "Od Szarlejki" might have been created in Medieval Ages. The length of the drift was 2,8 km. It was located in the vicinity of Srebrna Góra settlement and discharged water into Szarlejka river.

In the 16th century new groundwater corridors were planned and designed only to abandon their construction after the start-up of the earth works. In 1547 new adit "Daniela" was notified to mining authorities. The location of this adit was in Repty with the water discharge to the Drama River.

Another adit was notified in 1563 with the name of "Swiety Jakub" ("Saint Jacob"). This adit was active up to 1624 and then, after a short break, from 1667-1718 (Abt, 1957).

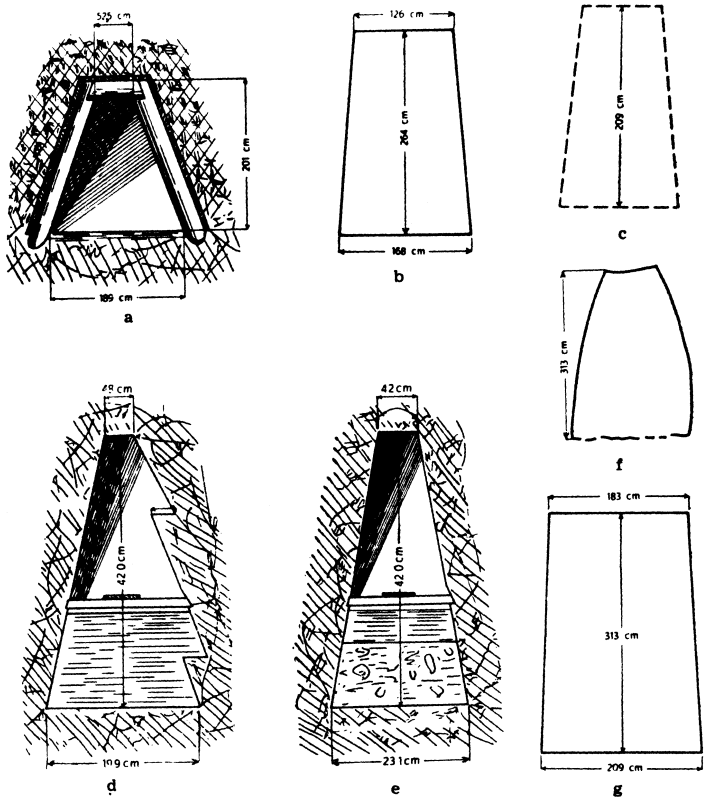


Fig. 11 Typical cross section of medieval adits

a-c for sections with casing (a – Starczynowska adit in Olkusz, b – Ponikowska adit in Olkusz, c – Boze Dopomóz adit in Tarnowskie Góry
d-g – for sections developed without casing (d,e – Ponikowska adit in Olkusz, f – Boze Dopomóz – Tarnowskie Góry, g – Swiety Jakub – Sowice)

The outlet of this adit was into a pond at the Stola River in Sowice settlement. The first, open section was 900 m long. The drift was at the depth of 34 m below the town of Tarnowskie Góry. The total length of this adit was 3,3 km. The adit was connected with side-drifts called

"sztros". Construction of another small adit called "Bozy Dar" started in 1566 in the vicinity of the St. Jacob adit in Sowice. One year later another adit was excavated. In 1568 under Sowice settlement new gallery "Pomagaj Bóg" with a total length of 440 m was excavated. In the same year construction works of the longest and the deepest adit started. The adit began in Ptakowice . Its function was dewatering the deposits in Repty and Liszcz. The total length of this adit was more than 4 km. The excavation of the next adit started in 1652 year. The outlet of the adit was located in Strzybnica (formerly Rybna village). The name of the corridor was "Boze dopomóz". This adit was active till 1695.

In the 17th century the mining of ores in Tarnowskie Góry decreased. Galena extraction was replaced with calamine exploitation (discovered in 1569). The period of stagnation in mining activity lasted till the end of the century.

In 1704 Giesche obtained licence for calamine exploitation for twenty years, which was later extended. The exploitation technology was changed into open pit excavation. The shafts after calamine exploitation were 10-12m deep, maximally 32m.

Further history of calamine exploitation is connected with Ruberg and his invention. In 1800 in Wesola settlement (Upper Silesia) he invented a technology of zinc production from sulphide minerals.

The alum, vitriol (sulphuric acid) as well as red paint were other products of metal ore processing.

Mines in Piekary Rudne and Bobrowniki, which date back to Medieval Ages, were still active in the 16th and 17th century. Beside the above-mentioned, mining of ores also developed in Zyglin, in the vicinity of Miasteczko and in the 17th century it started in Radzionków.

The second half of the 18th century was a period of stagnation in mining and the development of Tarnowskie Góry town.

A new chapter in Tarnowskie Góry area development started in 1784 when calamine ores started to be excavated in a new mine called "Fryderyk" located between Piaseczna and Bobrowniki

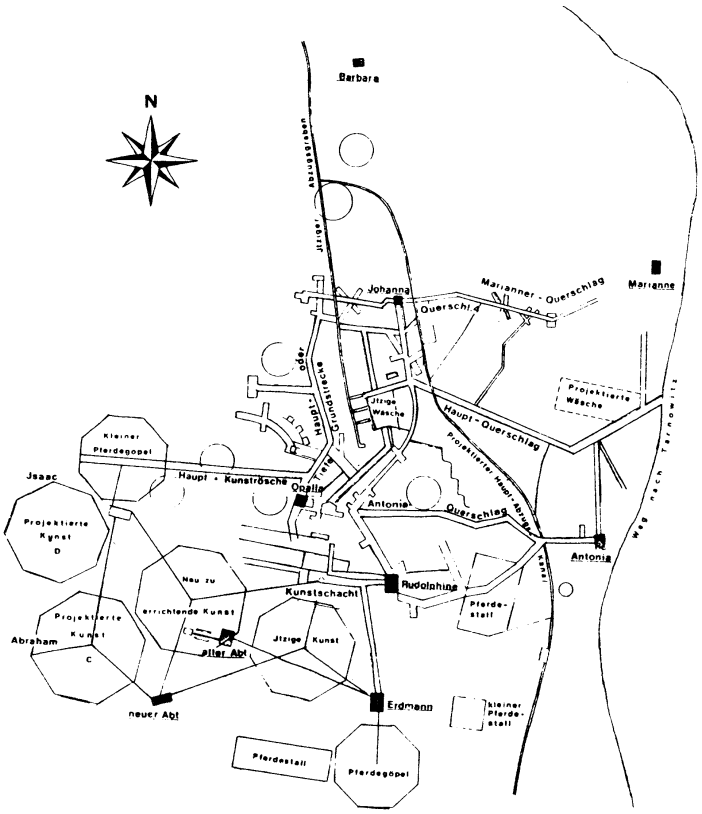


Fig. 12 Development of Fryderyk mine to the end of 1785y (reconstruction by Fechner)

Deposits were dewatered with a horse gear, later replaced with steam machines. The cost of dewatering was so high that a decision was made to reconstruct the old water adit "Boze Dopomóz". The works were completed in 1806. In 1821 construction works of a new deep adit were started. Plans were developed on the basis of an old "Krakowska" adit. The new adit was located parallel to the drifts of the old one. The adit was named "Sztolnia Fryderyka". The mining area was re-estimated in 1837 for 152,9 km^2. The mine "Fryderyk" was closed at in early 20th century.

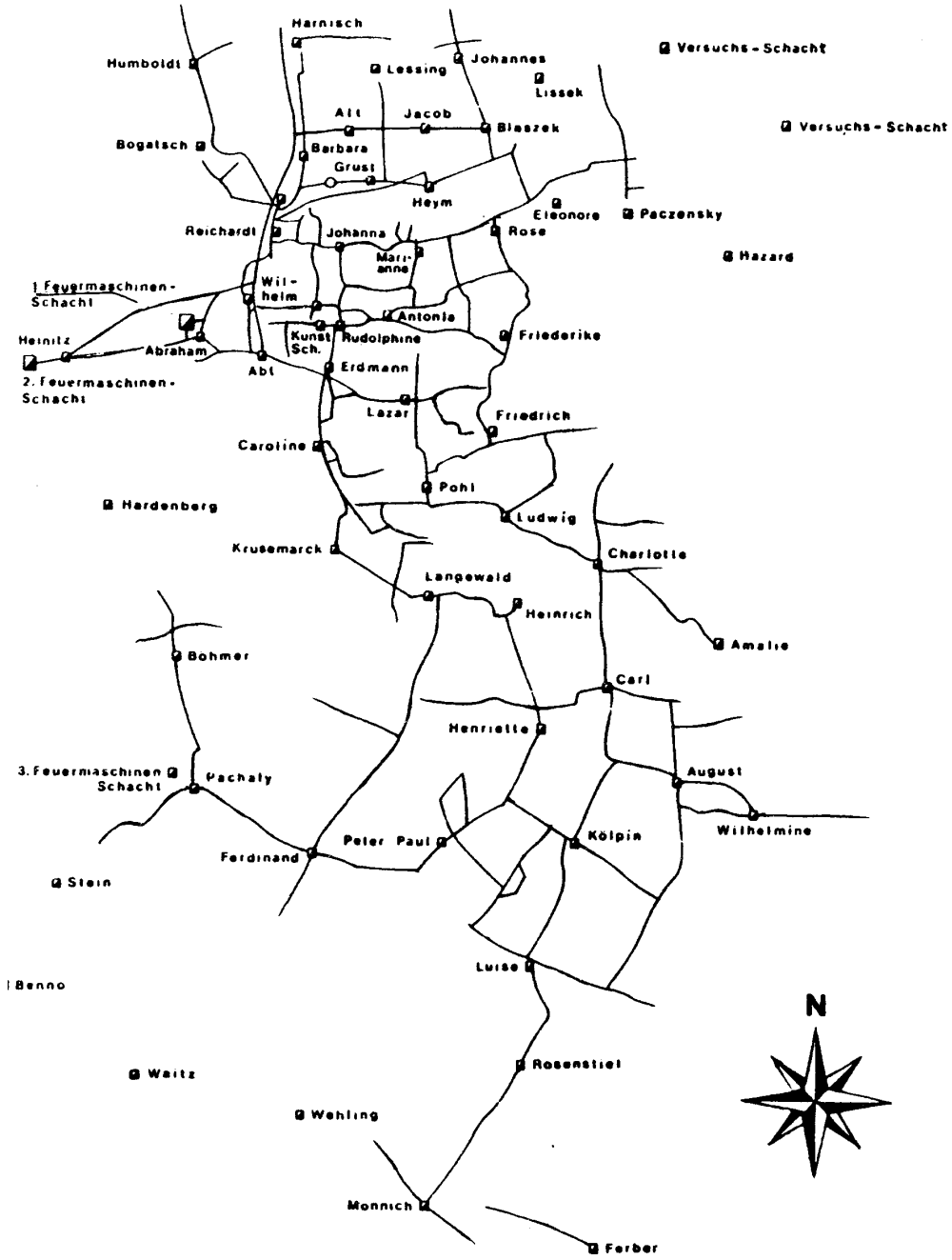


Fig. 13 Bobrowniki - development of Fryderyk mine in period 1785-1789 (reconstruction by Fechner)

In the second half of the century, apart from the deep state mine "Fryderyk" (Friedrichsgrube), other private mines were active: "Anna" (Miasteczko Sl., Zyglinek), "Abschluss" (Lasowice), "Bertram" (Pniowiec, Piaseczna), "Constantin III" (Miasteczko, Zyglin), "Comtesse Elisabeth" (Lasowice), "Eduards Gluck" (Bibiela), "Elinor" (Piaseczna, Lasowice), "Ernestine (Miasteczko, Zyglinek), "Gruffin Wanda" (Bibiela), "Graf Edwin" (Piaseczna, Pniowiec), "Graf Hugo" (Bibiela), "Gewagt" (Lasowice, Pniowiec), "Herminne"

(Zyglinek, Pasieka-Bibiela), “Markgraf Georg I” (Miasteczko), “Verinigte Sowitz Bleierz Grube” (Sowice), “Wictor” (Bibiela), “Zarroch II” (Zyglinek, Pasieka-Bibiela). Around the town open mines and mining fields of zinc ores operated: “Gretchen” (in the vicinity of Góra Reden), “Carl Auguste I” (in the vicinity of Gliwicka Street), “Hedwig”, “Carolinenwunsch”, “Gertrud” and others. At the beginning of the 20th century about 50 mining fields of zinc ores were active in the region.

The mining of iron ores in the region of Tarnowskie Góry was represented by mines that were owned by Steel Works Reden in Zabrze (Redenshutte A.G.), Tarnowskie Góry Steel Works (Tarnowitzer Kiesenerzbergwerk), count Guido Henckel von Donnersmarck, count Hugo Henckel von Donnersmarck, Joint Stock Company of King Steelworks (Laura/Koenigs und Lauerhutte A.G.) [Jankiewicz at all, 1990]. Another large mine of iron and lead ores was located in Bibiela settlement. It was put to operation in 1889 and closed down in 1917 due to flooding.

In general, mining activity in the Tarnowskie Góry region existed for over seven hundred years. The last mine was closed down in 1922. An open pit mine of dolomite (Sucha Góra) was active till the end of the second millennium.

7.4 RECENT STATE OF CORRIDORS AND GALLERIES

Recently, deep excavations can be carried out at a few vertical shafts: “Aniol”, “Zmija”, “Staszic”, “Ewa”, “Sylwester”, “Koehler”, “Fryderyk”, “Glück” and also some uncontrolled shafts (mainly in the region of Dolomite Mine in Sucha Góra) as well as by adit gates of “Fryderyk” and “Boze Dopomóz”.

Medieval shafts that were located in mining areas of Tarnowskie Góry and its neighbourhood are now inaccessible. Deep excavations located in the area of “Fryderyk” mine are hardly recognized and assessment of their age is often impossible.

Beside deep excavations, adits and shafts are treated as cultural heritage and tourist attraction.

In 1957 a historical adit “Czarny Pstrag” (“Black Trout”) was opened for public. In 1976 three vertical shafts: “Aniol”, “Zmija”, “Szczesc Boze” became a part of a museum mine.

An emergency route leads from the mine through a system of chambers and drift “Heinitz” to the “Staszic” shaft (former name “Adolf”). The “Staszic” shaft is recently owned by the

Upper Silesian Water-Supply Enterprise. This plant provides about 30000 m^3 of drinking water per day.

There are four adits running from the “Staszic” shaft in four directions. To the west - “Fryderyk” adit, to the east - “Heinitz” drift, to the north - “Fryderyk”’ adit called also “Paulina”, to the south-east - further sections of the “Fryderyk” adit.

During works conducted in “Heinitz” drift southern part of excavations and bottom shafts “Stefania”, “Zofia” and “Pokój” were explored. Also the “Urban” vertical shaft is accessible at a low water level. This shaft is located in the region of Srebrna Góra.

The basic corridor of the “Fryderyk” adit which runs from the “Staszic” shaft in the south-east direction towards Sucha Góra region is inaccessible due to rock slides.

The west drift of “Fryderyk” adit is flooded. It was originally connected with the “Glück” shaft. Passing the “Pokój” shaft in Stare Repty it is possible to reach a section of “Fryderyk” adit called “Czarny Pstrag” (Black Trout).This section is presently a tourist attraction. It is 600 m long and linked with two vertical shafts “Ewa” and “Sylwester” (depths: 20m and 30m, respectively). Moving further to the west and passing the “Adam” shaft there is an exit from the “Fryderyk” adit through a gate called “Brama Gwarków” (Old Miners Gate) located in the vicinity of the Zbroslawice village.

The drift called “Paulina” running from “Staszic” shaft northwards is 1300 m long and ends with an inaccessible vertical shaft called also “Paulina”.

Exploration of the “Fryderyk” corridors showed that there are also other systems developed which communicate vertically with the “Fryderyk” system.

The “Boze Dopomóz” adit can be explored through an open part (adit window) in Strzybnica towards the town. The first section of the adit is a drift with walls covered with bricks. The next part of the drift, excavated in dolomite is going under a petrol station and in the vicinity of FASER Plant. It ends with a rock slide.

The vertical “Fryderyk” shaft is located near Opolska Street in Tarnowskie Góry. It is linked with “Koehler” shaft by a system of flooded drifts.

The system of mining corridors and water galleries of a total length of over 250 km constructed in Triassic rocks (mainly dolomites and limestone formations) forms an artificial path of contaminants migration.

When the mining activities gave way to steel industry development in the district (poviat), and then also to other branches of industry in the 20th century, the industrial character of the megasite was determined by several plants and the key role of the Tarnowskie Góry railway node in the railway transportation system of the Upper Silesia Region. The most important industrial facilities operating in the 20th century were as follows: "Tarnowskie Góry" Chemical Plant, NITRON-ERG Chemical Plant in Krupski Mlyn, Zinc and Lead Smelter in Miasteczko Slaskie, Chemet factory and mining industry supportive facilities such as FAZOS and TAGOR.

7.5 GEOLOGY

A comprehensive geological profile of the Tarnowskie Góry Megasite is presented in Fig. 14. The geological map of the area is presented in Card no 27.

The structural map of the bottom of Quaternary permeable formations and a structural map of Triassic carbonate formation roof is presented in Part II of the Deliverable 4.1.

7.5.1 Triassic

The sediments of the Lower and Middle Bunter are the oldest layers of the Mesozoic era within Megasite. Formations of this age are laying discordant on Carboniferous formations and they crop out on the surface or spread directly below Quaternary sediments in vicinity of Swierklaniec and Kozlowa Góra. The dominant sediments of this stratigraphic layer are: terrigenous, grey and rose-red, weakly consolidated sandstone and sands with conglomerates at the bottom and mudstone and claystones on the roof.[12], [13]. Their total thickens fluctuates in the range of several to over 50 m. The sediments of Bundsandstein – Roet are lithologicaly very diversified. Light-grey, thin-layered beds of dolomitic marls with frequent interlayers of mudstones and claystones prevail in the bottom section . Upper part of Roet series is formed mostly as thick layered beds of marled dolomites that continuously transfer into dolomitic

[12] Bardzinski, Lewandowski; 2000; Budowa geologiczna rejonu Tarnowskich Gór. Zastosowanie interaktywnych systemów kartografii geologicznej na obszarze miasta Tarnowskie Góry Geological Structure of. Tarnowskie Góry Area. Application of geological cartography systems in the area of the Tarnowskie Góry town). Konferencja Naukowa Tarnowskie Góry 2000.

[13] Intergeo - Koncepcja Monitoringu 2002

limestones in the roof. The thickness of the Roet formation varies: from about 60-80m at the southern part of Megasite up to 120m at the northern part of the Megasite.

The layers of Muschelkalk are formed as pelmicrite and fine detrital limestones. Their thickness does not exceed 20 m in the vicinity of Tarnowskie Góry town.

The limestone roof is formed of claystones topped by ores-bearing dolomites and limestones. Their thickness is up to tens of meters [Card no 27, Fig. 14]. The ore-bearing dolomites are epigenetic rocks that originate from hydrothermal conversion of limestones. They are characterised by numerous caverns and cavities and dispersed, generally point mineralization of lead and zinc sulphides. Majority of the ores-bearing dolomites are formed as average-bedding, grey and greyish-yellow dolomites as well as dolomitic limestones. These formations frequently crop out on terrain surface or lay directly below Quaternary sediments.

The youngest part of the Triassic formations in investigated area is formed of Keuper sediments that are generally present directly below Quaternary sediments. The Keuper formations are formed as coloured clays as well as claystones and mudstones, locally marls further replaced by sandstone and limestones.

The thickness of whole complex is diversified: from several meters in the peripheral zone up to 80-120m in the local grabens. In the north from Pniowiec, these formations create one separate oval hill. The Upper Triassic formation is locally completely reduced in the axis of Mala Panew pre-valley (in a vicinity of the Kalety town) as well as on the crest of dome (in the vicinity of Mikoleska village).

7.5.2 Jurassic

The sediments of the Jurassic period in Tarnowskie Góry region, have been eroded in a prevailing part of the area. This resulted in local presence of these sediments. The Jurassic formations are represented by sediments of Lias formed as sandy gravels that are replaced further by loams and sandstones. Their thickness varies from several to tens of meters.

Jurassic formations are pervious and constitute one of the components of the of the first water-bearing horizon of the Megasite. Locally, in vicinity of “Tarnowskie Góry” Chemical

Plant their character changes into impervious. In this area Jurassic formations are locally formed as loams and clays.

7.5.3 Tertiary

Tertiary sediments of the Tarnowskie Góry area are of local occurrence. A number karstic sinks filled with regolith which is composed of clay, sand and rock debris, highly enriched with limonite can be found on the outcrops of Middle Triassic formations – directly on the surface or under a cover of Quaternary sediments. Thickness of these sediments is extremely diversified: from several up to 40 metres. In the southern part of the area, a cover of Miocene sea-formations is present under Quaternary sediments. These formations are represented by muds and clays which facially transit into sands. These sediments fill the peripheral fragment of the Pyskowice graben as well as so called "Gliwice bay" (local under-miocene depression) and their thickness varies from several up to more than 50 metres.

7.5.4 Quaternary

Quaternary sediments occupy over 80% of the Megasite. Their thickness and spreading increase northwards (pre-valleys of Stola and Mala Panew) as well as westwards (pre-valley of Drama and its tributaries). The thickness distribution and lithology of Quaternary formations are tightly related to the morphology of pre-Quaternary surface[14].

The most complete profile of these sediments can be observed in pre-valley zones of Pre-Stola and Pre-Mala Panew.

The bottom part of the profile is represented by sands and gravels (with thickness of several meters). This layer is generally covered by two strata of loams with a maximum thickness of few to several meters. They are interleaved by a layer of sands, locally also of muds. The lower stratum of loams with a maximum thickness of several meters is discontinuous and occurs only in zones of fossilized slopes. This horizon along with the lower-lying sands and gravels represents the South-Polish Glacial – San II Glacial. Upper stratum of the boulder tilts is continuous in the northern and western part of the Megasite. Only on the axis of recent river valleys: Brynica, Mala Panew, Stola and Drama this stratum is completely washed away by

[14] Rózkowski A., Chmura A., Sieminski A. [red] Uzytkowe wody podziemne Górnoslaskiego Zaglebia Weglowego i jego obrzezenia. Prace PIG CLIX, Warszawa 1997.

fluvial processes.

Stratigraphicaly, this horizon along with the upper-lying muds and sands represents Middle-Polish Glacial – Odra Glacial.

In the neighbourhood of Bobrowniki and Piekary Rudne, to the south from Tarnowskie Góry, a series of sandy muds of few to several meters thickness spreads under a thin layer of fluvioglacial sands. This series was accumulated probably in local ponds (stagnant waters) that were developed on the outwash plain of Odra ice-sheet.

Wide-spread series of similar origin (silts and clays) appear also northward from the Stola Valley. This stratum lays on the upper horizon of boulder tilts and is covered by sands of various thickness.

Small, sandy-gravel hills situated in the vicinity of Tarnowskie Góry, are probably of fluvioglacial origin. They represent saved residuals of push moraine and sander of Odra Glacial [2].

Alluvial sands cover the broadest area of the Megasite. Their maximum thickness is reached in zones of river valleys (Drama, Stola, Mala Panew and Brynica) and can exceed 20 metres.

The thickness of the sands cover is generally a few meter (in some places several meters) in the area of Tarnowice Upland slopes. They are of fluvio-peryglacial origin (diluvial-fluvial). In the Mala Panew valley the sand cover is represented by fluvioglacial sediments, transformed by periglacial and eolian processes of the last glacial period.

In local depressions and in zones of old river beds peaty muds and peat are accumulated.

The high level of water table of the first water horizon results from shallow occurrence of impervious Upper Triassic formations (clayish-silty). The Quaternary formation cover is completely reduced or its thickness does not exceed few meters on the hills of elevation over 300-310m a.s.l., particularly in southern and eastern part of the Megasite.

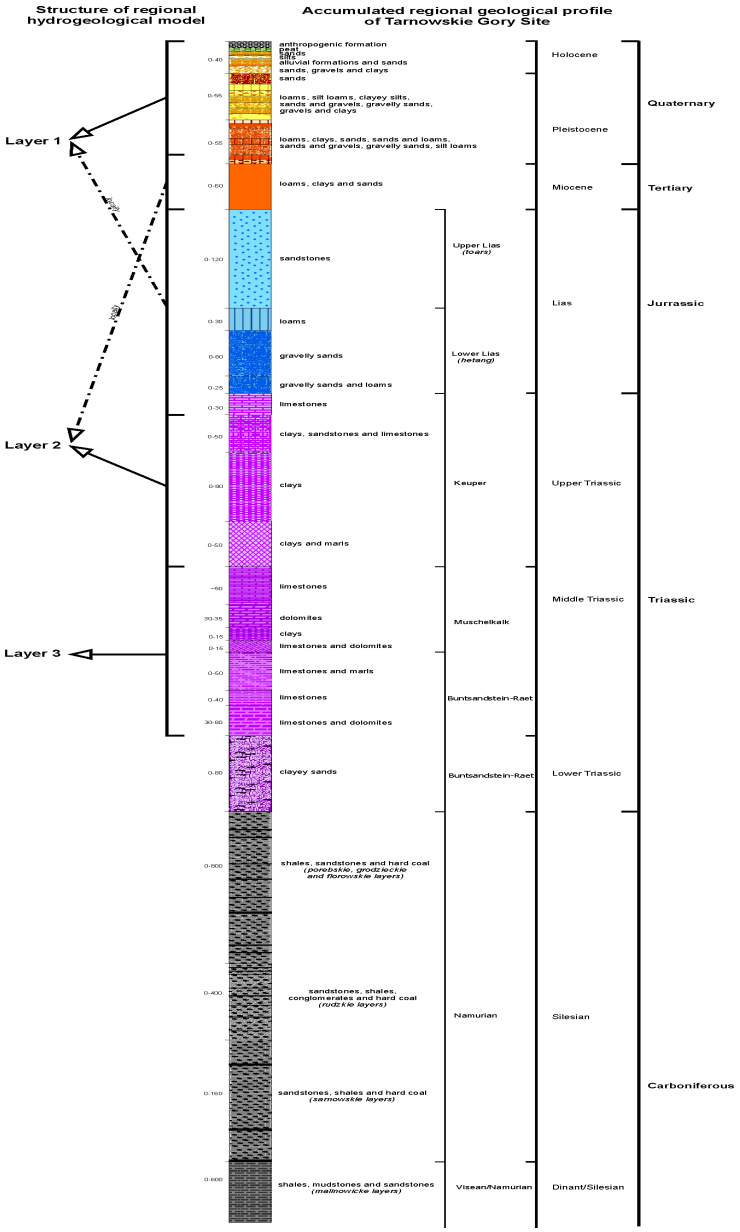


Fig. 14 Regional hydro- and geological profile of Tarnowskie Góry Megasite

7.5.5 Tectonics

In the region of Tarnowskie Góry, Triassic formations create a wide basin, which axis runs along the Sucha Góra- Stare Tarnowice line[15]. The NE limb of the basin is gentle and lightly folded. It is a part of an anticline which crop out on the surface in the vicinity of Swierklaniec.

[15] Bardzinski, Lewandowski, Budowa geologiczna rejonu Tarnowskich Gór. Zastosowanie interaktywnych systemów kartografii geologicznej na obszarze miasta Tarnowskie Góry. Konferencja Naukowa Tarnowskie Góry 2000.

The east limb of the Tarnowskie Góry syncline is overlaid on a peripheral limb of Pyrzowice flexure which strikes to the west. The south-west limb is cut by the Bedzin-Radzionków fault. The dislocation zone is composed of a set of parallel faults that decrease in the west direction and change into flexure. The Tarnowskie Góry Basin is separated from the Bytom Basin by a gentle crest, which axis is runs along the Radzionków-Stolarzowice-Zbroslawice line. As results of fold deformation during Laramide orogeny episode, local slopes of the strata in Tarnowskie Góry Basin differ from general, monoclinal northward strike of the layers. Synclinal pattern of the Tarnowskie Góry Basin as well as the pattern of large-radius northern basins and crests is disturbed by numerous faults. The later resulted in development of the structures of lower order within Monocline boundary. They appear as tectonic horsts and half-grabens called tilt-block tectonics.

The Triassic plate in southern-western part is folded by basins and crests which are overlaid by young-alpine horsts and tectonic graben of the peripheral part of the Carpathian Foredeep (Gliwice horst, Pyskowice graben and Lubia graben on the north).

Older system (probably Old-Kimmeridgian phase of Alpine orogeny) is composed of two crossing sets of faults, one with NNW-SSE strike, the other with NNE-SSW strike.

Their magnitude of throws, frequently pivot-faults varies from several to 30 meters. The dip of the fault plane is mostly vertical and distances between parallel faults vary within a range of hundreds of meters to few kilometres. The strikes of the faults of the youngest system (young-alpine) are nearly S-W. The magnitudes of throws vary in the range of 20-50 meters. The distances among larger faults of this system reach at least a few kilometres.

The faults with smaller throws of 0,5-2 m, can be observed in the pits. The azimuths of these faults strike is about 60°, their upthrow blocks form the outcrops of Gogolin layers limestones. Various fault systems and cracks generations can be observed in the pit mines of the Tarnowskie Góry neighbourhood. The principal character of the cracks is generated by a joint system, which is composed of perpendicular joints set (joint distance about 2-4m) overlaid with more dense joints set (joint distance tens centimetres). The fractures and cracks with a dip smaller than 60°, 45°, even 30° are generally less frequent than vertical and very steep ones.

The map of the faults that are present within Megasite boundary is presented on Fig. 15.

From the view of the Tarnowskie Góry structural model development, it is important that a larger part of the discovered faults can be described only nominally as vertical faults without a sure value of throw.

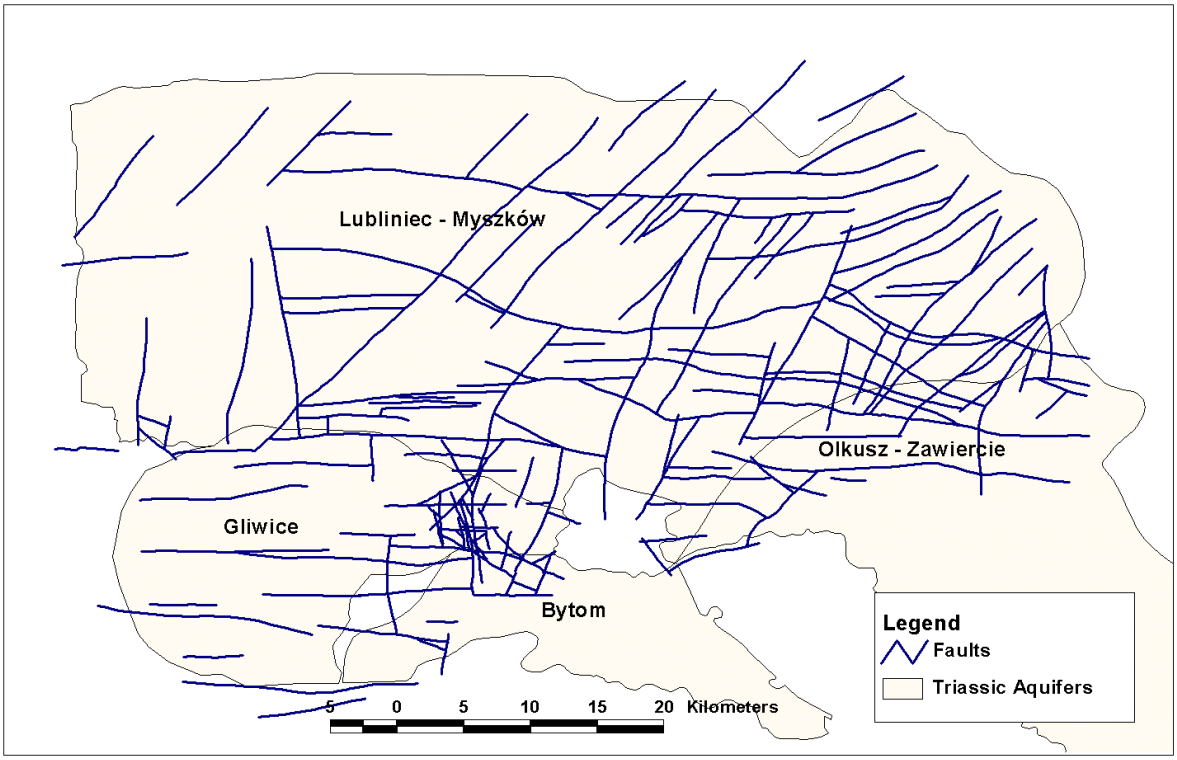


Fig. 15 The main faults in Triassic and older formation

7.5.6 Hydrogeology

The boundaries of the Useable Groundwater Basins (UGWB) and Major Groundwater Basins (MGBW) along with their geologic age are presented in Fig. 16.

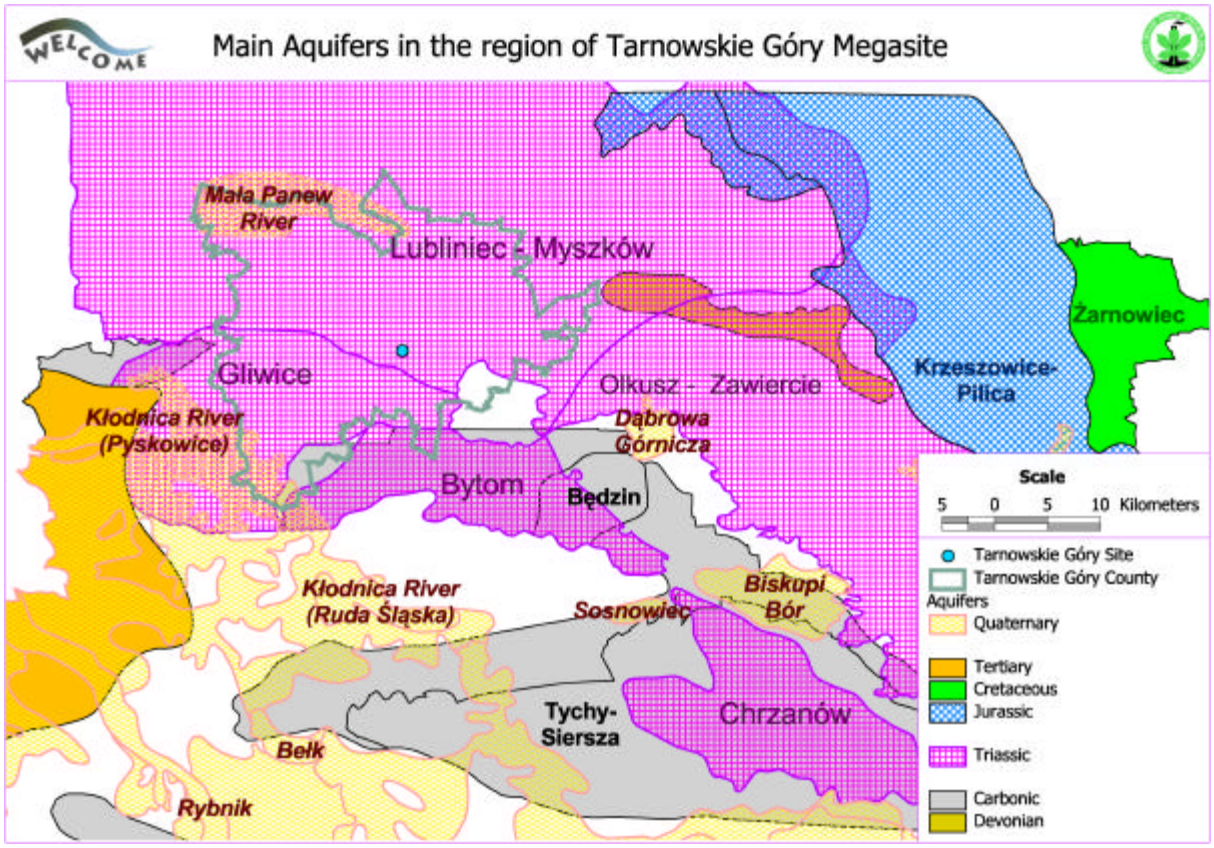


Fig. 16. Main useful groundwater basins in central part of Silesian Voivodeship

The deepest useful resources of groundwater in the central part of the Voivodeship are of Carbonic age. The aquifers of Triassic age are of strategic character. Jurassic waters are located in the eastern part of the Voivodeship. Cretaceous and Tertiary waters in the Silesian Voivodeship are of local importance.

The boundaries of three Triassic aquifers: “Gliwice”, “Lubliniec-Myszków” and “Bytom” that contain groundwater resources of strategic importance are presented below (Fig. 17).

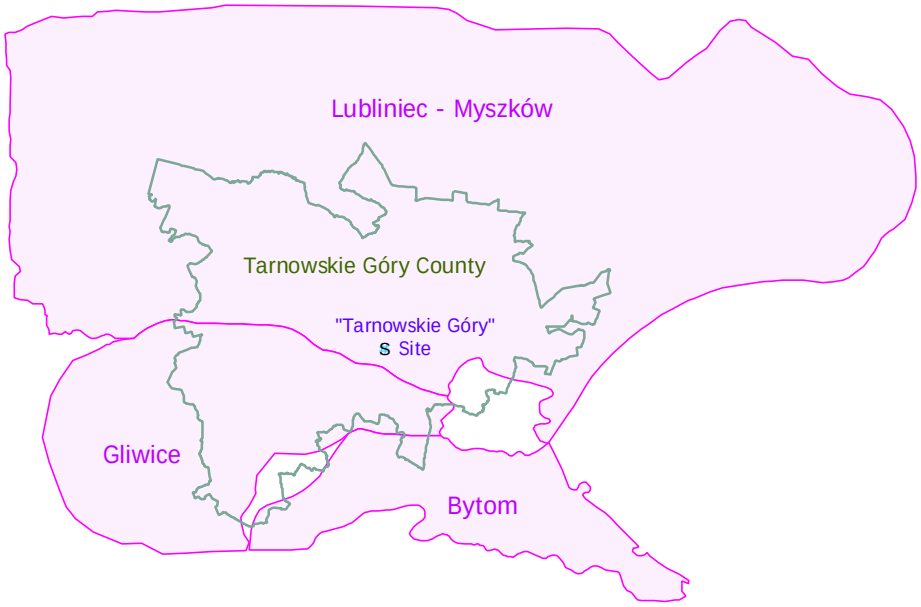


Fig. 17. Boundaries of the Triassic aquifers

Up to early nineties, water from these aquifers was uncontaminated and supplied directly to consumers without any additional treatment. In early nineties, the monitoring network of groundwater revealed that the quality of water in Triassic aquifers is deteriorating. The "Tarnowskie Gory" Chemical Plant was identified as one of the major sources of contamination. Until now, several other important sources of contamination were identified however the “Tarnowskie Gory” Chemical Plant remains the main hot-spot in the region.

Tarnowskie Góry Site is located on the boundary of two Triassic groundwater basins. Northern basin - “Lubliniec – Myszków” ($T_{1,2}$) covers the area ca 2000 km^2. The southern basin – “Gliwice” is smaller, with an area of ca 438 km^2. The Quaternary aquifers have character of porous media. The carbonate Triassic aquifers are generally karstic-fractured. The main useful water horizon is connected with formation of Lower and Middle Triassic.

Water horizons in basins are considered as one level due to numerous local tectonic contacts as well as frequent lack of impermeable layers.

Boundary between these two basins is connected with the morphological structure of the Triassic formation but actually it has a hydrodynamic character. The third groundwater basin – “Bytom” has a strong impact on the hydrodynamic field of the “Gliwice” Basin. At present, groundwater level in the Bytom basin is 80-100m below its natural state. As an effect, the level of water in the “Gliwice” Basin is lowered : from 50-60m on the boundary with “Bytom” Basin to 20- 30 m in the western part of the basin. Intensity of water abstraction in

these two basins is the main force shaping the boundary of "Gliwice" and "Lubliniec – Myszków" basins.

Groundwater recharge takes place directly in the region of contact of Triassic formations with terrain surface as well as indirectly by Quaternary formations from quaternary horizons of groundwater. The thickness of Triassic aquifers in Tarnowskie Góry region varies from 100 – 170m. Permeability of Triassic aquifers hardly varies and is determined by the number and dimensions of fractures as well as intensity of karstification. Filtration coefficient for wells pumping waters from these aquifers varies from $1.1x10^{-6}$ to $9,3x10^{-4}$ m/s. Quality of waters in these aquifers varies from 1b class to 2 class with dominant fraction of waters classified as 1c.

In 1994, resources of the "Lubliniec – Myszków" were estimated as 232000 m^3/d at the total intake of 186000 m^3/d. Resources of "Gliwice" Basin were estimated as 208750 m^3/d at the total intake of 107700 m^3/d.

Resources of useful Quaternary aquifers in the Silesian Voivodeship are very low. Generally, shallow aquifers are highly disrupted.

Three Quaternary horizons were identified at the Chemical Plant site. Two of them extend throughout entire of the site, the third one occurs only locally. The highest horizon has a free water table close to terrain surface. The second and the third horizon have water level under pressure that stabilizes on the depth of the first horizon. The horizons have numerous hydraulic contacts. Filtration coefficient for fine sands is determined in the range of $3.4x10^{-6}$ m/s to $1.4x10^{-5}$ m/s and for medium sands in range of $1.4x10^{-5}$ m/s to $1x10^{-4}$ m/s.

General view of created hydrogeological model (three layers) is presented in Fig. 18

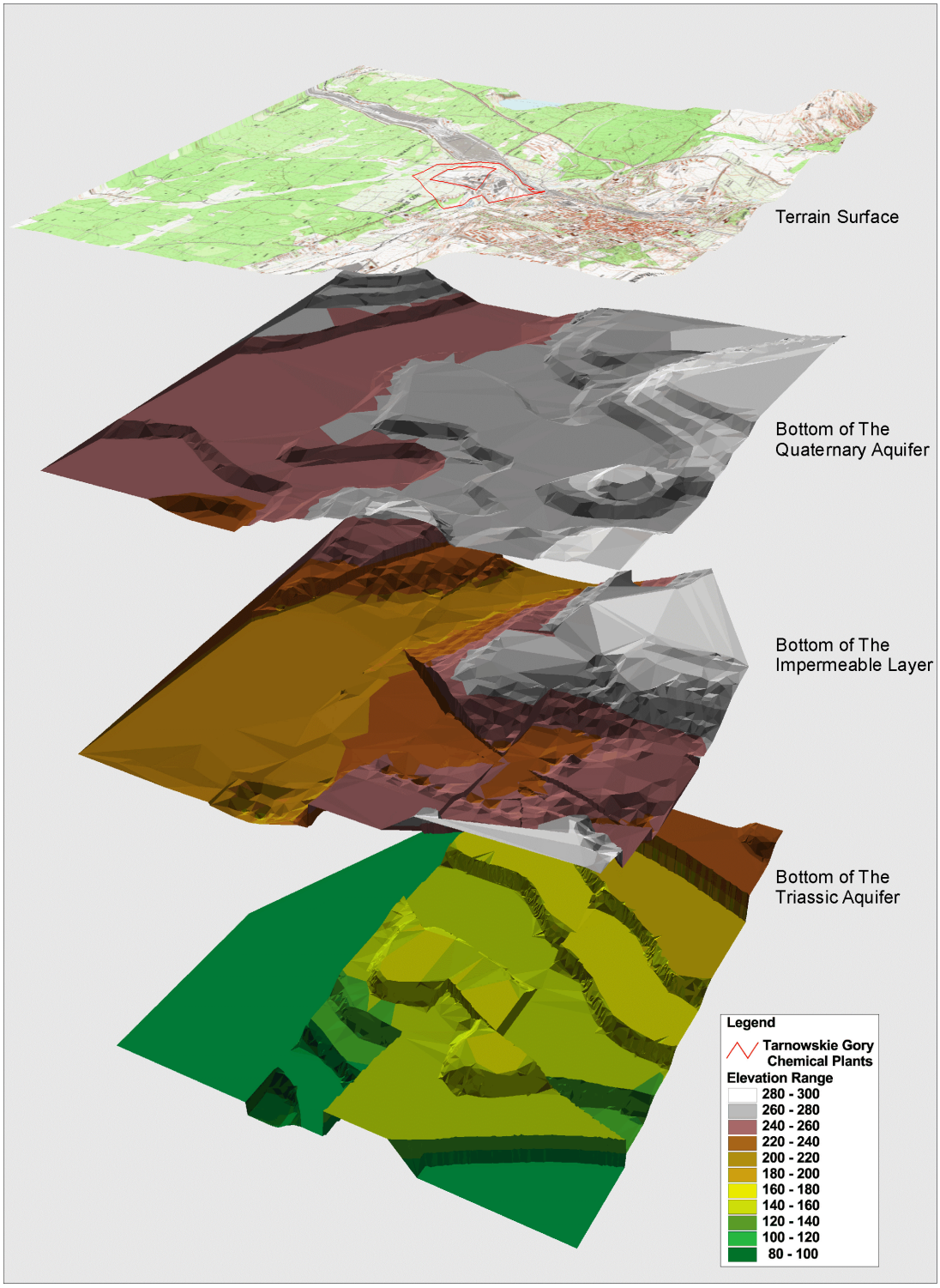


Fig. 18 3D view of structural hydrogeological model

A detailed description of hydrogeological situation of Tarnowskie Góry Megasite is presented in Part II of Deliverable 4.1.

8 REMARKS TO THE MEGASITE

Analysis of the situation in the region allowed identifying two primary routes of contaminants migration to Triassic aquifer: vertical penetration from surface sources through sandy Quaternary formations down to the Triassic aquifer and numerous galleries and adits remained form abandoned mining activities.

Heavy metals and boron proved to be the most important and most common contaminants. While the presence of organic contaminants was detected in wells abstracting Triassic waters, an inventory of all organic contamination sources (including solvents) has not been completed so far. Also a qualitative and quantitative analysis of surface groundwater contamination sources has not been completed either. Nevertheless, it can be stated that the “Tarnowskie Góry” Chemical Plant Site has been recognised the most important source of inorganic (metals and boron) groundwater contamination. Another source of an extremely high heavy metal emission is the “Miasteczko Slaskie” Zinc Smelter. So far the impact ranges of both sites on groundwaters have not been found to overlap.

From the water management viewpoint, the system of underground adits and mining workings is one of the most interesting elements of the megasite. Their natural and cultural qualities are another reason which makes these elements interesting, However, from the water protection perspective, the fact that the adits and workings modify vertical water flows including contaminated waters is of high importance. The system of adits limits the flow of Quaternary waters to Triassic orogen, discharging them directly to rivers. This action is especially effective in areas in which individual adit sections are not backfilled. Thus it can be stated that beside the impermeable layer composed of Quaternary, Tertiary and Triassic clayey-loamy formations, an artificial system of deep Triassic groundwaters protection was developed in the past. Improvement and reconstruction of the adits system along with a precise definition of its protective role should be recognised as priority tasks for water management bodies. A detailed inventory and establishing a monitoring system for adits waters would allow for a quantitative determination of the role which the system of mining workings actually plays in the protection of the Tarnowskie Góry Megasite.

Due to the structure of the reservoirs it should be assumed that remediation of the Triassic aquifer waters is practically impossible. Therefore the search for appropriate remediation technologies should concentrate on methods impacting the porous Quaternary medium and methods for controlling water flow in orogen.

For the purposes of generating scenarios and assessment of risk, the following tasks need to be accomplished:

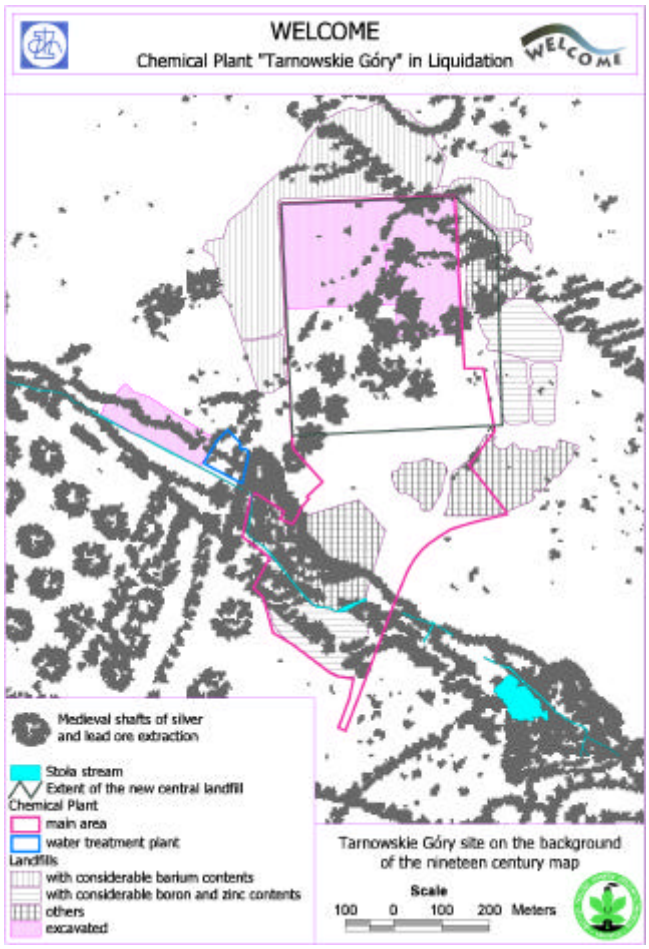
- development of a model of contaminant emission to waters and soil based on collected data;
- development of a hydrologic area model allowing simulating the effect of land use changes on the Megasite water balance,
- development of hydrologic response units (HRU) classification due to a potential capacity of metals immobilisation
- combining the hydrologic model with the already developed three-layer hydrogeological model
- categorising environmental components from the viewpoint of metal contamination (waters, soils) to satisfy the needs of preliminary risk assessment.

An assumption was made that these tasks will be performed during development of the final GIS, i.e. a system compatible with or containing hydrologic and hydrogeological models as well as risk models. Based on these models, scenarios of environmental use could be developed for the most sensitive parts of the Megasite along with a prognosis of risk reduction.

9 CHEMICAL PLANT SITE DESCRIPTION

9.1 SITE HISTORY

Similarly as in the entire area of the district, the “Tarnowskie Góry” Chemical Plant Site was an area of zinc and lead ores extraction. Beside numerous small shafts presented in Fig. 19, there were also adits at the site which discharged waters from the deposits area to the Stola River.



Source: Tarnowskie Góry Town Archive and IETU GIS

Fig. 19. Old map of site incorporated into GIS

Development of mining industry at the discussed site was followed by the development of chemical industry, mainly production of potassium, aluminium sulphate and sulphur acid.

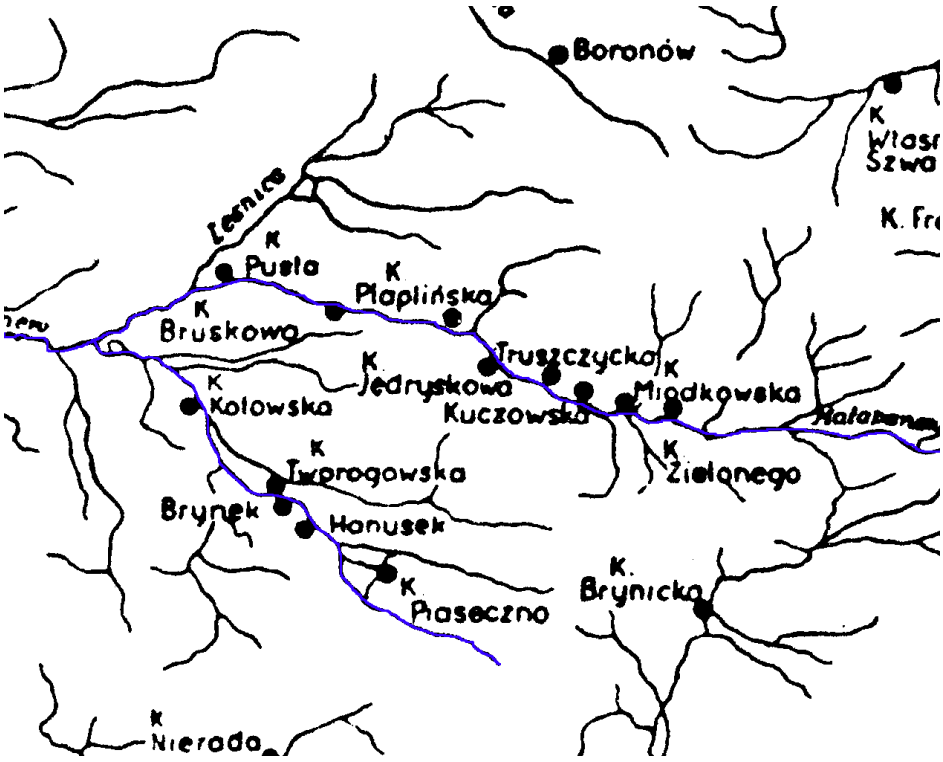


Fig. 20 Steel works in XVI century in Tarnowskie Góry region

Simultaneously, steel works were built and put into operation. First furnaces started work in the middle of the 19th century and operated until 1892. Also in 1892 production of silk paper was started. The product was exported to China and Japan. Production of paper was abandoned in 1919. The dump of cellulose waste (No 6 - Table 14) is a trace of this activity.

In 1922, chemical industry was developed at the site. Production of oil paint pigments, sodium dichromate ($Na_2Cr_2O_7$), barium chloride($BaCl_2$), boric acid (H_3BO_3), borax ($Na_2B_4O_7 \cdot 10H_2O$), barium nitrate ($Ba(NO_3)_2$), zinc oxygen (ZnO), zinc sulphate ($ZnSO_4$) as well as sodium perborate ($NaBO_3$) was started.

Before the World War II the Chemical Plant produced aluminium sulphate ($Al_2(SO_4)_3$), copper sulphate ($CuSO_4$), zinc sulphate ($ZnSO_4$) and potassium aluminium sulphate ($K,Al\ (SO_4)_2 \cdot 12H_2O$).

In 1943 the plant started to produce active soot (black carbon) and after World War II, in 1945 - barium salts and lithopone ($ZnS \cdot BaSO_4$) white pigments. In the following years the plant produced also strontium carbonate ($SrCO_3$) and chemical soot (black carbon).

In 1965 a water treatment plant was built at the site with the goal to decrease the concentration of zinc load discharged into the Stola River. Zinc was neutralized with lime and acidity was controlled with sulphate acid.

In the course of this many-year industrial activity, several uncontrolled dumps were created (Table 14.)

Landfill no.1a was operated within the boundaries of the Chemical Plant site, in its northern part. Composition of wastes from that landfill was similar to landfill no.1. Now the landfill 1a is liquidated and a new controlled landfill is being constructed in this place. Two parts of the new landfill have already been completed and partially filled with wastes recovered from landfills no. 1a, 2 and debris from building demolition.

Additionally other landfill of sludge wastes was discovered on the left edge of the Stola River, just at the front of landfill no. 2.

According to IETU report developed in 1999 only landfills no. 1 and 1a, contain waste listed on the official list of hazardous wastes.

The pond basin was filled with wastes from the Chemical Plant. The course of the Stola River was shifted to the south. All the dumping sites and landfills as well as inefficient measures of environmental protection resulted in severe contamination of soil and groundwater with heavy metals and boron. In 1995 the Chemical Plant was closed.

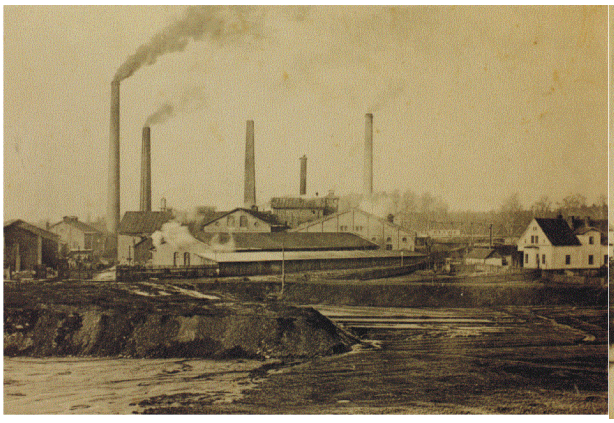


Fig. 21. View of the site from SE , 1892

Source: Chemical Plant Archive

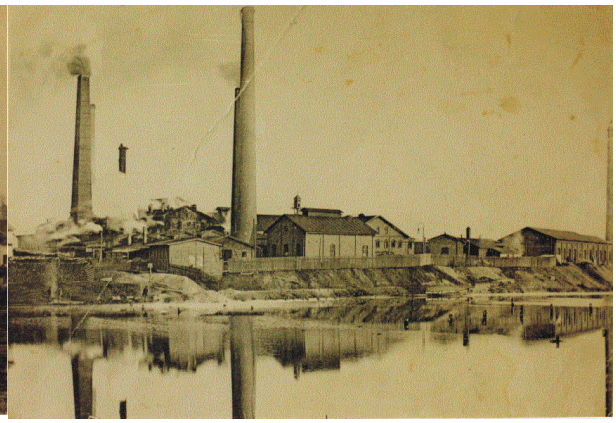


Fig. 22. View of the site from SW, 1905

Source: Chemical Plant Archive

In 1997 the liquidation process of the chemical plant was initiated. That year opened a new chapter in the history of the site. A plan of site reclamation was developed and is currently under realization (Fig. 23). Revitalization of the Stola river is also part of the reclamation project.



Fig. 23. Present view of the Chemical Plant under liquidation from E.

Photo: Wojciech Kierzkowski, Chemical Plant Archive

9.2 LANDUSE AND HYDROLOGY

The area of the site is about 184ha while the area of the existing uncontrolled old landfills has been estimated as 25,75 ha.

Table 14 List of recognized landfills at the "Tarnowskie Góry" Chemical Plant Site with average concentration of main contaminants

No	Area [ha]	Capacity [m^3 x 1000]	Type of waste	Operational period	Ba [%]	B [%]	Zn [%]
1	10,27	165	Waste from production of: mainly barium sulphide; also from barium chloride, barium nitrate as well as rubber, isolation materials, demolition waste	1922-1990	1,8	0,1	0,4
2	1,72	42	Sludge from mechanic and chemical wastewater treatment plant, top layer formed of slugs (coarse fraction of waste from hard coal burning).	1922-1975	0,012	0,055	2,001
3a (right edge of Stola)	4,17	206	Waste from production of boron compounds	1922-1975	0,85	0,09	0,58
3 (left edge of Stola)	2,61	93	Waste from production of boron compounds	1922-1975	0,096	0,24	1,1
4	2,11	64	Sludge from mechanic and chemical wastewater treatment plant	1974 -1994	0,01	0,004	3,24
5	1,65	46	Sludge from mechanic and chemical wastewater treatment plant and waste from boron compounds production	1979-1988	0,01	0,11	2,26

No	Area [ha]	Capacity [m^3 x 1000]	Type of waste	Operational period	Ba [%]	B [%]	Zn [%]
6	3,56	76	Waste from paper production	? - 1919	0,01	0,00	0,93
7	2,06	37	Dried sludge recovered from landfill no. 4	1987-1990	0,01	0,45	1,13

Remark: red colour - landfill already excavated

These landfills are the sources of contaminants that pose the major threat to groundwater.

Below, a description of landfills has been presented in form of documentation cards.

In the east, the site boundary is determined by a railway line and in the south – by the Stola River bed and a residential area. There is a wastewater treatment plant and a complex of residential buildings in the south-west. A small area of idle land categorised as arable land expands to the north from the residential buildings. An old post-fire area spreads to the north-west from the site. It is presently covered with humid meadows with dominating vegetation species such as chee reedgrass (*Calamagrostis epigeios* (L.)Roth). The northern side of the site, drained by a drainage system comprises meadows of a humid pine forest habitat transforming northwards into pine forest.

The site area is comprised by two sub-watersheds: the Stola River watershed and the PA trench sub-watershed which is part of the Pniowiec Stream. The share of the PA sub-watershed in the entire site surface is smaller than that of the Stola River. However, a large part of the Stola sub-watershed is covered by buildings and roads what makes the effective permeable surface of this sub-watershed significantly reduced; while practically the whole area of the PA sub-watershed area is permeable. The map below presents the directions of the surface runoff. (Fig. 24).

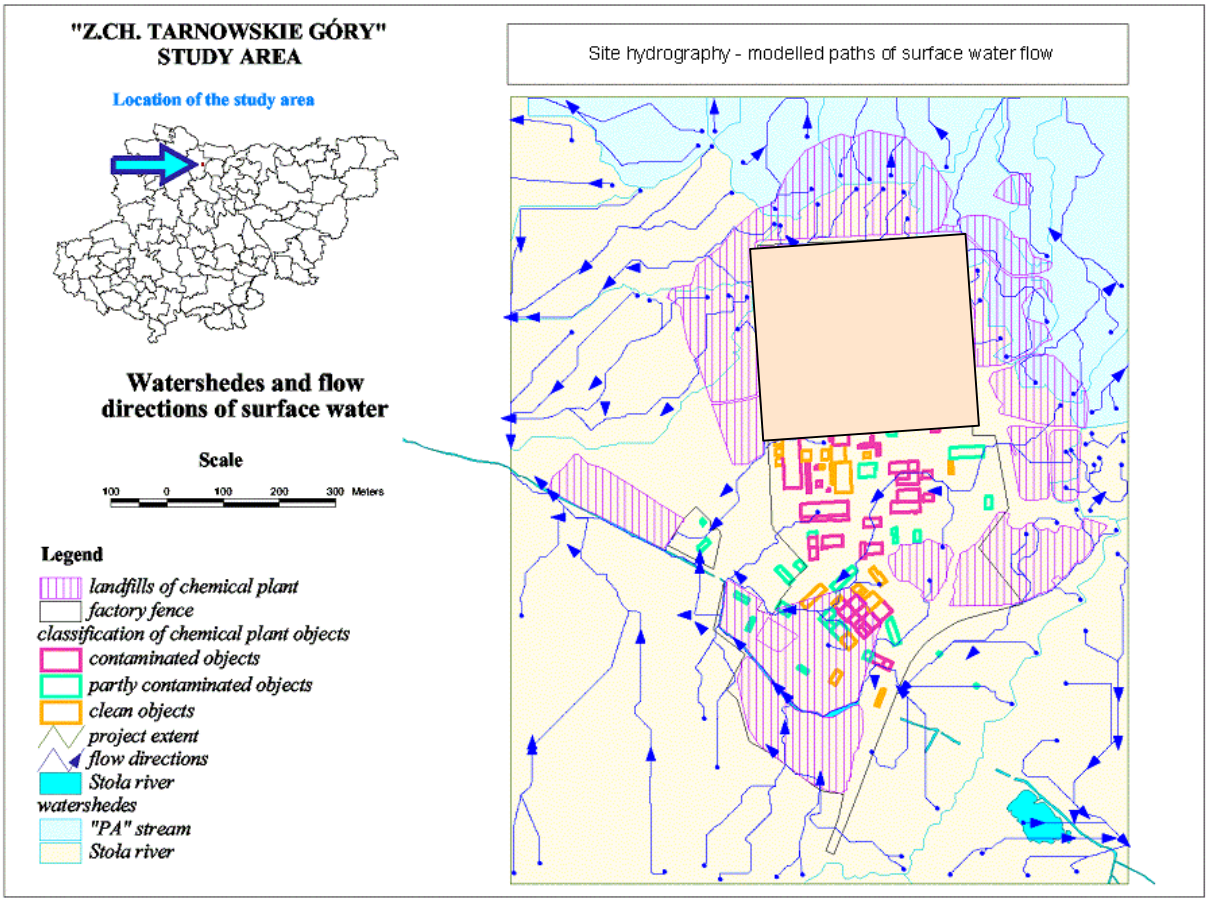
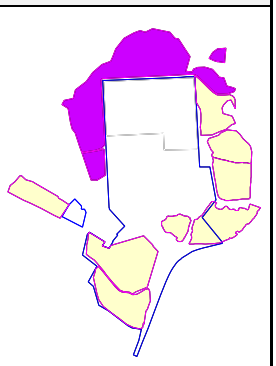


Fig. 24 The flow directions of surface water

NUMBER AND NAME	***LANDFILL No. 1***
Landfill of waste from production of barium compounds (mainly barium sulphide, secondarily barium chloride and barium nitrate)	

LOCATION

In the area of a former military base, in the north direction from the fence of the chemical plant . From the north, the landfill is surrounded by meadows and a forest area. Approximately 200m southwest – there is a residential area. Between the landfill and the residential area – idle land. Eastwards from the landfill –a repair shop of Polish State Railways (PKP). To the south of the landfill - the chemical plant.



CARTOGRAPHICAL COORDINATES (IN PUW1965)

X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
230530	***892246***	***231213***	***892840***

OPERATION PERIOD			
Start- up	***1922***	Closing down	***1990***

LOCATION IN RELATION TO THE NEIGHBOURHOOD OBJECTS

Residential area of Tarnowskie Góry town - 200m
Repair shop of the PKP 200m
The closest groundwater intake point (deep well) – well no 1, about 280m southwards from the landfill
Surface current waters (Stola river) 200m, stream P6 (tributary of Pniowiec)

LANDFILL DIMENSIONS AND VOLUME OF WASTES

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
10.2667	***165***	***166***	***2.28***	***234***

METHOD OF OPERATION

Up to 1990 wastes were transported to the landfill by trucks. After unloading they were levelled by a bulldozer. In the years 1992-93 some small amounts of waste were utilized by cement industry for clinker production. Utilization of a larger amount of wastes was difficult because of an unselective waste disposal. Some of the dumped wastes contained chloride barium, nitrate barium as well as rubber, insulating material and construction debris. All the dumped materials were mixed.

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Over the ground level, without determined extent of waste deposition, unselective, directly on the ground (without any insulation layer) in the area of meadows and idle land

METHODS OF LEACHATE CONTROL (PROTECTION FROM WATER INFLOW)

Uncontrolled, directly to the ground without treatment

MONITORING OF THE LANDFILL (WATER SOIL)

Piezometer network established in 1990, around all chemical plant landfills, boreholes nr 8/93-15/93, 17/93, 19/93, 21/93 drilled in 1993 as well as boreholes nr 55/96-73/96 drilled in 1996. There are two piezometers in the vicinity of the landfill: P1-P7.

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.78	$8.11 \cdot 10^{-5}$

MASS AND AVERAGE CONCENTRATION OF BARIUM BORON AND ZINC

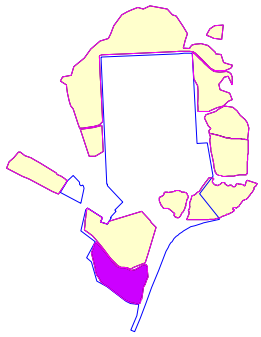
No.	Metal	Concentration [%]	Mass [Mg]
1	**Ba**	***1.847***	***5459***
2	**B**	***0.112***	***332***
3	**Zn**	***0.444***	***1313***

NUMBER AND NAME	*LANDFILL No. 3*

Landfill of wastes from production of boron compounds

LOCATION

On the left bank of the Stola River, in the southern part of the chemical plant (four ground tailing ponds). "Elektrocarbon" enterprise is located southwest from the landfill, while a residential area and a public road are located in the south from the tailing ponds. Idle land spreads in the east, beyond which there is another public road. North from the landfill, over the Stola river, there is another landfill of the chemical plant containing wastes from boron production (3a).



CARTOGRAPHICAL COORDINATES (IN PUW1965)

X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
230653	891661	230878	891907

OPERATION PERIOD

Start- up	***1922***	Closing down	***1975***

LOCATION IN RELATION TO THE NEIGHBORHOOD OBJECTS

- Residential area of Tarnowskie Góry town – 100m
- Public objects (road and House of culture) 50m
- The closest groundwater intake point (deep well) – 100m

LANDFILL DIMENSIONS, AND VOLUME OF WASTES

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
2.6080	***93***	***96***	***5.26***	***137***

METHOD OF OPERATION

Boron containing wastes were transported to the landfill using hydraulic transport by pipelines

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Over ground level (tailing ponds), selective, without insulation layer

METHODS OF LEACHATE CONTROL (PROTECTION FROM WATER INFLOW)

None

Monitoring of the landfill (water soil)

Piezometer network established in 1990, around all chemical plant landfills, boreholes no 36/93-45/93 drilled in 1993 as well as boreholes no 99/96-104/96 and 107/96 made in 1996. There are two piezometers in the vicinity of the landfill P18/1, P18/2

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.49	***$4.803 \cdot 10^{-8}$***

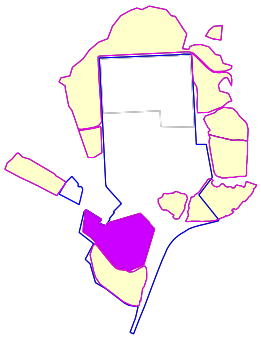
Mass and average concentration of barium boron and zinc

No.	Metal	Concentration [%]	Mass [Mg]
1	**Ba**	*0.096*	*137*
2	**B**	*0.240*	*80*
3	**Zn**	*1.100*	*1574*

NUMBER AND NAME	***LANDFILL NO 3A***
Landfill of wastes from production of boron compounds	

LOCATION

On the right bank of Stola river, landfill no 3 located on the opposite side of the river The southern boundary of the landfill is determined by the Stola riverbed. Beyond the river, in south-west direction – "Elektrocarbon" enterprise. 100-250m west from the landfill - Czarnohucka street, a residential area north-west from the landfill. The north-eastern boundary of the landfill is determined by the infrastructure of the chemical plant (including a boiler-house). There is a railway line to the east. Within the landfill no. 3a, a transient landfill containing waste from sulphate cooper production was located.



CARTOGRAPHICAL COORDINATES (IN PUW1965)

X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
230626	***891799***	***230909***	***892041***

OPERATION PERIOD

Start- up	***1922***	Closing down	***1975***

LOCATION IN RELATION TO THE NEIGHBOURHOOD OBJECTS

Residential area of Tarnowskie Góry town – about 50-100m

Public objects (road and House of culture) 15-20m westwards

The closest groundwater intake point (deep well nr III) – in distance of 20m north of the landfill, not operating dug well within the landfill limits

Recreational area (playing field) 60m westward

Landfill dimensions, and volume of wastes

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
4.1706	***206***	***214***	***7.10***	***296***

METHOD OF EXPLOITATION

N/A

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Over ground level, non-selective, without insulation layer. Waste were dumped directly on the ground of Stola valley (probably some part of the river bed was covered with waste, what resulted in change of the river run)

METHODS OF LEACHATE CONTROL (PROTECTION FROM WATER INFLOW)

None

MONITORING OF THE LANDFILL (WATER SOIL)

Piezometer network established in 1990, around all chemical plant landfills, boreholes nr 46/93, 47/93 drilled in 1993 as well as boreholes nr 105/96, 106/96 and 122/96-129/96 drilled in 1996. In the vicinity of the landfill there are two piezometers: P17/1, P17/2. In 1963 and 1976 several boreholes were drilled to establish geo-technical parameters for construction of the chemical plant objects.

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.74	Data not available

MASS AND AVERAGE CONCENTRATION OF BARIUM BORON AND ZINC

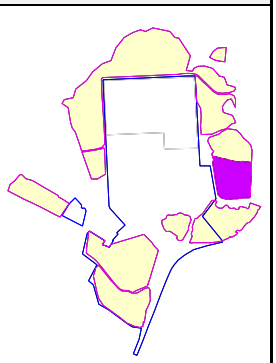
No.	Metal	Concentration [%]	Mass [Mg]
1	**Ba**	***0.849***	***3162***
2	**B**	***0.090***	***334***
3	**Zn**	***0.576***	***2146***

NUMBER AND NAME	***LANDFILL NO. 4***

The landfill consists of two sedimentation ponds and their embankments containing waste sludge from mechanic and chemical wastewater treatment plant of the Tarnowskie Góry Chemical Plant

LOCATION

In the east from the chemical plant fence, it adjoins sedimentation ponds covered with grass in the north. The sedimentation ponds contain sludge from the mechanic-chemical wastewater treatment plant as well as sludge from barium compounds production. About 200m to the east and south-east, there is a railway line. In the south, the landfill adjoins a barren area. In the distance of about 70m westwards, the landfill borders on the fence of the chemical plant.



CARTOGRAPHICAL COORDINATES (IN PUW1965)

X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
231122	***892165***	***231277***	***892336***

OPERATION PERIOD

Start- up	***1976***	Closing down	***1994***

LOCATION IN RELATION TO THE NEIGHBOURHOOD OBJECTS

Residential area of Tarnowskie Góry town – about 600m
Repair shop of the PKP 200m
The closest groundwater intake point – 400m;
Surface water (Stola river) – about 700m

LANDFILL DIMENSIONS, AND VOLUME OF WASTES

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
2.1111	***64***	***67***	***0.55, 4.20***	***50***

METHOD OF OPERATION

Sludge from the mechanic-chemical wastewater treatment plant was transported to the sedimentation ponds by pipelines. Ponds were drained however their bottom was not sealed. Until 1990 the ponds were operated alternatively, i.e. after a complete filling of one pond, sludge was dried up and eventually emptied. During the drying phase of the first pond, the other was used. After dry-up, wastes were excavated by means of a digger, and transported by trucks to the area of meadows and barren land, north from the ponds. Since 1990 as the production intensity slowed down, only one pond was used. In 1998 ponds were filled in 80%. Water above the sediment and the leachate were collected by a drainage system and recirculated to the mechanic-chemical wastewater treatment plant.

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Under -and over ground level, non-selective (sedimentation pond). The drainage is installed made in the bottom of the pond. At the lack of bottom sealing, the surface is not protected against leachate penetration to soil.. Landfill side walls are made of concrete..

METHODS OF LEACHATE CONTROL (PROTECTION FROM WATER INFLOW)

Leachate collection system connected to the system of the chemical plant's mechanic and chemical wastewater treatment plant

MONITORING OF THE LANDFILL (WATER SOIL)

Piezometer network established in 1990, around all chemical plant landfills, boreholes 32/93-35/93 drilled in 1993 as well as boreholes no 75/96-77/96 drilled in 1996. There is one piezometer in the vicinity of the landfill: P11.

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.37	$6.472 \cdot 10^{-8}$

MASS AND AVERAGE CONCENTRATION OF BARIUM BORON AND ZINC

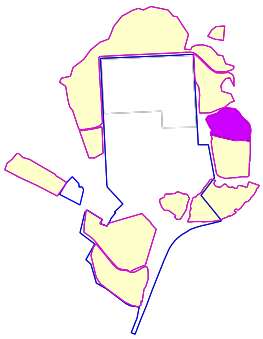
No.	Metal	Concentration [%]	Mass [Mg]
1	**Ba**	***0.011***	***10***
2	**B**	***0.004***	***3***
3	**Zn**	***3.238***	***2972***

NUMBER AND NAME	*LANDFILL NO 5*

Landfill of wastes from wastewater treatment plant and wastes from production of boron compounds (borax and boric acid)

LOCATION

In the east from the fence of the chemical plant. In the north, the landfill adjoins an area of meadows and barren land. Until 1990 the chemical plant used this area for dumping sludge from the wastewater treatment plant. Eastwards, in distance of about 250-300m, beyond the area of barren land, there is a railway line. There are two sedimentation ponds with concrete walls in the south from the landfill. The fence of the chemical plant runs in the distance of about 70m westwards from the landfill.



CARTOGRAPHICAL COORDINATES (IN PUW1965)

X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
231103	***892312***	***231279***	***892444***

OPERATION PERIOD

Start- up	***1979***	Closing down	***1988***

LOCATION IN RELATION TO THE NEIGHBOURHOOD OBJECTS

Residential area of Tarnowskie Góry town – about 600m
Repair shop of the PKP 200m
The closest groundwater intake point – 400m
Surface water (Stola river) – about 700m

LANDFILL DIMENSIONS, AND VOLUME OF WASTES

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
1.6470	***46***	***46***	***3.0***	***49***

METHOD OF OPERATION

Tailing ponds were filled using hydraulic transport. Leachate through a drainage system was carried out into the chemical plant's wastewater treatment plant

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Over ground level, non-selective, a drainage system in the bottom of the pond is constructed. The bottom is not equipped with sealing.

METHODS OF LEACHATE CONTROL (PROTECTION FROM WATER INFLOW)

Through drainage system to wastewater system and to chemical plant's mechanic-chemical wastewater treatment plant

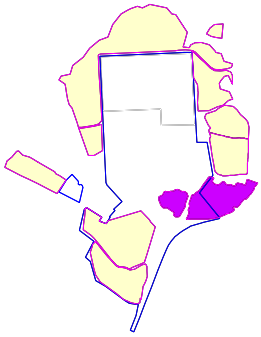
MONITORING OF THE LANDFILL (WATER SOIL)

Piezometer network established in 1990, around all chemical plant landfills, boreholes no. 27/93-30/93 drilled in 1993 as well as boreholes no. 78/96-83/96 drilled in 1996. There is one piezometer in the vicinity of the landfill: P8.

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.47	$3.589 \cdot 10^{-8}$

MASS AND AVERAGE CONCENTRATION OF BARIUM BORON AND ZINC

No.	Metal	Concentration [%]	Mass [Mg]
1	**Ba**	***0.011***	***8***
2	**B**	***0.112***	***76***
3	**Zn**	***2.265***	***1532***

NUMBER AND NAME			***LANDFILL NO. 6***
Landfill of waste from cellulose production. Residue of former cellulose production (before the World War I)			
LOCATION			
In eastern part the plant. In the west and north-west it borders on the chemical plant objects, in the north-east with two sedimentation ponds of the landfill nr 4, in the east and south with the railway line			
CARTOGRAPHICAL COORDINATES (IN PUW1965)			
X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
230923	***891994***	***231312***	***892162***
OPERATION PERIOD			
Start- up	***Probably since the last decade of XIX century***	Closing down	***Probably before the World War I***

LOCATION IN RELATION TO THE NEIGHBOURHOOD OBJECTS

Residential area of Tarnowskie Góry town – about 300-400m westwards
The closest groundwater intake point (well nr III)– 95m westwards
Surface water (Stola River) – 220m westwards and south-westwards

LANDFILL DIMENSIONS, AND VOLUME OF WASTES

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
3.5638	***76***	***80***	***4.95***	***176***

METHOD OF OPERATION

Landfill not operated, remediated

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Over ground level, waste dumped directly on the ground without bottom sealing

Methods of leachate control (protection from water inflow)

Uncontrolled, directly to the ground without treatment

MONITORING OF THE LANDFILL (WATER SOIL)

Boreholes no 48/93-51/93 drilled in 1993 as well as boreholes no 108/96, 109/96, 117/96-120/96 drilled in 1996. There is one piezometer in the vicinity of the landfill: p8.

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.43	*DATA NOT AVAILABLE*

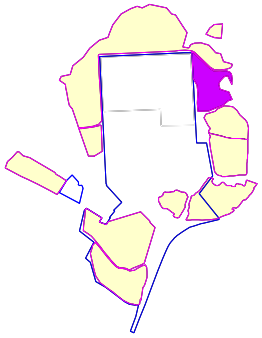
MASS AND AVERAGE CONCENTRATION OF BARIUM BORON AND ZINC

No.	Metal	Concentration [%]	Mass [Mg]
1	***Ba***	***0.012***	***14***
2	***B***	***0.000***	***0***
3	***Zn***	***0.926***	***1060***

NUMBER AND NAME	*LANDFILL NO. 7*
Landfill of sewage sludge removed from the sedimentation ponds (the ponds of landfill no 4)	

LOCATIONS

North-east of the chemical plant fence. In the north and north-west, it borders on landfill no 1. In the east the landfill adjoins barren land, beyond which there is a railway line. Landfill no 5 is situated to the south from the landfill. In the west the landfill borders on the chemical plant fence.



CARTOGRAPHICAL COORDINATES (IN PUW1965)

X_{MIN}	Y_{MIN}	X_{MAX}	Y_{MAX}
230959	***892375***	***231253***	***892656***

OPERATION PERIOD

Starting up	***1987***	Closing down	***1990***

LOCATION IN RELATION TO THE NEIGHBOURHOOD OBJECTS

Residential area of Tarnowskie Góry town – about 600m
Repair shop of the PKP - 300m
The closest groundwater intake point – 300m
Surface water – 600m

LANDFILL DIMENSIONS, AND VOLUME OF WASTES

IETU calculations			**Preliminary calculations**	
Surface area	Volume: triangulation method and linear interpolation	Volume: triangulation method and 5th degree polynomial interpolation	Average thickness	Volume as product of a landfill area and average thickness
[ha]	10^3. m^3	10^3. m^3	[m]	10^3. m^3
2.0684	***37***	***41***	***2.49***	***52***

METHOD OF OPERATION

Dried-up sludge from sedimentation ponds were excavated by means of digger, and transported to the area of meadows and barren land and dumped creating thus a new landfill

TYPE OF LANDFILL AND METHOD OF WASTE DUMPING

Over ground level, non-selective, without bottom sealing

Methods of leachate control (protection from water inflow)

Uncontrolled, directly into the ground

MONITORING OF THE LANDFILL (WATER SOIL)

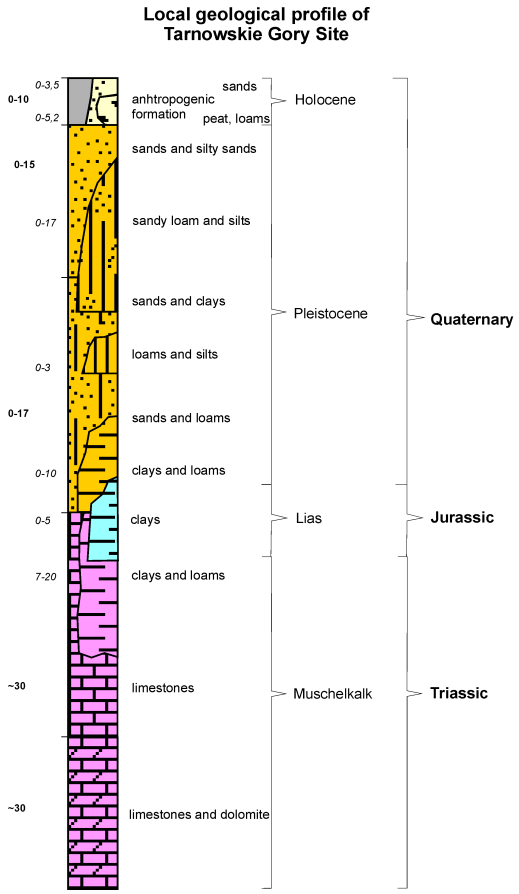
Boreholes no 20/93, 22/93-26/93 drilled in 1993 as well as a borehole no 74/96 drilled in 1996. There is one piezometer in the vicinity of the landfill: P9

Average bulk density [Mg/m^3]	**IGO calculations of hydraulic conductivity coefficient [m/s]**
1.74	$3.73 \cdot 10^{-6}$

MASS AND AVERAGE CONCENTRATION OF BARIUM BORON AND ZINC

No.	Metal	Concentration [%]	Mass [Mg]
1	**Ba**	***0.011***	***8***
2	**B**	***0.449***	***320***
3	**Zn**	***1.130***	***806***

9.3 GEOLOGY AND HYDROGEOLOGY OF THE SITE



The top layer of the Triassic formation at the Chemical Plant Site was recognized by several boreholes and piezometers. These are mainly black clays and grease loams with inclusions of limestone gravels. Triassic formations form a zonal (parallel to lines of latitude) underground morphological structure which southern edge can be observed on Fig. 25. (tens to 100m form the Stola river). The surface is uneven with many hollows and erosion gutters. The thickness of these weathered rocks varies from 2 to several meters.

Triassic formations are topped with postglacial Quaternary formations of middle - Polish glacial. These are mainly fluvioglacial sands and silts with locally present fragments of tillites (boulder clays). The bottom layer is mainly made of loams and silts. Impermeable layers of loams and loamy silts of discontinued character occur in different profiles as two or three layers.

In the riverbed, Holocene formations are recognized mainly as muds, consolidated peats, fine sands, silty sands and silts.

The thickness of the natural Quaternary rocks varies from 0 to several meters; in the central part of the Chemical Plant Site it is about 5m. In two old boreholes (1/76 and 8/76), located in the eastern part of landfill No 3, natural quaternary rocks were not observed. New boreholes made in 1999 did not prove this gap.

The highest geological layer is formed by anthropogenic uncontrolled soils – industrial waste of different age. Waste material is being removed from the entire area of the site and disposed in a new, controlled landfill site.

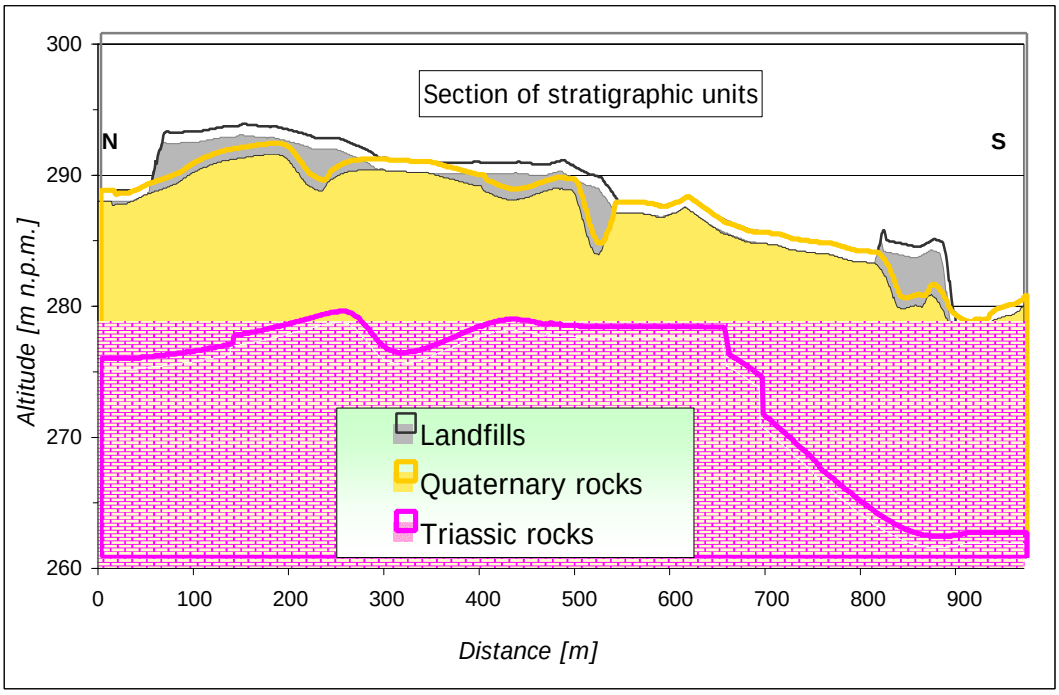


Fig. 25. Geological cross-section of the "Tarnowskie Góry" Chemical Plant

9.4 WATER CONTAMINATION WITH BORON

The principal source of boron contamination are industrial landfills: no.3 and no.3a located on both sites of the Stola River in the southern part of the site, and landfills no. 4, no.4a and no. 5 – adjacent to the fence of the site, in the eastern part of the site. Due to the location of the sources, the highest concentration of boron was originally observed in the direct vicinity of the site. In 1999, the highest boron concentrations were noted in waters sampled from the

ELECTROCARON well. In subsequent two years, further spread of the contamination plume was observed westward, at simultaneous shift of the highest concentration zone towards well III of the Chemical Plant. While the area of elevated boron concentrations increased: from 335 ha in 1999 to 640 in 2001, a simultaneous decrease of the highest values was recorded (Fig. 26).

Year 2000

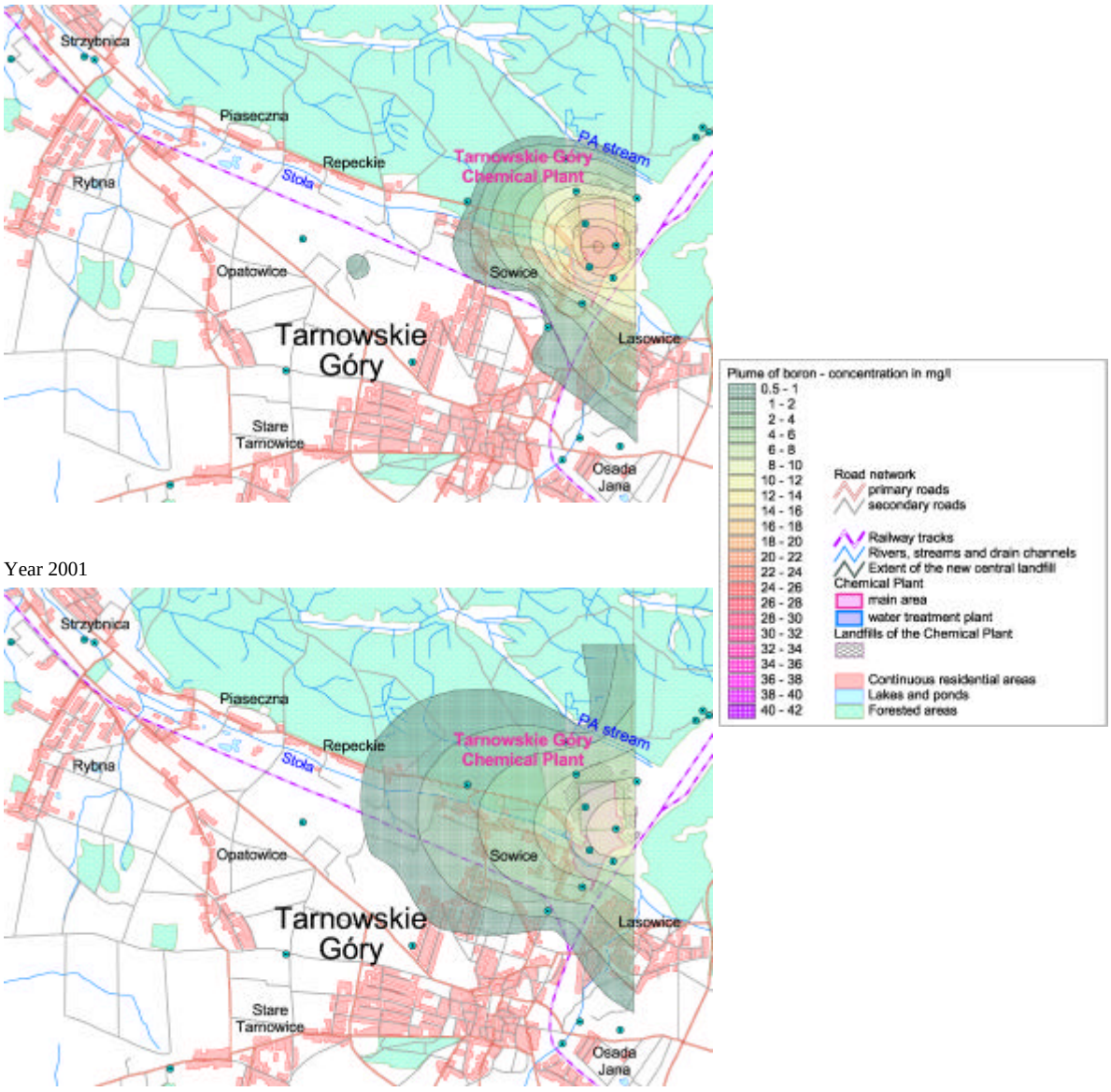


Fig. 26. Contamination of Triassic aquifer with boron

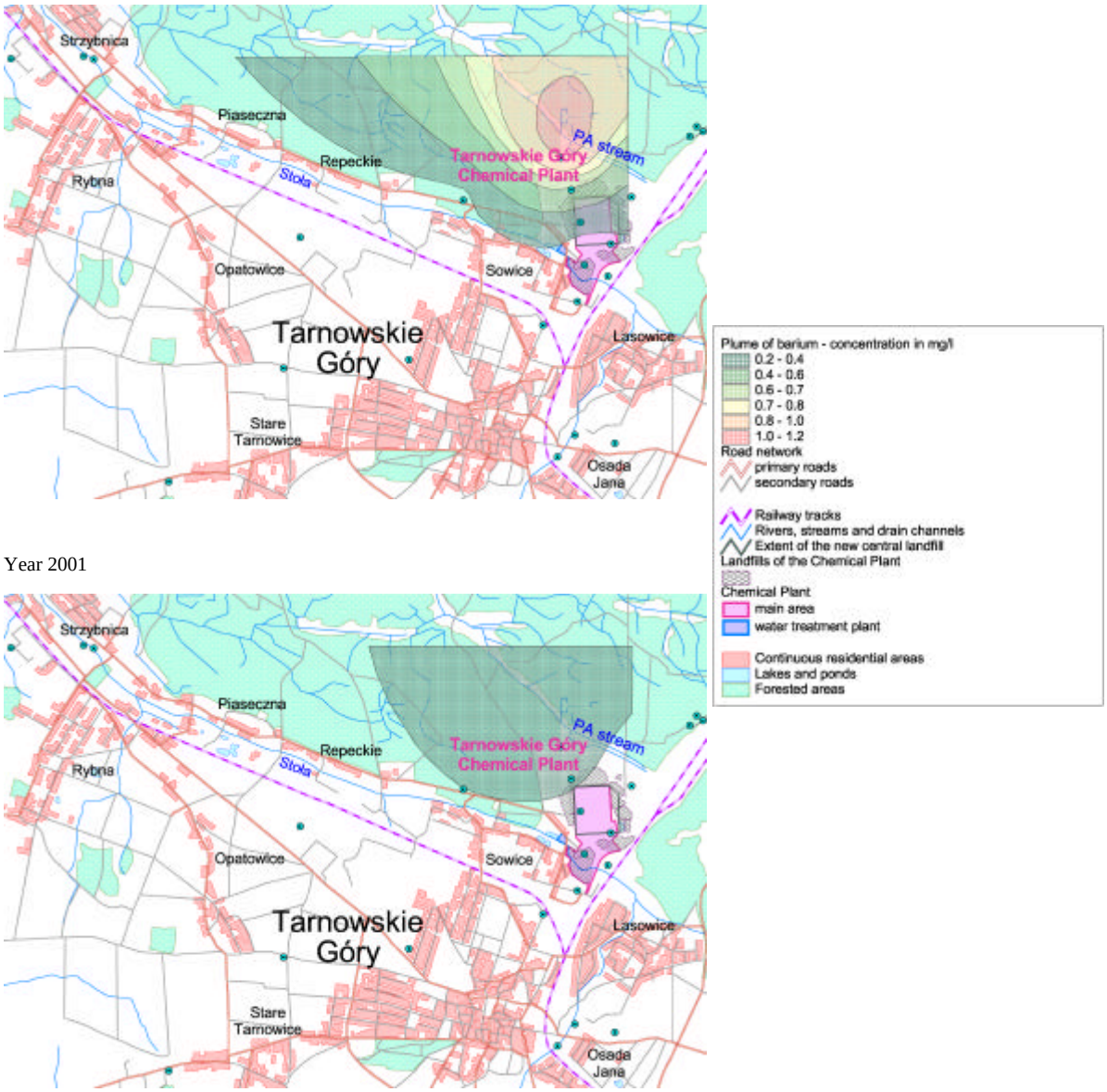
9.5 WATER CONTAMINATION WITH BARIUM

The primary source of barium contamination is landfill no. 1, surrounding the northern corner of the site's fence. Additionally, elevated concentrations of barium were observed in soils in the vicinity of the buildings and installations located in the western part of the site, in the vicinity of the present landfill. The highest barium concentrations were noted in well VII of the Chemical Plant, which is situated to the north from the landfill zone. The highest range and concentrations of barium contamination were noted in 2000, while in 1999 and in 2001 the range of contamination plume was smaller, so were its concentrations in the water-bearing horizon. The difference between the direction of barium and boron plume spread is distinctive. It results from different location of the primary contamination sources as well as different directions of groundwater outflow. The area of elevated barium concentrations increased: from 270 ha in 1999 to 490 in 2000, and eventually dropped to 320 ha in 2001 (Fig. 27).

9.6 WATER CONTAMINATION WITH STRONTIUM

Analysis of cartographic data related to strontium content in groundwater allowed identifying two areas of elevated strontium concentrations: area 1 – the vicinity of well III in the Chemical Plant and area 2 – vicinity of the well located at "Koehler" Water Supply and Sewerage Enterprise. Area 1 reflects a direct impact of the Chemical Plant on groundwater, while area 2 may show a local anomaly related to an unrecognised source of contamination. Total area of elevated concentrations identified during three measurement campaigns was approximately 1400 ha (Fig. 28).

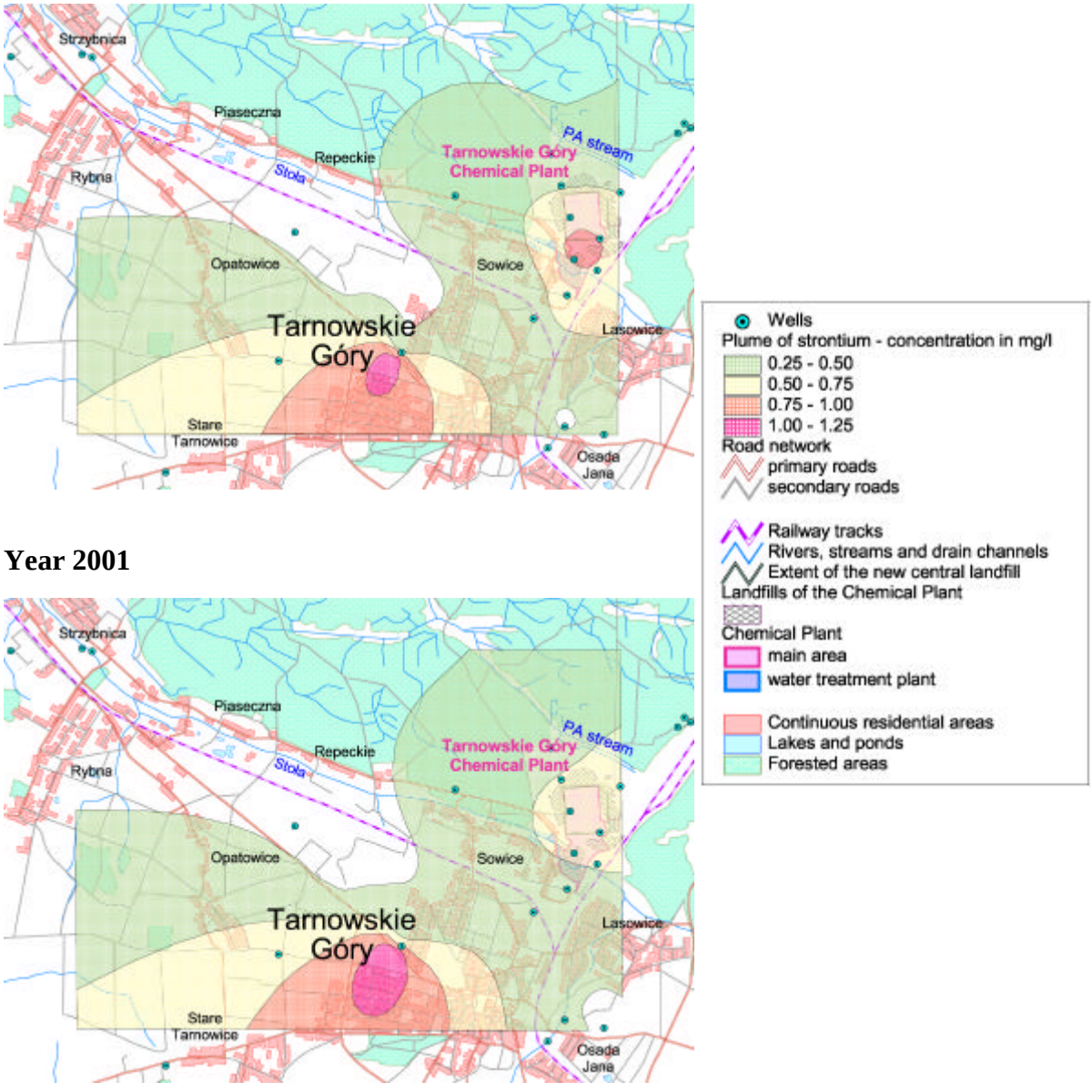
Year 2000



Year 2001

Fig. 27. Contamination of Triassic aquifer with barium

Year 1999



Year 2001

Fig. 28. Contamination of Triassic aquifer with strontium

A detailed description of the groundwater contamination at the „Tarnowskie Góry" Chemical Plant Site and in its vicinity is presented in Part III of the D 4.1. Deliverable.

ANNEX 1

10 LIST OF COVERAGES ELABORATED AND INTEGRATED WITHIN WELCOME GIS

I Extent of the coverage: **M**egasite **S**ite	**II** Type of GIS coverages and databases: **P**reliminary **I**nterim **F**inal	**III** Group of the coverage: **E**arth surface, Surface **w**aters **G**roundwaters, **A**uxiliary

I	II	III	Name of information layer (coverage)	Card
M	**P**	**E**	Geographical regions	Card no. 1
M	**P**	**E**	Geomorphologic regions	Card no. 2
M	**P**	**A**	Map decoder	Card no. 3
M	**P**	**EWG**	Borders of municipalities	Card no. 4
M	**P**	**EWG**	River basin	Card no. 5
M	**P**	**G**	Boundaries of the Carboniferous aquifer	Card no. 6
M	**P**	**G**	Boundaries of the Triassic aquifer	Card no. 7
M	**P**	**G**	Boundaries of the Quaternary aquifer	Card no. 8
M	**P**	**G**	Aquifers protection status	Card no. 9
M	**P**	**EWG**	Extent of the Megasite	Card no. 10
M	**P**	**A**	2 km grid in the Megasite extent	Card no. 11
M	**P**	**G**	Map of Fridrich Grube 1871	Card no. 12
M	**P**	**G**	Former excavation shafts (including medieval ones)	Card no. 13
M	**P**	**G**	Former adits and drifts (including medieval ones)	Card no. 14
M	**I**	**E**	Digital elevation model (altitude)	Card no. 15
M	**I**	**E**	Slope of the surface	Card no. 16
M	**I**	**E**	Aspect of the surface	Card no. 17
M	**I**	**W**	Flow direction	Card no. 18
M	**I**	**W**	Flow accumulation	Card no. 19
M	**I**	**E**	Surface area – real areas of grid cells	Card no. 20
M	**I**	**W**	River basin small	Card no. 21
M	**I**	**W**	River basin large	Card no. 22
M	**I**	**E**	Land use of the Megasite - NATLAN	Card no. 23
M	**I**	**E**	Land use of the Megasite	Card no. 24
M	**I**	**E**	Urban plan of Tarnowskie Góry Municipality	Card no. 25
M	**I**	**E**	Soil	Card no. 26

M	**I**	**G**	Geology	Card no. 27
M	**I**	**G**	Faults within Triassic formation	Card no. 28
M	**I**	**E**	Residential area of the Megasite	Card no. 29
M	**I**	**E**	Industrial plants	Card no. 30
M	**I**	**E**	Large excavations (greater than 1ha)	Card no. 31
M	**I**	**E**	Small excavations (less than 1ha)	Card no. 32
M	**I**	**E**	Large industrial landfills	Card no. 33
M	**I**	**E**	Small industrial landfills	Card no. 34
M	**I**	**E**	Small municipal landfills	Card no. 35
M	**I**	**E**	Petrol stations	Card no. 36
M	**I**	**E**	Resource storages	Card no. 37
M	**I**	**E**	Waste water treatment plants	Card no. 38
M	**I**	**E**	Sewage discharge points	Card no. 39
M	**I**	**E**	Cemeteries	Card no. 40
M	**I**	**G**	Wells and boreholes of the HYDRO database	Card no. 41
M	**I**	**G**	Ground water conductivity	Card no. 42
M	**I**	**G**	Ground water barium concentration	Card no. 43
M	**I**	**G**	Ground water zinc concentration	Card no. 44
M	**I**	**W**	River network within the Megasite extent	Card no. 45
M	**I**	**W**	Water bodies within the Megasite extent	Card no. 46
M	**I**	**E**	Road network	Card no. 47
M	**I**	**E**	Railway network	Card no. 48
M	**I**	**E**	Settlements	Card no. 49
M	**I**	**E**	Tarnowskie Góry Chemical Plant	Card no. 50
S	**P**	**A**	Extent of the site	Card no. 51
S	**P**	**A**	Topographic map of TGCP	Card no. 52
S	**P**	**EWG**	Tarnowskie Góry Chemical Plant boundaries	Card no. 53
S	**P**	**EWG**	Landfills of the TGCP	Card no. 54
S	**P**	**EWG**	Boundary of the central landfill and investment area of the TGCP	Card no. 55
S	**I**	**E**	Topsoil characteristics in the vicinity of TGCP	Card no. 56
S	**I**	**E**	Results from soil sampling in April 19th 2002	Card no. 57

S	**I**	**E**	Results from soil sampling in May 17th 2002	Card no. 58
S	**I**	**E**	Results from soil sampling in May 28th 2002	Card no. 59
S	**I**	**E**	Results from soil sampling in summer 2002	Card no. 60
S	**I**	**E**	Results from plant sampling in June and July 2002	Card no. 61
S	**I**	**W**	Results from surface water sampling in 2002	Card no. 62
S	**I**	**G**	Results from GW sampling in the first quarter of 2002	Card no. 63
S	**I**	**E**	Digital Elevation Model of the site	Card no. 64
M	**F**	**E**	Sand contents in surface layer (0-50cm)	Card no. 65
M	**F**	**E**	Clay contents in surface layer (0-50cm)	Card no. 66
M	**F**	**E**	Hydraulic conductivity at saturation of surface layer (0-50cm), units - 10^{-6}m/s	Card no. 67
M	**F**	**E**	Saturation of surface layer (0-50cm)	Card no. 68
M	**F**	**E**	Bulk density of surface layer (0-50cm)	Card no. 69
M	**F**	**E**	Field Capacity of surface layer (0-50cm)	Card no. 70
M	**F**	**E**	Permanent wilting point of surface layer (0-50cm)	Card no. 71
M	**F**	**E**	Plant available water of surface layer (0-50cm)	Card no. 72
M	**F**	**E**	Sand contents in subsurface layer (50-100cm)	Card no. 73
M	**F**	**E**	Clay contents in subsurface layer (50-100cm)	Card no. 74
M	**F**	**E**	Hydraulic Conductivity at saturation of subsurface layer (50-100cm), units - 10^{-6}m/s	Card no. 75
M	**F**	**E**	Saturation of subsurface layer (50-100cm)	Card no. 76
M	**F**	**E**	Bulk density of subsurface layer (50-100cm)	Card no. 77
M	**F**	**E**	Field Capacity of subsurface layer (50-100cm)	Card no. 78
M	**F**	**E**	Permanent wilting point of subsurface layer (50-100cm)	Card no. 79
M	**F**	**E**	Plant available water of subsurface layer (50-100cm)	Card no. 80
M	**F**	**E**	Cadmium concentration in topsoil	Card no. 81
M	**F**	**E**	Lead concentration in topsoil	Card no. 82
M	**F**	**E**	Zinc concentration in topsoil	Card no. 83
S	**F**	**G**	Interpolated barium concentration in Quaternary water bearing horizon	Card no. 84
S	**F**	**G**	Interpolated barium concentration in Triassic water bearing horizon	Card no. 85
S	**F**	**G**	Interpolated boron concentration in Quaternary water bearing horizon	Card no. 86
S	**F**	**G**	Interpolated boron concentration in Triassic water bearing horizon	Card no. 87
S	**F**	**G**	Interpolated strontium concentration in Quaternary water bearing horizon	Card no. 88

S	**F**	**G**	Interpolated strontium concentration in Triassic water bearing horizon	Card no. 89
S	**F**	**G**	Interpolated concentration of dissolved substances in Quaternary water bearing horizon	Card no. 90
S	**F**	**G**	Interpolated concentration of dissolved substances in Triassic water bearing horizon	Card no. 91
S	**F**	**G**	Interpolated concentration of chlorides in Quaternary water bearing horizon	Card no. 92
S	**F**	**G**	Interpolated concentration of chlorides in Triassic water bearing horizon	Card no. 93
S	**F**	**G**	Interpolated concentration of sulphates in Quaternary water bearing horizon	Card no. 94
S	**F**	**G**	Interpolated concentration of sulphates in Triassic water bearing horizon	Card no. 95
M	**F**	**EWG**	Number of residents in 1 ha square	Card no. 96

Card no. 1	Coverage mnemonic name	Coverage descriptive name
	Region-geography	Geographical regions

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME		
Transformation from Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Updating of new classification and division clipping to the Megasite extent		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Name of sub-Voivodeship, name of mezo-region

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite		1.1

Card no. 2	Coverage mnemonic name	Coverage descriptive name
	Region-geomorphology	Geomorphologic regions

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Updating of new classification and division clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter, mean altitude, mean slope, relief index	Region name, name of sub-region, mezo-region, and macro-region

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite		1.1

Card no. 3	Coverage mnemonic name	Coverage descriptive name
	Dek-50-92	Map decoder

Source		
Name	**Format of data**	**Scale / resolution**
ARC/INFO, ARCVIEW	ARC/INFO coverage	N/A

Technique of data integration within GIS WELCOME
Application of ARCINFO and ARCVIEW procedures, populating records with attributes, transformation from ellipsoidal coordinates into PUW1992 (WGS84 datum).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 428100 X max 571150 Y min 162860 Y max 366760	0m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Name of map sheet, map emblem, map type

Coverage application	Links with other coverages	No of the map composition
Index map for coverage management.		Not presented on map composition

Card no. 4	Coverage mnemonic name	Coverage descriptive name
	Municipalities	Borders of municipalities

Source		
Name	**Format of data**	**Scale / resolution**
Topographic map – Marshal Office of Silesian Voivodeship	Raster map sheet	1: 50 000
Internal IETU Spatial Information System	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Updating of boundaries on the basis of topographical maps in 1:50 000 due to creation of new municipal units. Selecting district (poviat) within the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon, arc	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter, statistical number, population in year 2000 (according to Polish Statistical Office)	Name of municipality, name of district

Coverage application	Links with other coverages	No of the map composition
Improvement of map legibility, determination of the Megasite extent		From 1.1 up to 1.11 (no for 1.2)

Card no. 5	Coverage mnemonic name	Coverage descriptive name
	River-basin	River basins

Source		
Name	**Format of data**	**Scale / resolution**
Hydrological Map of The Silesian Voievodeship	Hardcopy paper maps	1: 50 000

Technique of data integration within GIS WELCOME
Scanning and geo-referencing of raster map, vectorisation, assigning the watersheds codes.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Code name of river basin (watershed)

Coverage application	Links with other coverages	No of the map composition
Delimitation of the Megasite extent	extent of the Megasite	Not presented on map composition

Card no. 6	Coverage mnemonic name	Coverage descriptive name
	GZWP-carbon	Boundaries of the Carboniferous aquifer

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 100 000

Technique of data integration within GIS WELCOME		
Transformation from Polish Cartographic System – PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Name of Main GW basins

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, delimitation of the Megasite extent	Map of aquifer protection status	1.8

Card no. 7	Coverage mnemonic name	Coverage descriptive name
	GZWP-triass	Boundaries of the Triassic aquifer

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 100 000

Technique of data integration within GIS WELCOME		
Transformation from the Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Name of Main GW basins

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, delimitation of the Megasite extent	Map of aquifer protection status	1.8

Card no. 8	Coverage mnemonic name	Coverage descriptive name
	GZWP-Quaternary	Boundaries of the Quaternary aquifer

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 100 000

Technique of data integration within GIS WELCOME		
Transformation from the Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Name of Main GW basins

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, delimitation of the Megasite extent	Map of aquifer protection status	1.8

Card no. 9	Coverage mnemonic name	Coverage descriptive name
	GW-protection	Aquifers protection status

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 200 000

Technique of data integration within GIS WELCOME		
Transformation from the Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	200m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Description of the aquifer protection status

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, delimitation of Megasite extent	Maps of Carboniferous, Triassic and Quaternary aquifers	1.8

Card no. 10	Coverage mnemonic name	Coverage descriptive name
	Extent	Extent of the Megasite

Source		
Name	**Format of data**	**Scale / resolution**
Grid2km	polygon	N/A

Technique of data integration within GIS WELCOME		
Application of standard ARCVIEW procedure based on the accepted extent of the Megasite		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	0m

Primary coverage attributes	
Digital	**Descriptive**

Coverage application	Links with other coverages	No of the map composition
Used in map composition and for clipping coverages to the Megasite		From 1.1 up to 1.11 (no for 1.2)

Card no. 11	Coverage mnemonic name	Coverage descriptive name
	Grid-2km	2 km grid in the Megasite extent

Source		
Name	**Format of data**	**Scale / resolution**
ARCVIEW spatial analyst command	Grid	N/A

Technique of data integration within GIS WELCOME		
Application of standard ARCVIEW procedures		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	0m

Primary coverage attributes	
Digital	**Descriptive**
Id	

Coverage application	Links with other coverages	No of the map composition
Used in map composition for improvement of map legibility		From 1.1 up to 1.11 (no for 1.2)

Card no. 12	Coverage mnemonic name	Coverage descriptive name
	Fridrich-grube-1871.tif	Map of Fridrich Grube 1871

Source		
Name	**Format of data**	**Scale / resolution**
Archive of Tarnowskie Góry Municipality	Paper map sheet (copy of original map)	Not defined

Technique of data integration within GIS WELCOME		
Scanning and geo referencing		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Raster image	X min 474543 X max 498451 Y min 272894 Y max 296009	5m

Primary coverage attributes	
Digital	**Descriptive**

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite history		1.2

Card no. 13	Coverage mnemonic name	Coverage descriptive name
	Shafts	Former excavation shafts (including medieval ones)

Source		
Name	**Format of data**	**Scale / resolution**
Tarnowskie Góry Municipal Spatial Information System	Digital - coverage	Not defined

Technique of data integration within GIS WELCOME		
Transformation from PUW1965 into PUW1992 and conversion into shape ARCVIEW format.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Point	X min 474543 X max 498451 Y min 272894 Y max 296009	5m

Primary coverage attributes	
Digital	**Descriptive**
	Shaft name

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite history. Determination of possible zones of contamination migration		1.2

Card no. 14	Coverage mnemonic name	Coverage descriptive name
	Adits	Former adits and drifts (including medieval ones)

Source		
Name	**Format of data**	**Scale / resolution**
Tarnowskie Góry Municipal Spatial Information System	Digital - coverage	Not defined

Technique of data integration within GIS WELCOME
Transformation from PUW1965 into PUW1992 and conversion into shape ARCVIEW format.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Arc	X min 474543 X max 498451 Y min 272894 Y max 296009	5m

Primary coverage attributes	
Digital	**Descriptive**
Section length	Adit name

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite history. Determination of possible contamination migration pathways		1.2

Card no. 15	Coverage mnemonic name	Coverage descriptive name
	DEM	Digital elevation model (altitude)

Source

Name	Format of data	Scale / resolution
Topographic map – Marshal Office of Silesian Voivodeship	Raster map sheet	1: 50 000
Internal IETU Spatial Information System (water bodies)	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME

Use of 9 sheets of topographic maps in 1:5000 scale in PUW1992. Vectorisation of contour lines, altitude points, assigning altitude attributes. Generating preliminary DEM using contour lines, points, water bodies (water table altitude). Correction of profiles of main rivers. Generating the final DEM. Clipping to the Megasite extent.

Generating DEM derivatives: ***slope***, ***aspect***, ***flow direction***, ***flow accumulation*** *and* ***surface area***

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes

Digital	Descriptive
value	

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite. Hydrological modelling	River basins large, river basins small, river network, slop, aspect, flow direction, flow accumulation, surface area, geomorphology	1.3 and 1.4 (in 3d shaded view)

Card no. 16	Coverage mnemonic name	Coverage descriptive name
	SLOPE	Slope of the surface

Source		
Name	**Format of data**	**Scale / resolution**
DEM	Grid	1: 50 000

Technique of data integration within GIS WELCOME		
Application of the ARCVIEW standard spatial procedure		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
value	

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite. Hydrological modelling	DEM, geomorphology	1.3

Card no. 17	Coverage mnemonic name	Coverage descriptive name
	ASPECT	Aspect of the surface

Source		
Name	**Format of data**	**Scale / resolution**
DEM	Grid	1: 50 000

Technique of data integration within GIS WELCOME		
Application of the ARCVIEW standard spatial procedure		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite. Possible modelling of local micro-climate	DEM	1.3

Card no. 18	Coverage mnemonic name	Coverage descriptive name
	Flow-direction	Flow direction

Source		
Name	**Format of data**	**Scale / resolution**
DEM	Grid	1: 50 000

Technique of data integration within GIS WELCOME		
Application of the ARCVIEW extension for hydrological modelling		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
value	

Coverage application	Links with other coverages	No of the map composition
Modelling of watersheds	DEM, flow accumulation, river basins	1.4

Card no. 19	Coverage mnemonic name	Coverage descriptive name
	Flow-accumulation	Flow accumulation

Source		
Name	**Format of data**	**Scale / resolution**
DEM	Grid	1: 50 000

Technique of data integration within GIS WELCOME		
Application of the ARCVIEW extension for hydrological modelling.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
value	

Coverage application	Links with other coverages	No of the map composition
Modelling of watersheds	DEM, flow direction river basins	1.4

Card no. 20	Coverage mnemonic name	Coverage descriptive name
	Surface-area	Surface area – actual area of grid cells

Source		
Name	**Format of data**	**Scale / resolution**
DEM	grid	1: 50 000

Technique of data integration within GIS WELCOME		
Application of the ARCVIEW extension from ESRI home page		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
value	

Coverage application	Links with other coverages	No of the map composition
Hydrological modelling	DEM, river basins	Not presented

Card no. 21	Coverage mnemonic name	Coverage descriptive name
	River-basin-small	River basin small

Source		
Name	**Format of data**	**Scale / resolution**
River network (Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database)	Digital - coverage	1: 50 000
DEM (Internal IETU Spatial Information System)	grid	10m

Technique of data integration within GIS WELCOME
Correction of the river network topology: node connection, direction flipping. Development of ARCVIEW Avenue scripts for topology correction and watersheds delineation. Assigning the watersheds codes and names. Clipping to the Megasite extent. Generating watersheds larger than 50 000 cells (1 cell 10x10m)

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Code and name of watershed

Coverage application	Links with other coverages	No of the map composition
Hydrological modelling	DEM, flow direction, flow accumulation, extent of the Megasite	1.5

Card no. 22	Coverage mnemonic name	Coverage descriptive name
	River-basin-large	River basin large

Source		
Name	**Format of data**	**Scale / resolution**
River network (Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database)	Digital - coverage	1: 50 000
DEM (Internal IETU Spatial Information System)	grid	10m

Technique of data integration within GIS WELCOME
Correction of river network topology: node connection, direction flipping. Development of ARCVIEW Avenue scripts for topology correction and watersheds delineation. Assigning of watershed codes and names. Clipping to the Megasite extent. Generating watersheds larger than 1 000000 cell (1 cell 10x10m)

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Code and name of watershed

Coverage application	Links with other coverages	No of the map composition
Hydrological modelling	DEM, flow direction, flow accumulation, extent of the Megasite	1.5

Card no. 23	Coverage mnemonic name	Coverage descriptive name
	Landuse NATLAN	Land use of the Megasite - NATLAN

Source		
Name	**Format of data**	**Scale / resolution**
NATLAN map of Landuse	grid	100m

Technique of data integration within GIS WELCOME
Transformation from Lambert Equal-Area Azimuthal projection into WGS84 datum and the Polish Cartographic System - PUW1992; conversion into shape ARCVIEW format. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Type of land use

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite and conceptualisation of the Megasite model		1.6a

Card no. 24	Coverage mnemonic name	Coverage descriptive name
	Landuse	Land use of the Megasite

Source

Name	Format of data	Scale / resolution
Soil map of Katowice Voivodeship	Paper map sheet	1: 100 000
Tarnowskie Góry Municipal Spatial Information System	Digital - coverage	1: 10 000
Internal IETU Spatial Information System (Soils of Piekary Slaskie and Zabrze municipalities)	Digital - coverage	1:5000

Technique of data integration within GIS WELCOME

Digital coverages: transformation from PUW1965 into PUW1992 and conversion into shape ARCVIEW format. Paper map sheets: Scanning and screen vectorisation, attribute assigning.

Integration of different map sources in terms of land use spatial discrepancies. Clipping to the Megasite extent.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	1-10m depending on source

Primary coverage attributes

Digital	Descriptive
Area, perimeter	Type of land use complex including forests type

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite and conceptualisation of the Megasite model	Soil, hydraulic conductivity of the first (0-50cm) and second (50-100cm) soil layer	1.6a

Card no. 25	Coverage mnemonic name	Coverage descriptive name
	Urban-plan	Urban plan of Tarnowskie Góry Municipality

Source		
Name	**Format of data**	**Scale / resolution**
Tarnowskie Góry Municipal Spatial Information System	Digital - coverage	1: 10 000

Technique of data integration within GIS WELCOME
Digital coverages: transformation from PUW1965 into PUW1992. Translation and attributes assigning.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	1m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Code of projected land use type, name of projected land use category, code of administrative unit within the town

Coverage application	Links with other coverages	No of the map composition
Conceptualisation of the Megasite model	Landuse	Not presented on map composition

Card no. 26	Coverage mnemonic name	Coverage descriptive name
	Soil	Soil

Source		
Name	**Format of data**	**Scale / resolution**
Soil map of the Katowice Voivodeship	Paper map sheet	1: 100 000
Tarnowskie Góry Municipal Spatial Information System	Digital - coverage	1: 10 000
Internal IETU Spatial Information System (Soils of Piekary Slaskie and Zabrze municipalities)	Digital - coverage	1:5000

Technique of data integration within GIS WELCOME
Integration of different map sources in terms of soil taxonomy and spatial discrepancies

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	1-10m depending on source

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter, polygon number	Agricultural complex, soil type (genetic classification), soil textural classes (according to the Polish Soil-Science Society classification system) in two surface layers: 0-50 cm, 50-100cm)

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, calculation of hydro-geological characteristics of surface layer	Landuse, maps of sand and clay contents of surface layers, maps of hydrological parameters	1.6b (map of soil families and soil types)

Card no. 27	Coverage mnemonic name	Coverage descriptive name
	geology	Geology

Source		
Name	**Format of data**	**Scale / resolution**
Nine sheets of Detailed Polish Geological Maps	Raster map sheet	1: 50 000

Technique of data integration within GIS WELCOME
Scanning, raster vectorisation, labelling, attribute assigning, transformation from the Polish Cartographic System - PUW1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent, joining adjacent map sheets, correcting discrepancies between map sheets.

Type of data coverage	Cartographical extent	Data accuracy / resolution
polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Lithology and stratigraphy code, origin code, rock formation, era, period, epoch ages

Coverage application	Links with other coverages	No of the map composition
Geological and hydrogeological modelling	Soil, clay and sand contents in surface and subsurface layers	1.7

Card no. 28	Coverage mnemonic name	Coverage descriptive name
	Uskoki-92	Faults within Triassic formations

Source		
Name	**Format of data**	**Scale / resolution**
Spatial Information System of the Tarnowskie Gory District Office	ARC/INFO arc coverage	
Spatial Information System of Intergeo	MapInfo database	
Voivodeship Geological Archive	Hard copy	1: 100 000

Technique of data integration within GIS WELCOME
Scanning, geo-referencing, raster vectorisation, transformation from Polish Cartographic System PUW1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Merging and geometry correction of faults from different map sources

Type of data coverage	Cartographical extent	Data accuracy / resolution
arc	X min 461000 X max 535000 Y min 269000 Y max 320000	10m

Primary coverage attributes	
Digital	**Descriptive**
length	Default slope of faults = 90±5 degree

Coverage application	Links with other coverages	No of the map composition
Geological and hydrogeological modelling	geology	Not presented on map composition

Card no. 29	Coverage mnemonic name	Coverage descriptive name
	Built-up area	Built-up area

Source		
Name	**Format of data**	**Scale / resolution**
Topographic map – Marshal Office of Silesian Voivodeship	Raster map sheet	1: 50 000

Technique of data integration within GIS WELCOME
Use of 9 sheets of topographic maps in 1:5000 scale in PUW1992. Extraction of colours corresponding to dispersed building developments and vectorisation of continuous built-up fabric. Selection and classification of residential built-up areas, assigning the sanitation code. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Type of building developments and built-up area, sanitation code

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effect of built-up areas on GW quality, development of coverage of map population	Map of population density	1.9a

Card no. 30	Coverage mnemonic name	Coverage descriptive name
	Industrial	Industrial plants

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from Polish Cartographic System 1965 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter, code of industry type	Type of industry, name of industrial facility

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of industrial facilities on GW	Landuse map	1.9a

Card no. 31	Coverage mnemonic name	Coverage descriptive name
	Excavations-large	Large excavations (greater than 1ha)

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of the Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter, X, Y coordinates, suitability index for reclamation with flay ash, code of watershed	Type of industry, GW protection status

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effect of large excavations on GW	Landuse map	1.9a

Card no. 32	Coverage mnemonic name	Coverage descriptive name
	Excavations-small	Small excavations (less than 1ha)

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
X, Y coordinates, suitability index for reclamation with flay ash, code of watershed	Type of industry, GW protection status

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of small excavations on GW	Landuse map	1.9b

Card no. 33	Coverage mnemonic name	Coverage descriptive name
	Large-industrial-landfills	Large industrial landfills

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Code of industry type

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of large industrial landfills on GW	Landuse map	1.9a

Card no. 34	Coverage mnemonic name	Coverage descriptive name
	Small-industrial-landfills	Small industrial landfills

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
	Code and name of industry type

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of small industrial landfills on GW.		1.9a

Card no. 35	Coverage mnemonic name	Coverage descriptive name
	Small-municipal-landfills	Small municipal landfills

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	5m

Primary coverage attributes	
Digital	**Descriptive**
	Code and name of waste type

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of small municipal landfills on GW		1.9a

Card no. 36	Coverage mnemonic name	Coverage descriptive name
	Petrol-stations	Petrol stations

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
	Code of petrol type

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of petrol stations on GW		1.9b

Card no. 37	Coverage mnemonic name	Coverage descriptive name
	Resource-storages	Resource storages

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
	Code of industry type

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of storehouses on GW		1.9b

Card no. 38	Coverage mnemonic name	Coverage descriptive name
	Waste-water-treatment-plants	Wastewater treatment plants

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital – coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
	Code of treatment technology, user, code of wastewater type

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effect of wastewater treatment plants on GW	Sewage-discharge	1.9b

Card no. 39	Coverage mnemonic name	Coverage descriptive name
	Sewage-discharge	Sewage discharge points

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital – coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Discharge volume	Type of wastewater

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of sewage discharge points on GW	Waste-water-treatment-plants	1.9b

Card no. 40	Coverage mnemonic name	Coverage descriptive name
	Cemeteries	Cemeteries

Source		
Name	**Format of data**	**Scale / resolution**
Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into WGS84 datum and PUW1992. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of cemeteries on GW		1.9b

Card no. 41	Coverage mnemonic name	Coverage descriptive name
	Boreholes	Wells and boreholes of the HYDRO database

Source		
Name	**Format of data**	**Scale / resolution**
Central Hydrogeological HYDRO Database (CBDH), Polish Geological Institute (PGI) in Warsaw.	Digital – MS ACCESS database	N/A Location of wells and boreholes was determined on the basis of topographical maps in the scales of 1:25000 and 1:50000

Technique of data integration within GIS WELCOME
Field selection and record retrieval from HYDRO database. Coordinate transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	20% borehole number with altitude errors > 5m, maximum 180m; location error up to 200m

Primary coverage attributes	
Digital	**Descriptive**
Coordinate, well discharge (water output), depression	period, epoch

Coverage application	Links with other coverages	No of the map composition
Geological and hydrogeological modelling		1.10

Card no. 42	Coverage mnemonic name	Coverage descriptive name
	Pomiar-COND	Ground water conductivity

Source		
Name	**Format of data**	**Scale / resolution**
Central Hydrogeological HYDRO Database (CBDH), Polish Geological Institute (PGI) in Warsaw.	Digital – MS ACCESS database	N/A Location of wells and boreholes determined on the basis of topographical maps in the scales of 1:25000 and 1:50000

Technique of data integration within GIS WELCOME
Field selection and record retrieval from HYDRO database. Coordinate transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	20% borehole number with altitude errors > 5m, maximum 180m; location error up to 200m

Primary coverage attributes	
Digital	**Descriptive**
Coordinate, conductivity, pH	Period

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, Hydrogeological modelling	Geology	1.10

Card no. 43	Coverage mnemonic name	Coverage descriptive name
	Pomiar-bar	Ground water barium concentration

Source		
Name	**Format of data**	**Scale / resolution**
Central Hydrogeological HYDRO Database (CBDH), Polish Geological Institute (PGI) in Warsaw.	Digital – MS ACCESS database	N/A Location of wells and boreholes determined on the basis of topographical maps in the scales of 1:25000 and 1:50000

Technique of data integration within GIS WELCOME
Field selection and record retrieval from HYDRO database. Coordinate transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	20% borehole number with altitude errors > 5m, maximum 180m; location error up to 200m

Primary coverage attributes	
Digital	**Descriptive**
Coordinate, pH, barium concentration	period, epoch

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, Hydrogeological modelling	Geology	1.10

Card no. 44	Coverage mnemonic name	Coverage descriptive name
	Pomiar-cynk	Ground water zinc concentration

Source		
Name	**Format of data**	**Scale / resolution**
Central Hydrogeological HYDRO Database (CBDH), Polish Geological Institute (PGI) in Warsaw.	Digital – MS ACCESS database	N/A Location of wells and boreholes determined on the basis of topographical maps in the scales of 1:25000 and 1:50000

Technique of data integration within GIS WELCOME
Field selection and record retrieval from HYDRO database. Coordinate transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	20% borehole number with altitude errors > 5m, maximum 180m; location error up to 200m

Primary coverage attributes	
Digital	**Descriptive**
Coordinate, pH, zinc concentration	period, epoch

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, Hydrogeological modelling	Geology	1.10

Card no. 45	Coverage mnemonic name	Coverage descriptive name
	River-network-extent	River network within the Megasite extent

Source		
Name	**Format of data**	**Scale / resolution**
River network (Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database)	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Correction of river network topology: node connection, direction flipping. Development of ARCVIEW Avenue scripts for topology correction. Assigning attributes to river network. Updating the course in accordance with larger scale topographical maps. Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Arc	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Length	Name and code of watershed

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite, hydrological modelling	Watershed small, watershed large, DEM	1.3 and 1.4 (draped on 3d shaded view), 1.5, 1.9b

Card no. 46	Coverage mnemonic name	Coverage descriptive name
	Water-bodies-extent	Water bodies within the Megasite extent

Source		
Name	**Format of data**	**Scale / resolution**
Hydro-reservoirs (Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database)	Digital – coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Labelling the largest lakes. Updating the shorelines and locations in accordance with larger scale topographical maps Clipping to the Megasite extent.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Area, perimeter	Name of larger lakes

Coverage application	Links with other coverages	No of the map composition
Preliminary description of the Megasite; Building of DEM	DEM	1.5, 1.9a

Card no. 47	Coverage mnemonic name	Coverage descriptive name
	Roads	Road network

Source		
Name	**Format of data**	**Scale / resolution**
Road network (Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database)	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Arc	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Length, road number	Road code

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of roads as a linear contamination source on GW quality		1.9a, 1.9b

Card no. 48	Coverage mnemonic name	Coverage descriptive name
	Railways	Railway network

Source		
Name	**Format of data**	**Scale / resolution**
Railway network (Sozological Map of Silesian Voivodeship, Coverage from Marshal Office of Silesian Voivodeship database)	Digital - coverage	1: 50 000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1942 (Krasovsky ellipsoid) into PUW1992 WGS84 datum). Clipping to the Megasite extent.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Arc	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
Length	

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of railways on GW quality		1.9a

Card no. 49	Coverage mnemonic name	Coverage descriptive name
	Settlements	Settlements

Source		
Name	**Format of data**	**Scale / resolution**
Topographic map – Marshal Office of Silesian Voivodeship	Raster map sheet	1: 50 000

Technique of data integration within GIS WELCOME
Screen vectorisation on the base of topographic maps

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 470000 X max 510000 Y min 273000 Y max 307000	10m

Primary coverage attributes	
Digital	**Descriptive**
calculated population as of 2000, percentage of population connected to the sewage system	Name of settlement, municipality and district

Coverage application	Links with other coverages	No of the map composition
Evaluation of spatial variability of population within Megasite extent	Map of Inhabitants (population density)	Not presented on map composition

Card no. 50	Coverage mnemonic name	Coverage descriptive name
	Chemical-plant-centroid	Tarnowskie Góry Chemical Plant

Source		
Name	**Format of data**	**Scale / resolution**
Spatial Information System of the Tarnowskie Góry Chemical Plant (TGCP) in Liquidation. Map of the fence of Tarnowskie Góry Chemical Plant	polygon	N/A

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Application of sample ARCVIEW Avenue procedures

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	One point coordinates	0m

Primary coverage attributes	
Digital	**Descriptive**
X,Y coordinates	

Coverage application	Links with other coverages	No of the map composition
Used for TGCP location on map composition		From 1.1 up to 1.11 (no for 1.2)

Card no. 51	Coverage mnemonic name	Coverage descriptive name
	Extent-site	Extent of the site

Source		
Name	**Format of data**	**Scale / resolution**
ARCVIEW spatial analyst, ARCVIEW commands and sample ARCVIEW Avenue procedure	N/A	N/A

Technique of data integration within GIS WELCOME
Application of standard ARCVIEW procedure on the base of accepted extent of the site

Type of data coverage	Cartographical extent	Data accuracy / resolution
Arc	X min 490150 X max 491300 Y min 287600 Y max 289200	0m

Primary coverage attributes	
Digital	**Descriptive**

Coverage application	Links with other coverages	No of the map composition
Used as an extent of grid interpolation		2.1 up to 2.11

Card no. 52	Coverage mnemonic name	Coverage descriptive name
	Topo2.tif	Topographic map of TGCP

Source		
Name	**Format of data**	**Scale / resolution**
Spatial Information System of Tarnowskie Góry Chemical Plant (TGCP) in Liquidation. Six sheets of topographic map of Tarnowskie Góry Chemical Plant in 1:1000 scale.	Digital – raster “TIFF” format	1:1000

Technique of data integration within GIS WELCOME
Transformation of reference points from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Image map rectifying in PUW1992, joining adjacent map sheets and speckles cleaning.

Type of data coverage	Cartographical extent	Data accuracy / resolution
raster	X min 490150 X max 491300 Y min 287600 Y max 289200	0m

Primary coverage attributes	
Digital	**Descriptive**

Coverage application	Links with other coverages	No of the map composition
Used in map composition for improvement of map legibility		2.1 up to 2.5, 3.1,3.2, 4.1 and 4.2

Card no. 53	Coverage mnemonic name	Coverage descriptive name
	Chemical plant	Tarnowskie Góry Chemical Plant boundaries

Source		
Name	**Format of data**	**Scale / resolution**
Spatial Information System of Tarnowskie Góry Chemical Plant (TGCP) in Liquidation. Map of the fence the of Tarnowskie Góry Chemical Plant	Polygon	N/A

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 490150 X max 491300 Y min 287600 Y max 289200	0m

Primary coverage attributes	
Digital	**Descriptive**
Area	

Coverage application	Links with other coverages	No of the map composition
Used in map composition for improvement of map legibility, intended use as a barrier in interpolation of contamination of the TG site soils and for risk assessment		From 2.1 up to 2.11

Card no. 54	Coverage mnemonic name	Coverage descriptive name
	Landfills	Landfills of the TGCP

Source		
Name	**Format of data**	**Scale / resolution**
Spatial Information System of TGCP in Liquidation. Map of the TGCP fence	polygon	N/A

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Polygon	X min 490150 X max 491300 Y min 287600 Y max 289200	0m

Primary coverage attributes	
Digital	**Descriptive**
Area	Landfill number, time of operation, type of waste

Coverage application	Links with other coverages	No of the map composition
Used in map composition for improvement of map legibility, intended use as a barrier in interpolation of contamination of the TG site soils and for risk assessment		From 2.1 up to 2.11

Card no. 55	Coverage mnemonic name	Coverage descriptive name
	Central-landfill	Boundary of the central landfill and investment area of the TGCP

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System. Vectorisation on the basis of map from the investment project.	Arc	1:1000

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Arc	X min 490150 X max 491300 Y min 287600 Y max 289200	1m

Primary coverage attributes	
Digital	**Descriptive**
Length	Number of the boundary

Coverage application	Links with other coverages	No of the map composition
Used in map composition for improvement of map legibility, evaluation of future land-use scenario		From 2.1 up to 2.11

Card no. 56	Coverage mnemonic name	Coverage descriptive name
	Soil-monitoring-gig-average	Topsoil characteristics in the vicinity of TGCP

Source

Name	Format of data	Scale / resolution
Tarnowskie Góry Chemical Plant Monitoring – soil monitoring. Analyses performed by the Central Mining Institute	Paper report hardcopies	N/A

Technique of data integration within GIS WELCOME

Copying from paper reports into MS ACCESS database. Calculating arithmetic means of soil parameters comprising 1998-2001 period (13 subsequent quarterly analyses). Application of standard ARCVIEW procedures and generating point coverage. Transformation from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum).

Type of data coverage	Cartographical extent	Data accuracy / resolution
point	X min 490150 X max 491300 Y min 287600 Y max 289200	0m

Primary coverage attributes

Digital	Descriptive
X, Y coordination in two PUW, results of analyses: pH, conductivity, boron, barium, strontium, zinc, copper, iron, manganese, lead, cadmium, arsenic, aluminium , nickel, chromium	Topsoil type, point label

Coverage application	Links with other coverages	No of the map composition
Determination of soil stress due to contamination dispersion from TGCP and landfills of TGCP		From 2.1 up to 2.5

Card no. 57	Coverage mnemonic name	Coverage descriptive name
	Sampl-02-04-19	Results from soil sampling, date April 19th 2002

Source		
Name	**Format of data**	**Scale / resolution**
Analyses performed by the Central Laboratory of IETU	Text ASCI file	N/A

Technique of data integration within GIS WELCOME		
Coordinates determination using GARMIN GPS in field conditions. Application of standard ARCVIEW procedures and generating point coverage. Transformation from WGS84 into PUW1992		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
point	X min 490150 X max 491300 Y min 287600 Y max 289200	About 3m

Primary coverage attributes	
Digital	**Descriptive**
X, Y coordination in WGS84 datum and in PUW1992 laboratory number, results of analyses: pH, conductivity, boron, barium, strontium, zinc, copper, iron, manganese, lead, cadmium, arsenic	type of media, point label

Coverage application	Links with other coverages	No of the map composition
Determination of soil stress due to contamination dispersion from TGCP and landfills of TGCP		From 2.1 up to 2.5

Card no. 58	Coverage mnemonic name	Coverage descriptive name
	Sampl-02-05-17	Results from soil sampling, date May 17th 2002

Source		
Name	**Format of data**	**Scale / resolution**
Analyses performed by Central Laboratory of IETU	Text ASCI file	N/A

Technique of data integration within GIS WELCOME
Coordinates determination using GARMIN GPS in field conditions. Application of standard ARCVIEW procedures and generating point coverage. Transformation from WGS84 into PUW1992

Type of data coverage	Cartographical extent	Data accuracy / resolution
point	X min 490150 X max 491300 Y min 287600 Y max 289200	About 4m

Primary coverage attributes	
Digital	**Descriptive**
X, Y, Z coordination in WGS84 datum and in X, Y in PUW1992, laboratory number, results of analyses: pH, conductivity, boron, barium, strontium, zinc, copper, iron, manganese, lead, cadmium, arsenic	point label

Coverage application	Links with other coverages	No of the map composition
Determination of soil stress due to contamination dispersion from TGCP and landfills of TGCP		From 2.1 up to 2.5

Card no. 59	Coverage mnemonic name	Coverage descriptive name
	Sampl-02-05-28	Results from soil sampling, date May 28th 2002

Source		
Name	**Format of data**	**Scale / resolution**
Analyses performed by VITO Laboratory	Text ASCI file	N/A

Technique of data integration within GIS WELCOME
Coordinates determination using GARMIN GPS in field conditions. Application of standard ARCVIEW procedures and generating point coverage. Transformation from WGS84 into PUW1992

Type of data coverage	Cartographical extent	Data accuracy / resolution
point	X min 490150 X max 491300 Y min 287600 Y max 289200	About 5m

Primary coverage attributes	
Digital	**Descriptive**
X, Y coordination in WGS84 datum and in X, Y in PUW1992, results of analyses: dry matter contents, total inorganic carbon, boron, barium, strontium, zinc, copper, lead, cadmium, arsenic	point label

Coverage application	Links with other coverages	No of the map composition
Determination of soil stress due to contamination dispersion from TGCP and landfills of TGCP		From 2.1 up to 2.5

Card no. 60	Coverage mnemonic name	Coverage descriptive name
	Sampl-summer	Results from soil sampling in summer 2002

Source		
Name	**Format of data**	**Scale / resolution**
Analyses performed by the Central Laboratory of IETU	Text ASCI file	N/A

Technique of data integration within GIS WELCOME		
Coordinates determination using GARMIN GPS in field conditions. Application of standard ARCVIEW procedures and generating point coverage. Transformation from WGS84 into PUW1992		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
point	X min 490150 X max 491300 Y min 287600 Y max 289200	About 5m

Primary coverage attributes	
Digital	**Descriptive**
X, Y coordination in WGS84 datum and in X, Y in PUW1992, results of analyses: boron, barium, strontium, zinc, copper, lead, cadmium, arsenic	point label (2 fields)

Coverage application	Links with other coverages	No of the map composition
Determination of soil stress due to contamination dispersion from TGCP and landfills of TGCP		From 2.1 up to 2.5

Card no. 61	Coverage mnemonic name	Coverage descriptive name
	Sampl-plant	Results from plant sampling in June and July 2002

Source		
Name	**Format of data**	**Scale / resolution**
Analyses performed by the Central Laboratory of IETU	Text ASCI file	N/A

Technique of data integration within GIS WELCOME		
Coordinates determination using GARMIN GPS in field conditions. Application of standard ARCVIEW procedures and generating point coverage. Transformation from WGS84 into PUW1992		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
point	X min 490150 X max 491300 Y min 287600 Y max 289200 except one reference point	About 5m

Primary coverage attributes	
Digital	**Descriptive**
X, Y coordination in WGS84 datum and in X, Y in PUW1992, results of analyses: boron, barium, strontium, zinc, copper, lead, cadmium, arsenic	point label, date of sampling, plant species, plant part taken for sampling

Coverage application	Links with other coverages	No of the map composition
Determination of plant stress due to contamination dispersion from TGCP and landfills of TGCP		From 3.1 up to 3.2

Card no. 62	Coverage mnemonic name	Coverage descriptive name
	Sampl-surface-water	Results from surface water sampling in 2002

Source		
Name	**Format of data**	**Scale / resolution**
Analyses performed by the Central Laboratory of IETU	Text ASCI file	N/A

Technique of data integration within GIS WELCOME
Coordinates determination using GARMIN GPS in field conditions. Application of standard ARCVIEW procedures and generating point coverage. Transformation from WGS84 into PUW1992

Type of data coverage	Cartographical extent	Data accuracy / resolution
point	X min 489787 X max 492495 Y min 288576 Y max 291378	About 5m

Primary coverage attributes	
Digital	**Descriptive**
X, Y coordination in WGS84 datum and in X, Y in PUW1992, results of analyses: pH, conductivity, total organic carbon, boron, barium, strontium, zinc, copper, iron, manganese, lead, cadmium, arsenic, fluorides, nitrates, chlorides, sulphates	Sampling point label, date of sampling

Coverage application	Links with other coverages	No of the map composition
Determination of surface water quality as a result of contamination migration from TGCP and landfills of TGCP		From 2.6 up to 2.11

Card no. 63	Coverage mnemonic name	Coverage descriptive name
	Piezometer-geochemistry	Results from GW sampling in the first quarter of 2002

Source

Name	Format of data	Scale / resolution
Tarnowskie Góry Chemical Plant Monitoring – GW monitoring. Analyses performed by the Central Mining Institute	Paper report hardcopies	N/A

Technique of data integration within GIS WELCOME

Coordinates determination using GARMIN GPS in field conditions. Transformation from WGS84 into PUW1992. Archival data, rewritten into MS ACCESS database and transformed from PUW1965 into PUW1992. The database consists of parameters measured in 1998-2001 period (11 subsequent quarterly analyses of pH, conductivity, total dissolved substances, COD, arsenic, ammonium, nitrate, nitrite, barium, boron, zinc, aluminium, cadmium, magnesium, manganese, copper, nickel, lead, potassium, sodium, strontium, calcium, carbonates, hydrogen-carbonates, iron, chlorides, sulphates, detergents, phenols, chromium, fluorides, phosphates). Application of standard ARCVIEW procedures and generating point coverage. Linking the point coverage with selected set of data on the basis of a common field – well / piezometer name.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Point	X min 489787 X max 492495 Y min 288576 Y max 291378	About 1-5m

Primary coverage attributes

Digital	Descriptive
X, Y coordination in PUW1992, results of analyses: total dissolved substances, boron, barium, strontium, chlorides, sulphates	Well and piezometer label, stratigraphy period, source of coordination determination

Coverage application	Links with other coverages	No of the map composition
Determination of GW quality in the direct vicinity of TGCP as a result of contamination migration from the plant and landfills	Maps of interpolated concentration of barium, boron, strontium, total dissolved substances, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.1 and from 2.6 up to 2.11

Card no. 64	Coverage mnemonic name	Coverage descriptive name
	TG-elevation	Digital Elevation Model of the site

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	grid	1:1000

Technique of data integration within GIS WELCOME
Transformation of grid to point set and further transformation of points from the Polish Cartographic System 1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Final points transformation into grid format

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 490172 X max 491274 Y min 287550 Y max 288952	1m

Primary coverage attributes	
Digital	**Descriptive**
value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the TG site		Not presented on map composition

Card no. 65	Coverage mnemonic name	Coverage descriptive name
	100sand (surface directory)	Sand contents in surface layer (0-50cm)

Source

Name	Format of data	Scale / resolution
Geology	Digital – coverage	1:50 000
Soil (polygon, arc)	Digital – coverage	The same as the “soil” coverage

Technique of data integration within GIS WELCOME

IMPLEMENTATION OF A UNIQUE PROCEDURE CONSISTING OF SOME GIS STANDARD PROCEDURES AS WELL AS ARCVIEW AVENUE SCRIPTS DEVELOPED BY IETU GIS TEAM.

The procedure consists of establishing the arc left-right polygon topology relation of sand, silt and clay content, selecting arcs for calculation of grain size distribution, converting arcs into appropriate sets of points, point triangulation and TIN interpolation into 100m grid.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes

Digital	Descriptive
Value	

Coverage application	Links with other coverages	No of the map composition
Calculation of hydro-geological parameters of surface layer	Soil, map of clay contents of the surface layer, maps of hydrological parameters	1.6c

Card no. 66	Coverage mnemonic name	Coverage descriptive name
	100clay (surface directory)	Clay contents in surface layer (0-50cm)

Source

Name	Format of data	Scale / resolution
Geology	Digital - coverage	1:50 000
Soil (polygon, arc)	Digital - coverage	The same as the “soil” coverage

Technique of data integration within GIS WELCOME

IMPLEMENTATION OF A UNIQUE PROCEDURE CONSISTING OF SOME GIS STANDARD PROCEDURES AS WELL AS ARCVIEW AVENUE SCRIPTS DEVELOPED BY IETU GIS TEAM.

The procedure consists of establishing the arc left-right polygon topology relation of sand, silt and clay content, selecting arcs for calculation of grain size distribution, converting arcs into appropriate sets of points, point triangulation and TIN interpolation into 100m grid.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes

Digital	Descriptive
Value	

Coverage application	Links with other coverages	No of the map composition
Calculation of hydro-geological parameters of surface layer	Soil, map of sand contents of the surface layer, maps of hydrological parameters	1.6c

Card no. 67	Coverage mnemonic name	Coverage descriptive name
	100ksat-e6ms (surface directory)	Hydraulic conductivity at saturation of surface layer (0-50cm), units - 10^{-6}m/s

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of surface layer saturation, bulk density, field capacity, permanent wilting point, plant available water	1.6c

Card no. 68	Coverage mnemonic name	Coverage descriptive name
	100sat (surface directory)	Saturation of surface layer (0-50cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of surface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 69	Coverage mnemonic name	Coverage descriptive name
	100bd (surface directory)	Bulk density of surface layer (0-50cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of surface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 70	Coverage mnemonic name	Coverage descriptive name
	100fc (surface directory)	Field Capacity of surface layer (0-50cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of surface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 71	Coverage mnemonic name	Coverage descriptive name
	100pwp (surface directory)	Permanent wilting point of surface layer (0-50cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of surface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 72	Coverage mnemonic name	Coverage descriptive name
	100paw (surface directory)	Plant available water of surface layer (0-50cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of surface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 73	Coverage mnemonic name	Coverage descriptive name
	100sand (subsurface directory)	Sand contents in subsurface layer (50-100cm)

Source

Name	Format of data	Scale / resolution
Geology	Digital - coverage	1:50 000
Soil (polygon, arc	Digital - coverage	The same as the “soil” coverage

Technique of data integration within GIS WELCOME

IMPLEMENTATION OF A UNIQUE PROCEDURE CONSISTING OF SOME GIS STANDARD PROCEDURES AS WELL AS ARCVIEW AVENUE SCRIPTS DEVELOPED BY IETU GIS TEAM.

The procedure consists of establishing the arc left-right polygon topology relation of sand, silt and clay content, selecting arcs for calculation of grain size distribution, converting arcs into appropriate sets of points, point triangulation and TIN interpolation into 100m grid.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes

Digital	Descriptive
Value	

Coverage application	Links with other coverages	No of the map composition
Calculation of hydro-geological parameters of surface layer	Soil, map of clay contents of subsurface layer, maps of hydrological parameters	Not presented on map composition

Card no. 74	Coverage mnemonic name	Coverage descriptive name
	100clay (subsurface directory)	Clay contents in subsurface layer (50-100cm)

Source

Name	Format of data	Scale / resolution
Geology	Digital - coverage	1:50 000
Soil (polygon, arc	Digital - coverage	The same as the “soil” coverage

Technique of data integration within GIS WELCOME

IMPLEMENTATION OF A UNIQUE PROCEDURE CONSISTING OF SOME GIS STANDARD PROCEDURES AS WELL AS ARCVIEW AVENUE SCRIPTS DEVELOPED BY IETU GIS TEAM.

The procedure consists of establishing the arc left-right polygon topology relation of sand, silt and clay content, selecting arcs for calculation of grain size distribution, converting arcs into appropriate sets of points, point triangulation and TIN interpolation into 100m grid.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes

Digital	Descriptive
Value	

Coverage application	Links with other coverages	No of the map composition
Calculation of hydro-geological parameters of surface layer	Soil, map of sand contents of subsurface layer, maps of hydrological parameters	Not presented on map composition

Card no. 75	Coverage mnemonic name	Coverage descriptive name
	100ksat-e6ms (subsurface directory)	Hydraulic Conductivity at saturation of subsurface layer (50-100cm), units - 10^{-6}m/s

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME		
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of subsurface layer saturation, bulk density, field capacity, permanent wilting point, plant available water	Not presented on map composition

Card no. 76	Coverage mnemonic name	Coverage descriptive name
	100sat (subsurface directory)	Saturation of subsurface layer (50-100cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of subsurface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 77	Coverage mnemonic name	Coverage descriptive name
	100bd (subsurface directory)	Bulk density of subsurface layer (50-100cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	Digital - coverage	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of subsurface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 78	Coverage mnemonic name	Coverage descriptive name
	100fc (subsurface directory)	Field Capacity of subsurface layer (50-100cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of subsurface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 79	Coverage mnemonic name	Coverage descriptive name
	100pwp (subsurface directory)	Permanent wilting point of subsurface layer (50-100cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME		
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of subsurface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 80	Coverage mnemonic name	Coverage descriptive name
	100paw (subsurface directory)	Plant available water of subsurface layer (50-100cm)

Source		
Name	**Format of data**	**Scale / resolution**
100sand and 100clay	grid	100m

Technique of data integration within GIS WELCOME		
Application of Saxton model (Running Ricardo P. Braga from USGS-Biological Resources Division Glacier Bay Field Station ARCVIEW Avenue script).		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Hydrological and hydro-geological models	Soil, map of sand and clay contents of subsurface layer, maps of other hydrological parameters	Not presented on map composition

Card no. 81	Coverage mnemonic name	Coverage descriptive name
	Extent-Cd	Cadmium concentration in topsoil

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	grid	100m

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of topsoil contamination with cadmium on GW	Lead and zinc concentration in topsoil	1.6d

Card no. 82	Coverage mnemonic name	Coverage descriptive name
	Extent-Pb	Lead concentration in topsoil

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	grid	100m

Technique of data integration within GIS WELCOME		
Transformation from the Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of topsoil contamination with lead on GW	Cadmium and zinc concentration in topsoil	1.6e

Card no. 83	Coverage mnemonic name	Coverage descriptive name
	Extent-Zn	Zinc concentration in topsoil

Source		
Name	**Format of data**	**Scale / resolution**
Internal IETU Spatial Information System	grid	100m

Technique of data integration within GIS WELCOME
Transformation from the Polish Cartographic System - PUW1965 (Krasovsky ellipsoid) into PUW1992 (WGS84 datum). Clipping to the Megasite extent

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Assessment of potential effects of topsoil contamination with zinc on GW	Cadmium and lead concentration in topsoil	1.6f

Card no. 84	Coverage mnemonic name	Coverage descriptive name
	Barium-q	Interpolated barium concentration in Quaternary water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 490150 X max 491300 Y min 287850 Y max 288950	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.10

Card no. 85	Coverage mnemonic name	Coverage descriptive name
	Barium-t	Interpolated barium concentration in Triassic water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287600 Y max 289200	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.10

Card no. 86	Coverage mnemonic name	Coverage descriptive name
	Boron-q	Interpolated boron concentration in Quaternary water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287850 Y max 288950	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.9

Card no. 87	Coverage mnemonic name	Coverage descriptive name
	Boron-t	Interpolated boron concentration in Triassic water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 490150 X max 491300 Y min 287600 Y max 289200	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.9

Card no. 88	Coverage mnemonic name	Coverage descriptive name
	Strontium-q	Interpolated strontium concentration in Quaternary water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 490150 X max 491300 Y min 287850 Y max 288950	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.11

Card no. 89	Coverage mnemonic name	Coverage descriptive name
	Strontium-t	Interpolated strontium concentration in Triassic water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287600 Y max 289200	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.11

Card no. 90	Coverage mnemonic name	Coverage descriptive name
	Soluble-m-q	Interpolated concentration of dissolved substances in Quaternary water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287850 Y max 288950	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.6

Card no. 91	Coverage mnemonic name	Coverage descriptive name
	Soluble-m-t	Interpolated concentration of dissolved substances in Triassic water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287600 Y max 289200	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.6

Card no. 92	Coverage mnemonic name	Coverage descriptive name
	Chloride-q	Interpolated concentration of chlorides in Quaternary water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287850 Y max 288950	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.7

Card no. 93	Coverage mnemonic name	Coverage descriptive name
	Chloride-t	Interpolated concentration of chlorides in Triassic water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287600 Y max 289200	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.7

Card no. 94	Coverage mnemonic name	Coverage descriptive name
	Sulphate-q	Interpolated concentration of sulphates in Quaternary water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287850 Y max 288950	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.8

Card no. 95	Coverage mnemonic name	Coverage descriptive name
	Sulphate-t	Interpolated concentration of sulphates in Triassic water bearing horizon

Source		
Name	**Format of data**	**Scale / resolution**
Piezometer-geochemistry – Internal IETU-GIS spatial information system	Digital – point coverage	1:1000

Technique of data integration within GIS WELCOME		
Interpolation with inverse distance technique and power coefficient equal 2, all data were applied in interpolation process. Application of standard ARCVIEW spatial analyst procedures.		
Type of data coverage	**Cartographical extent**	**Data accuracy / resolution**
Grid	X min 490150 X max 491300 Y min 287600 Y max 289200	5m

Primary coverage attributes	
Digital	**Descriptive**
Value	

Coverage application	Links with other coverages	No of the map composition
Modelling of the contamination migration in the area of the TGCP site	Maps of interpolated concentration of B, Ba Sr, DS, chlorides, and sulphates in Quaternary and Triassic water bearing horizons	2.8

Card no. 96	Coverage mnemonic name	Coverage descriptive name
	Inhabitants	Number of residents in 1 ha square

Source		
Name	**Format of data**	**Scale / resolution**
Settlements	Digital-coverage - point	1: 50 000
Built-up area	Digital-coverage - polygon	1: 50 000

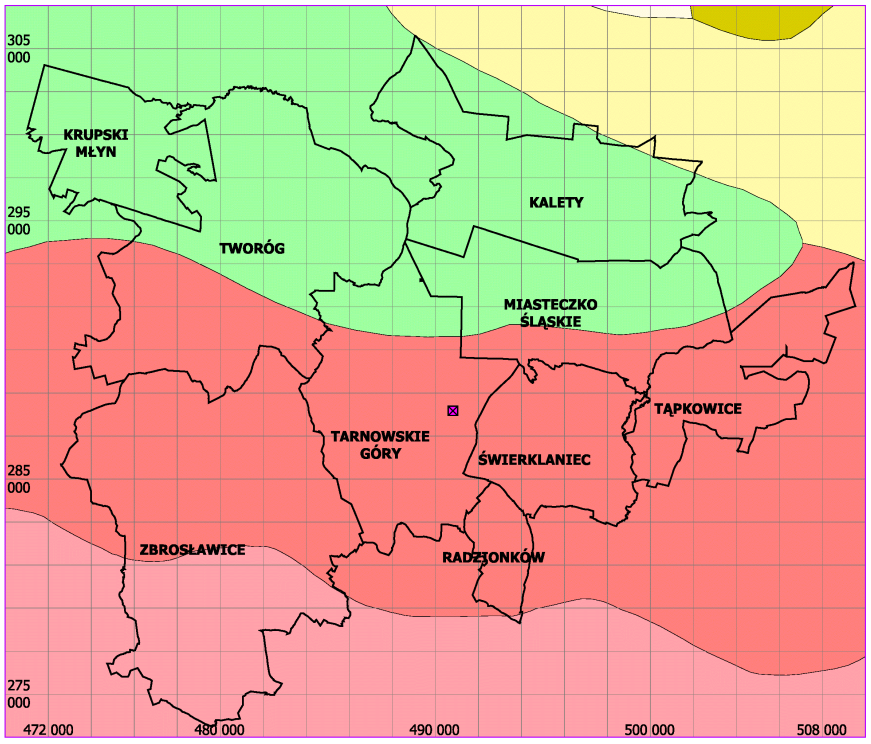
Technique of data integration within GIS WELCOME

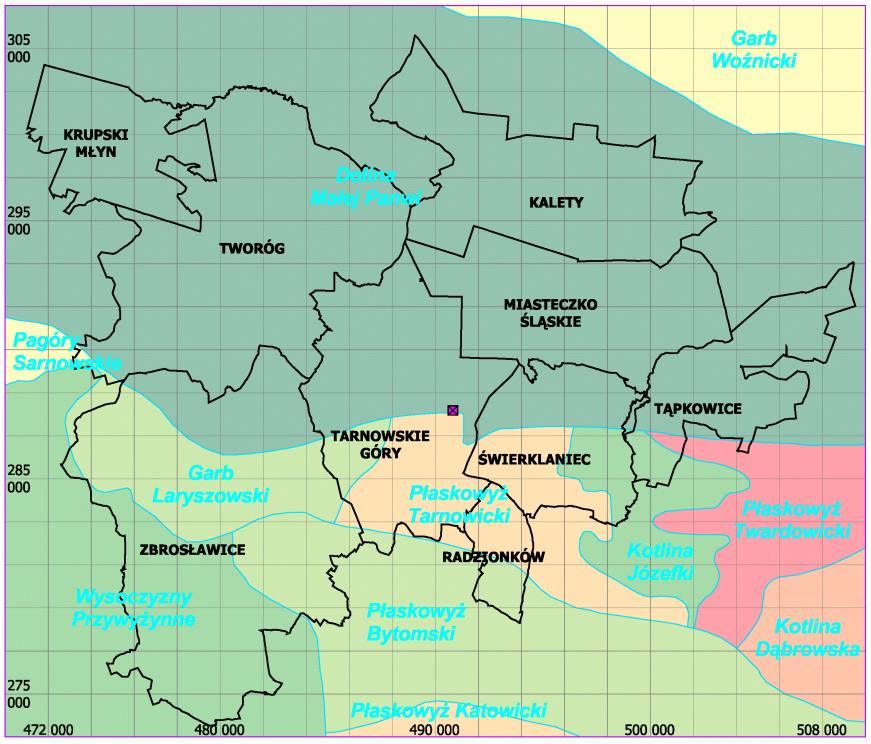
Assigning residential areas to municipalities and settlements. Calculation of population number within polygons representing residential areas, generation of an interim point coverage representing random distribution of inhabitants within polygons of built-up areas, generation of 100m grid, totalling people number in grid cells, transformation of polygon vector coverage into ARCINFO grid

Type of data coverage	Cartographical extent	Data accuracy / resolution
Grid	X min 470000 X max 510000 Y min 273000 Y max 307000	100m

Primary coverage attributes	
Digital	**Descriptive**
value	

Coverage application	Links with other coverages	No of the map composition
Risk analysis	Map of built-up area	1.11





2 0 2 4 6 8 10 Kilometers

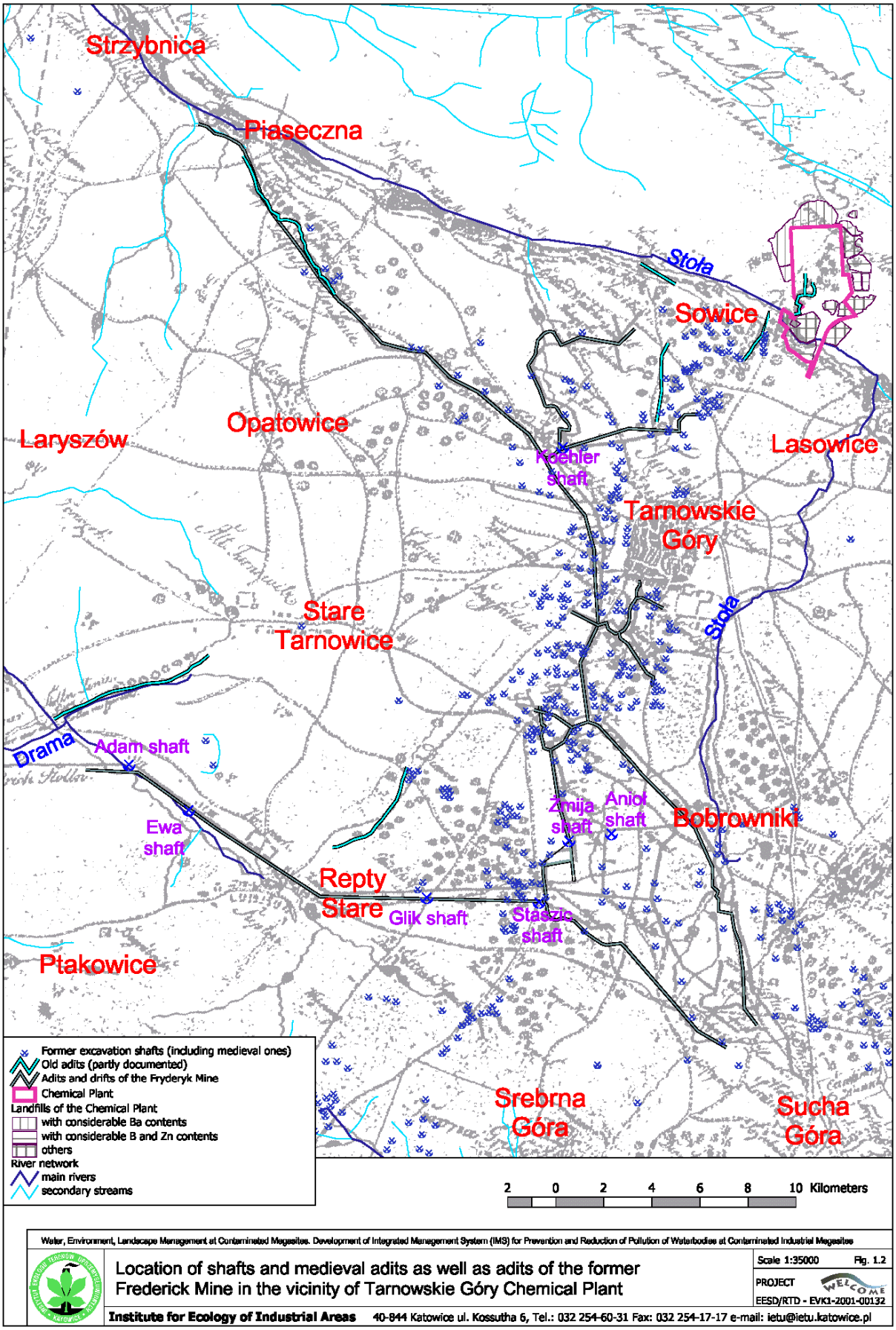
Water, Environment, Landscape Management at Contaminated Megasites. Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites

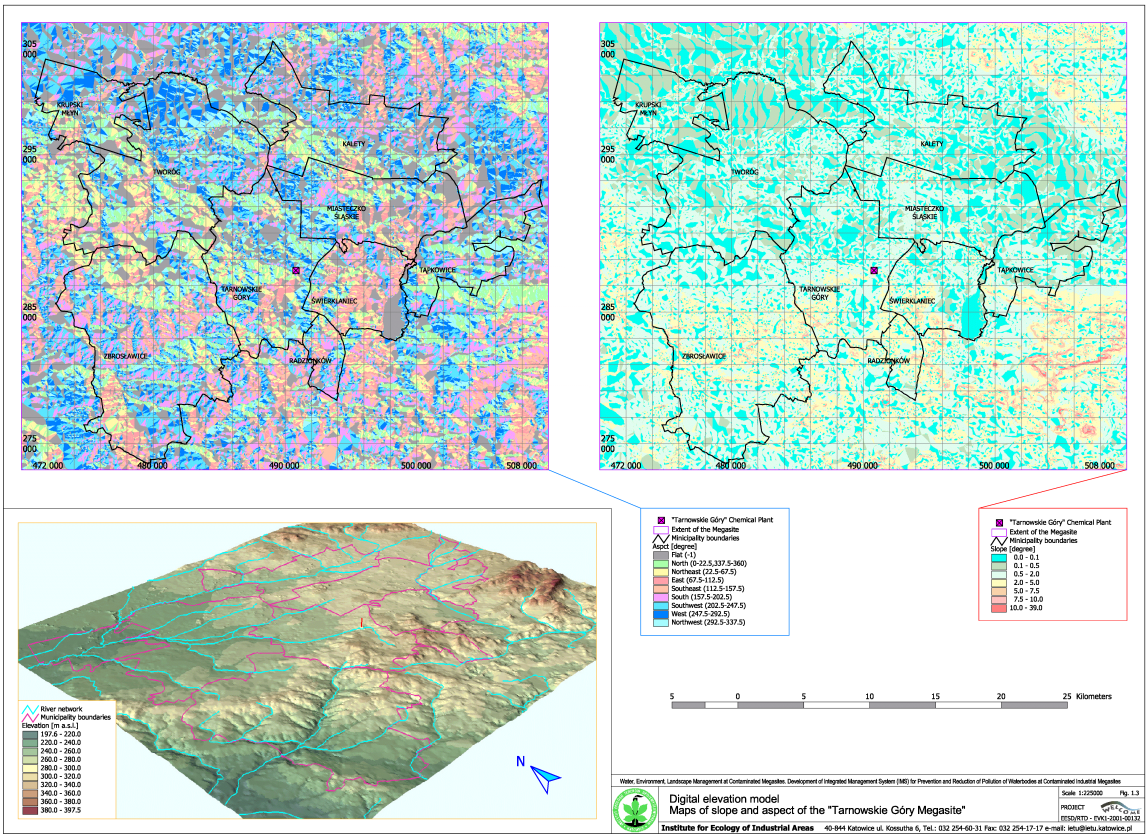
Maps of the geographical and geomorphological regions

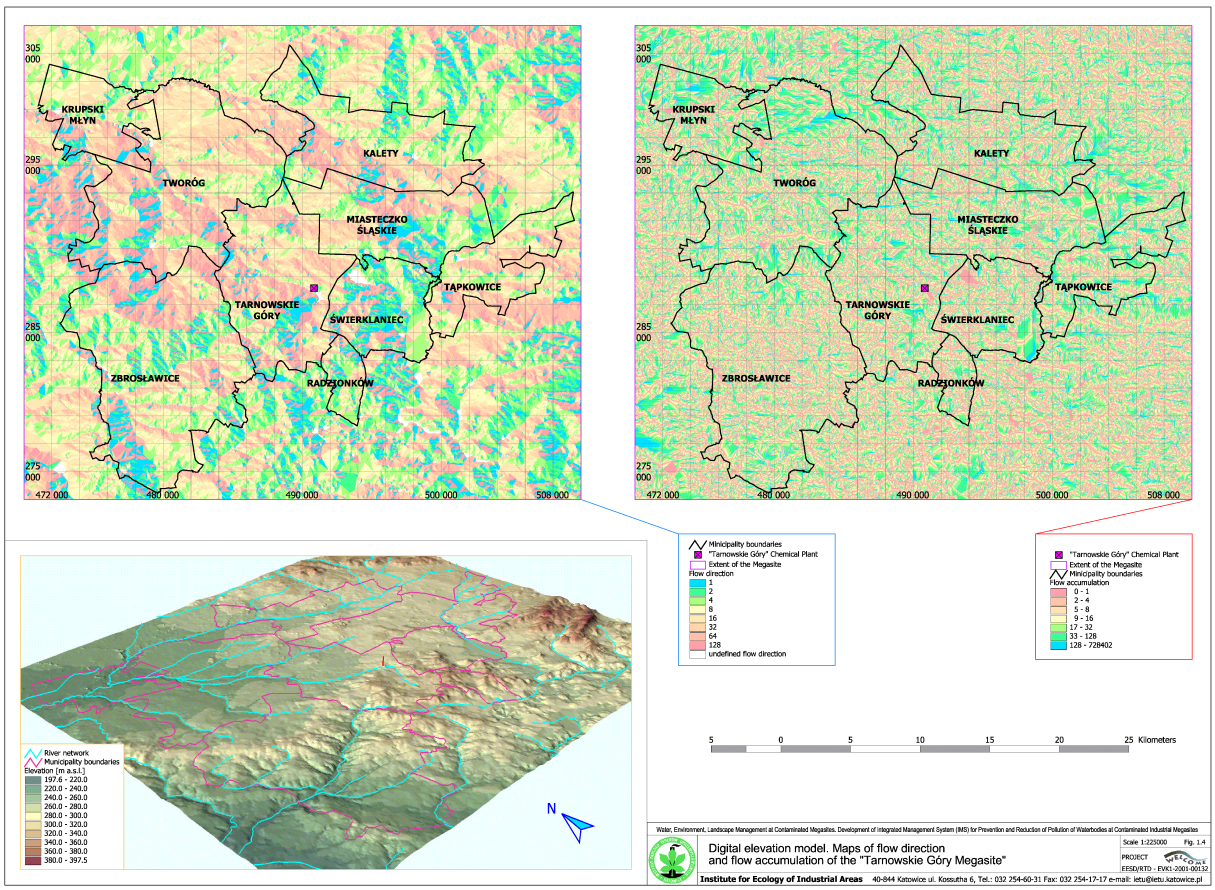
Scale 1:200000 Fig. 1.1

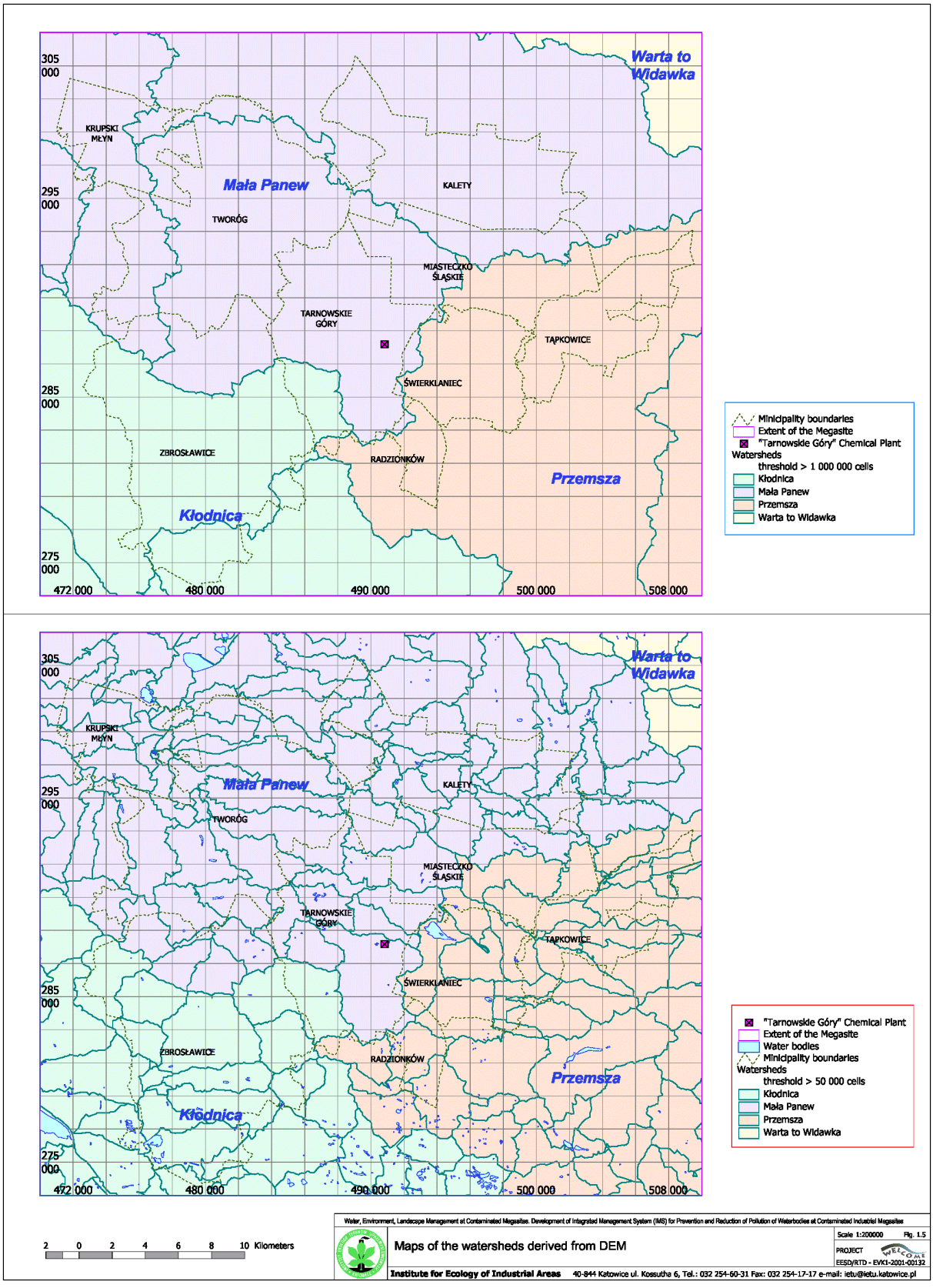
PROJECT EESD/RTD - EVK1-2001-00132

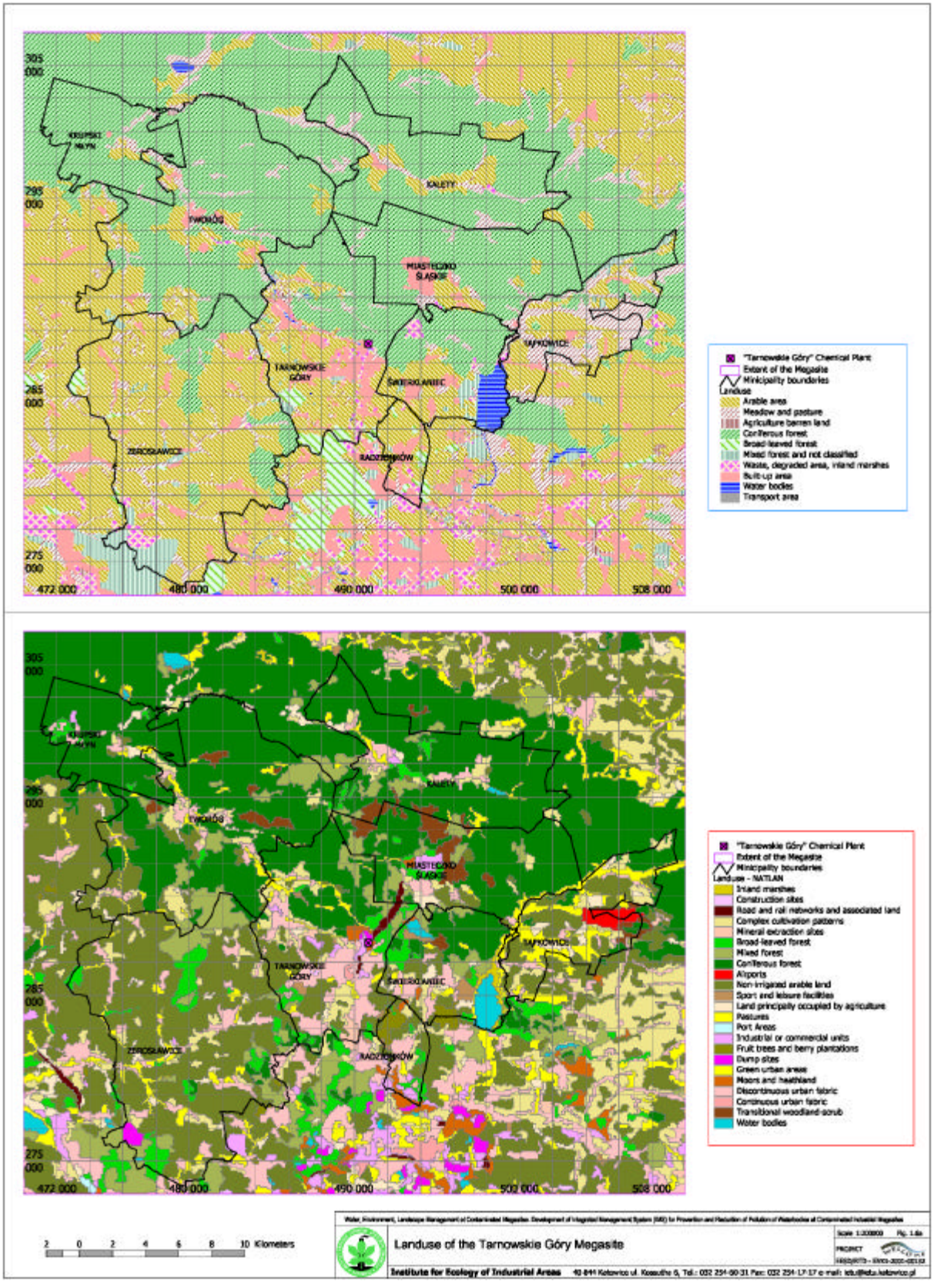
Institute for Ecology of Industrial Areas 40-844 Katowice ul. Kossutha 6, Tel.: 032 254-60-31 Fax: 032 254-17-17 e-mail: ietu@ietu.katowice.pl

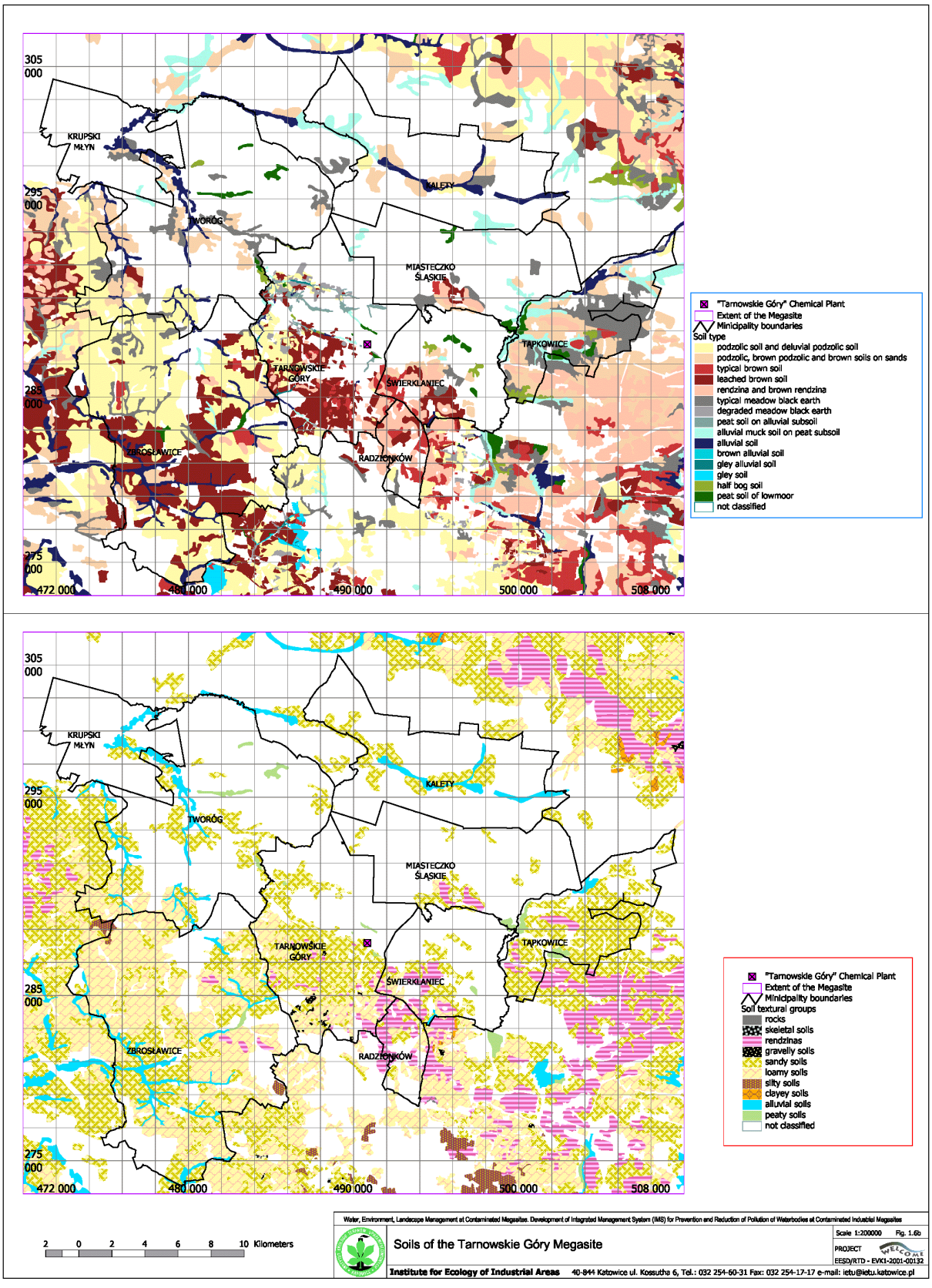

Strzybnica
Piaseczna
Stoła
Sowice
Laryszów
Opatowice
Lasowice
Koehler shaft
Tarnowskie Góry
Stare Tarnowice
Stoła
Drama
Adam shaft
Ewa shaft
Żmija shaft
Aniol shaft
Bobrowniki
Repty
Stare Glik shaft
Staszic shaft
Ptakowice
Srebrna Góra
Sucha Góra
Former excavation shafts (including medieval ones)
Old adits (partly documented)
Adits and drifts of the Fryderyk Mine
Chemical Plant
Landfills of the Chemical Plant
with considerable Ba contents
with considerable B and Zn contents
others
River network
main rivers
secondary streams
2 0 2 4 6 8 10 Kilometers
Water, Environment, Landscape Management at Contaminated Megasites. Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites
Location of shafts and medieval adits as well as adits of the former Frederick Mine in the vicinity of Tarnowskie Góry Chemical Plant
Scale 1:35000
Fig. 1.2
PROJECT
EESD/RTD - EVK1-2001-00132
Institute for Ecology of Industrial Areas
40-844 Katowice ul. Kossutha 6, Tel.: 032 254-60-31 Fax: 032 254-17-17 e-mail: ietu@ietu.katowice.pl

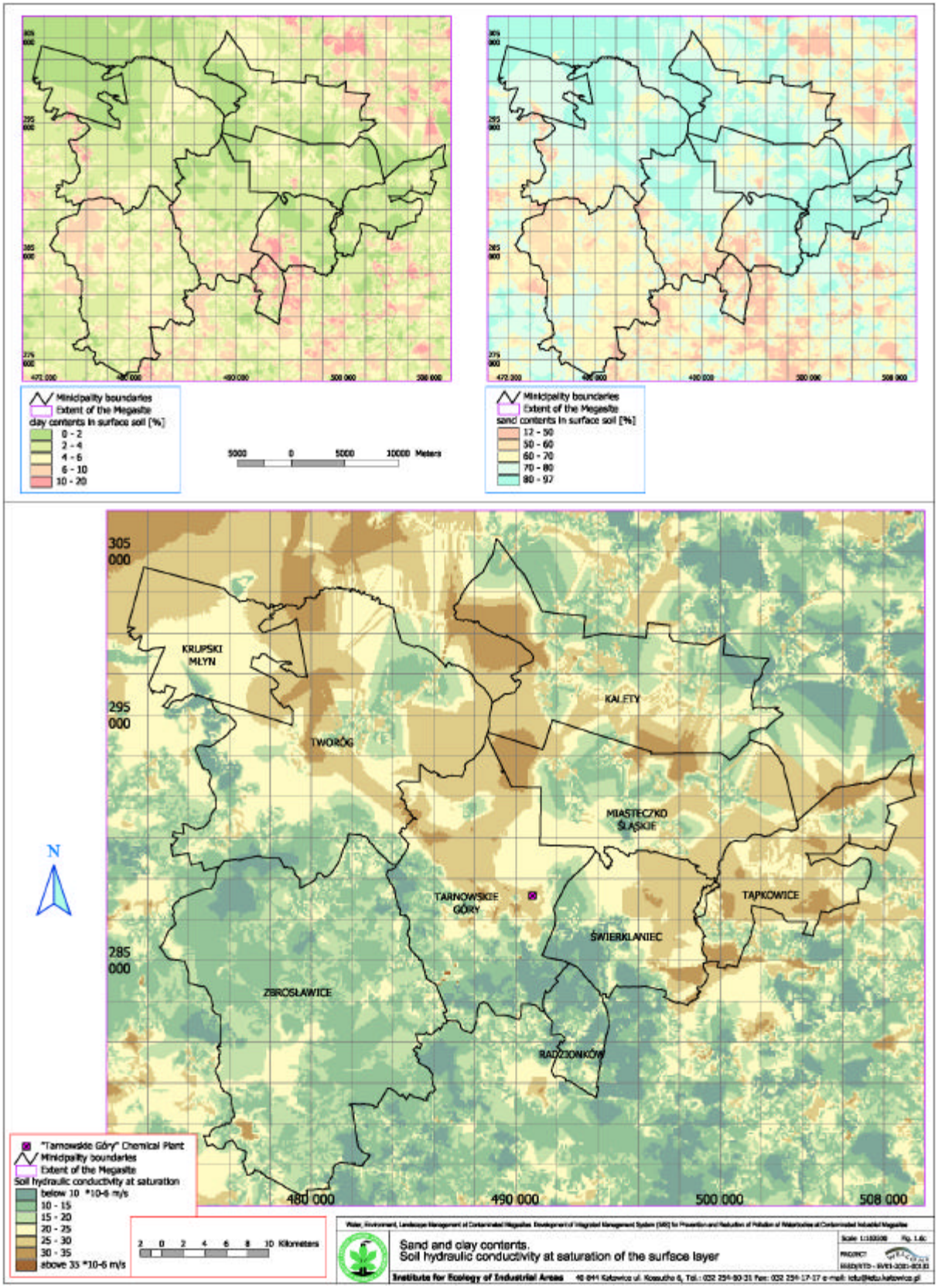

KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TĄPKOWICE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Minicipality boundaries
Aspect [degree]
Flat (-1)
North (0-22.5,337.5-360)
Northeast (22.5-67.5)
East (67.5-112.5)
Southeast (112.5-157.5)
South (157.5-202.5)
Southwest (202.5-247.5)
West (247.5-292.5)
Northwest (292.5-337.5)
Slope [degree]
0.0 - 0.1
0.1 - 0.5
0.5 - 2.0
2.0 - 5.0
5.0 - 7.5
7.5 - 10.0
10.0 - 39.0
5 0 5 10 15 20 25 Kilometers
River network
Municipality boundaries
Elevation [m a.s.l.]
197.6 - 220.0
220.0 - 240.0
240.0 - 260.0
260.0 - 280.0
280.0 - 300.0
300.0 - 320.0
320.0 - 340.0
340.0 - 360.0
360.0 - 380.0
380.0 - 397.5
N
Water, Environment, Landscape Management at Contaminated Megasites. Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites
Digital elevation model
Maps of slope and aspect of the "Tarnowskie Góry Megasite"
Scale 1:225000
Fig. 1.3
PROJECT
EESD/RTD - EVK1-2001-00132
Institute for Ecology of Industrial Areas
40-844 Katowice ul. Kossutha 6, Tel.: 032 254-60-31 Fax: 032 254-17-17 e-mail: ietu@ietu.katowice.pl

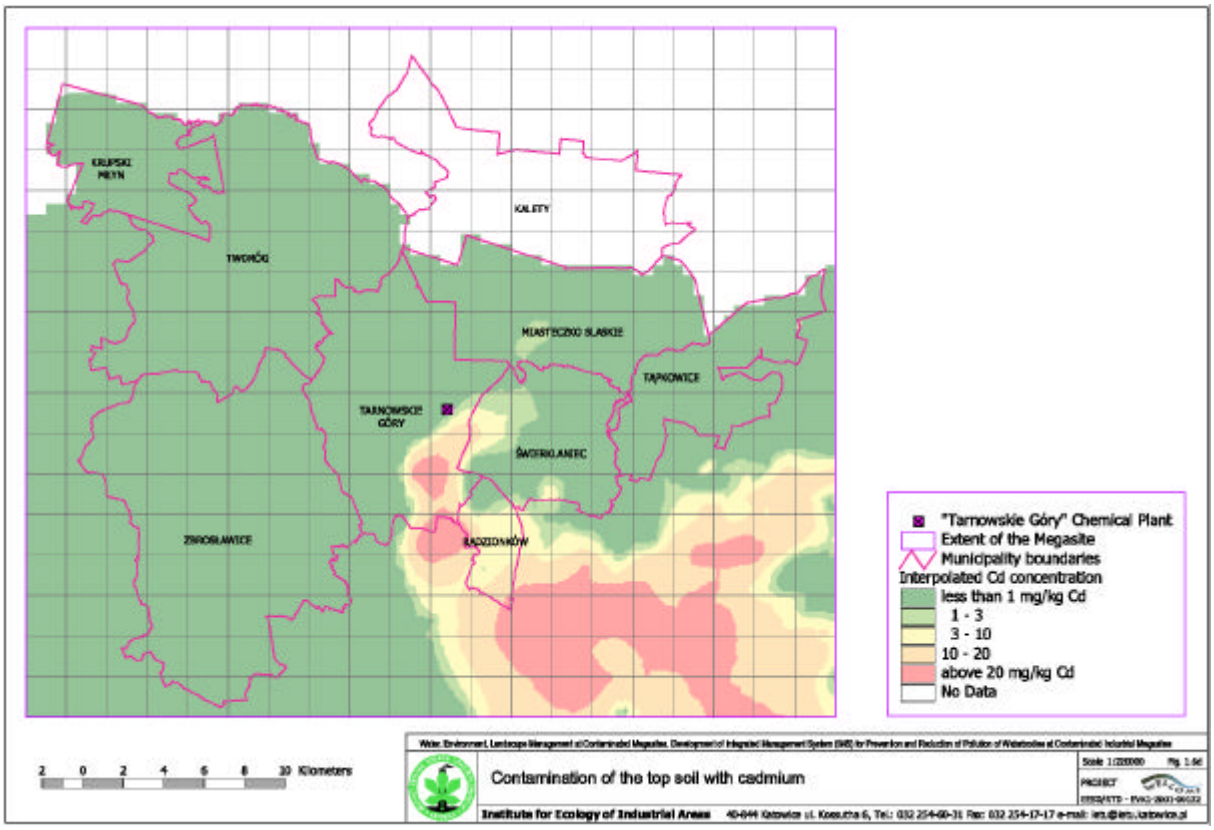

KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TĄPKOWICE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
Municipality boundaries
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Flow direction
1
2
4
8
16
32
64
128
Undefined flow direction
Flow accumulation
0 - 1
2 - 4
5 - 8
9 - 16
17 - 32
33 - 128
128 - 728402
5 0 5 10 15 20 25 Kilometers
River network
Municipality boundaries
Elevation [m a.s.l.]
197.6 - 220.0
220.0 - 240.0
240.0 - 260.0
260.0 - 280.0
280.0 - 300.0
300.0 - 320.0
320.0 - 340.0
340.0 - 360.0
360.0 - 380.0
380.0 - 397.5
N
Water, Environment, Landscape Management at Contaminated Megasites. Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites
Digital elevation model. Maps of flow direction
and flow accumulation of the "Tarnowskie Góry Megasite"
Scale 1:225000
Fig. 1.4
PROJECT
EESD/RTD - EVK1-2001-00132
Institute for Ecology of Industrial Areas
40-844 Katowice ul. Kossutha 6, Tel.: 032 254-60-31 Fax: 032 254-17-17 e-mail: ietu@ietu.katowice.pl

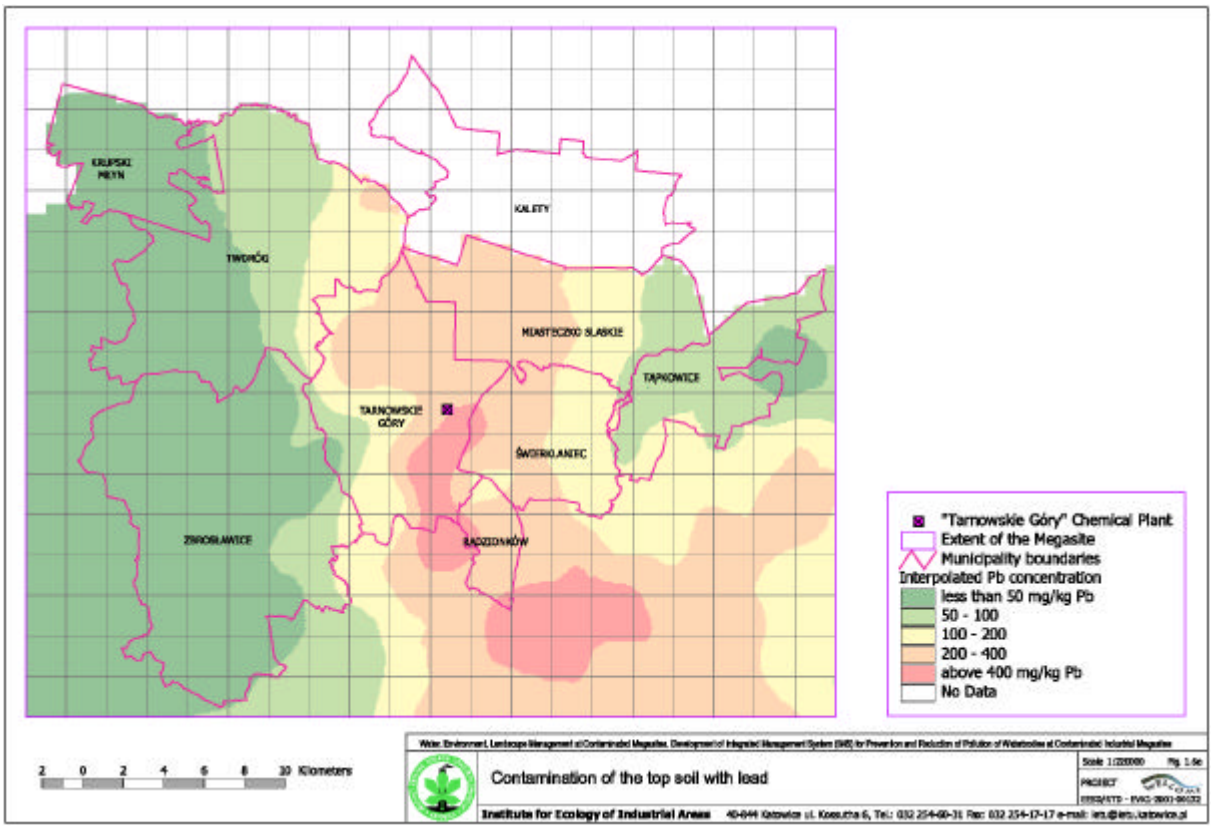

Warta to Widawka
Mała Panew
Kłodnica
Przemsza
KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
TĄPKOWICE
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
Minicipality boundaries
Extent of the Megasite
"Tarnowskie Góry" Chemical Plant
Watersheds
threshold > 1 000 000 cells
Kłodnica
Mała Panew
Przemsza
Warta to Widawka
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Water bodies
Minicipality boundaries
Watersheds
threshold > 50 000 cells
Kłodnica
Mała Panew
Przemsza
Warta to Widawka
2 0 2 4 6 8 10 Kilometers
Water, Environment, Landscape Management at Contaminated Megasites. Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites
Maps of the watersheds derived from DEM
Scale 1:200000
Fig. 1.5
PROJECT
EESD/RTD - EVK1-2001-00132
Institute for Ecology of Industrial Areas
40-844 Katowice ul. Kossutha 6, Tel.: 032 254-60-31 Fax: 032 254-17-17 e-mail: ietu@ietu.katowice.pl

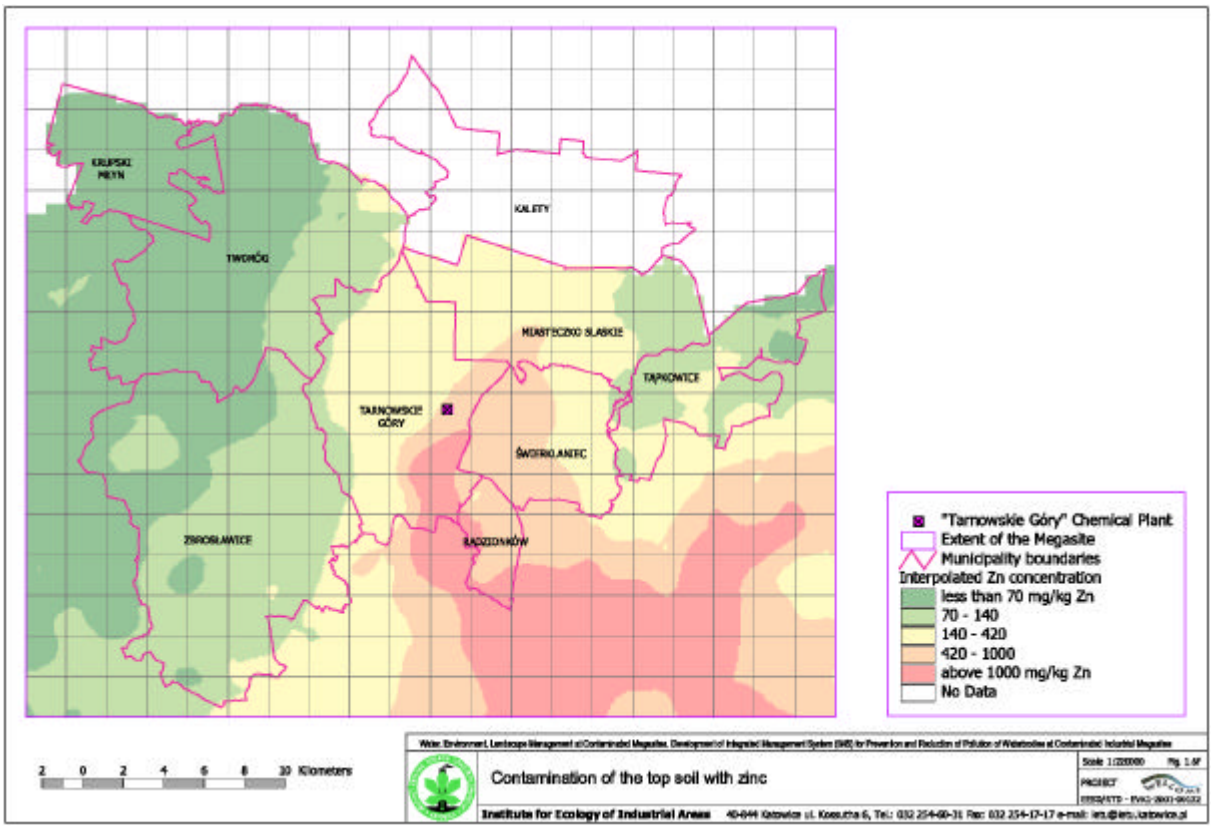

305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Minicipality boundaries
Landuse
Arable area
Meadow and pasture
Agriculture barren land
Coniferous forest
Broad-leaved forest
Mixed forest and not classified
Waste, degraded area, inland marshes
Built-up area
Water bodies
Transport area
Landuse - NATLAN
Inland marshes
Construction sites
Road and rail networks and associated land
Complex cultivation patterns
Mineral extraction sites
Broad-leaved forest
Mixed forest
Coniferous forest
Airports
Non-irrigated arable land
Sport and leisure facilities
Land principally occupied by agriculture
Pastures
Port Areas
Industrial or commercial units
Fruit trees and berry plantations
Dump sites
Green urban areas
Moors and heathland
Discontinuous urban fabric
Continuous urban fabric
Transitional woodland-scrub
Water bodies
2 0 2 4 6 8 10 Kilometers
Landuse of the Tarnowskie Góry Megasite
Institute for Ecology of Industrial Areas

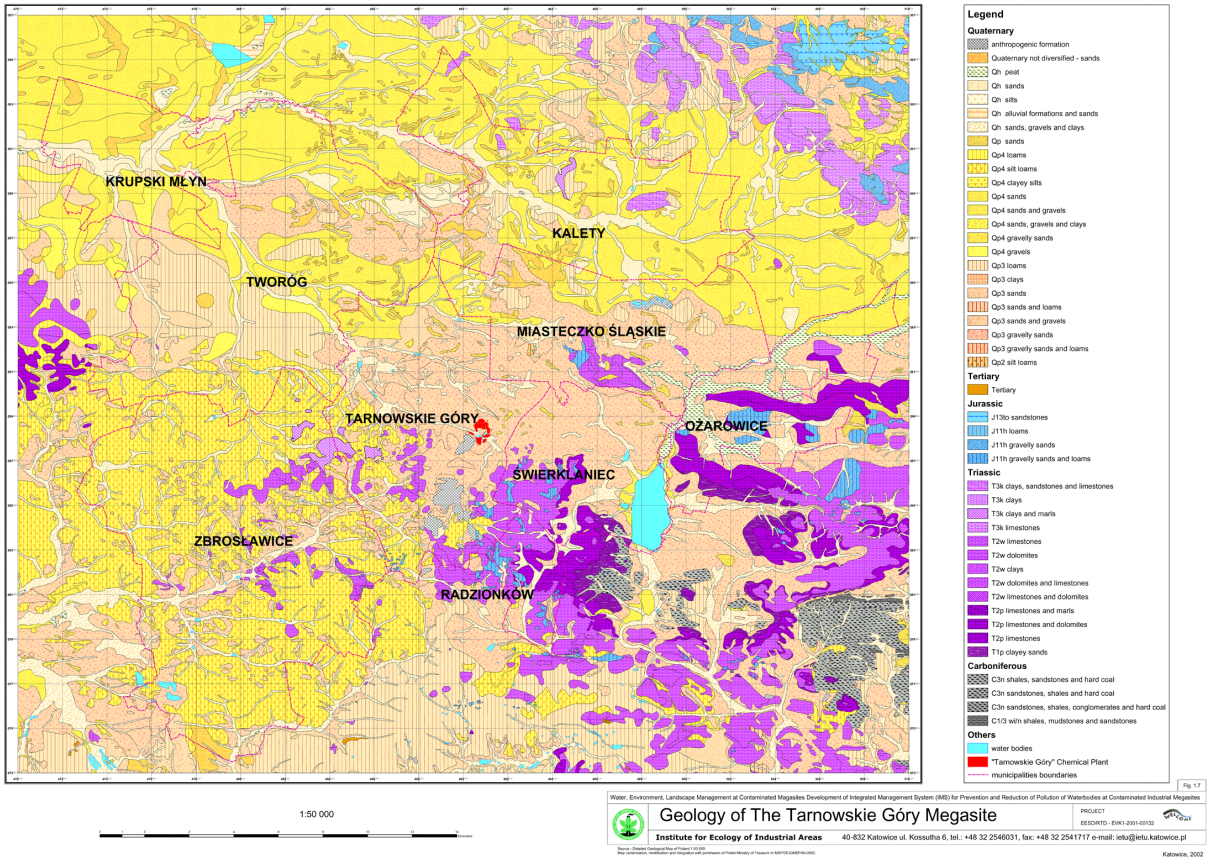

305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
TAPKOWICE
ZBROSŁAWICE
RADZIONKÓW
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Minicipality boundaries
Soil type
podzolic soil and deluvial podzolic soil
podzolic, brown podzolic and brown soils on sands
typical brown soil
leached brown soil
rendzina and brown rendzina
typical meadow black earth
degraded meadow black earth
peat soil on alluvial subsoil
alluvial muck soil on peat subsoil
alluvial soil
brown alluvial soil
gley alluvial soil
gley soil
half bog soil
peat soil of lowmoor
not classified
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Minicipality boundaries
Soil textural groups
rocks
skeletal soils
rendzinas
gravelly soils
sandy soils
loamy soils
silty soils
clayey soils
alluvial soils
peaty soils
not classified
2 0 2 4 6 8 10 Kilometers
Water, Environment, Landscape Management at Contaminated Megasites. Development of Integrated Management System (IMS) for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites
Soils of the Tarnowskie Góry Megasite
Scale 1:200000 Fig. 1.6b
PROJECT
EESD/RTD - EVK1-2001-00132
Institute for Ecology of Industrial Areas 40-844 Katowice ul. Kossutha 6, Tel.: 032 254-60-31 Fax: 032 254-17-17 e-mail: ietu@ietu.katowice.pl

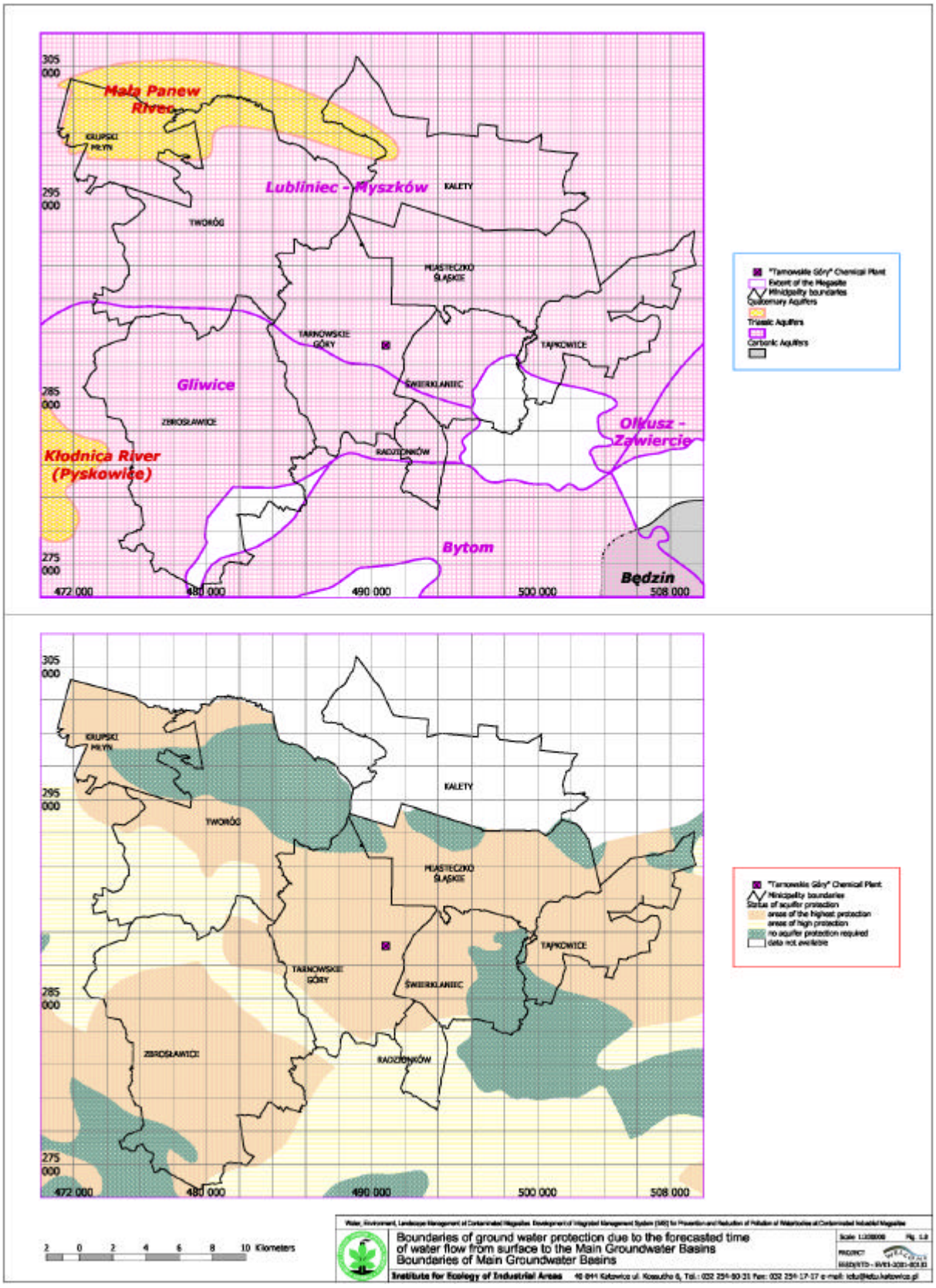

Municipality boundaries
Extent of the Megasite
clay contents in surface soil [%]
0 - 2
2 - 4
4 - 6
6 - 10
10 - 20
5000 0 5000 10000 Meters
Municipality boundaries
Extent of the Megasite
sand contents in surface soil [%]
12 - 50
50 - 60
60 - 70
70 - 80
80 - 97
305 000
295 000
285 000
480 000
490 000
500 000
508 000
KRUPSKI MŁYN
TWOROG
KALETY
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
TĄPKOWICE
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
N
"Tarnowskie Góry" Chemical Plant
Municipality boundaries
Extent of the Megasite
Soil hydraulic conductivity at saturation
below 10 *10-6 m/s
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
above 35 *10-6 m/s
2 0 2 4 6 8 10 Kilometers
Sand and clay contents.
Soil hydraulic conductivity at saturation of the surface layer
Institute for Ecology of Industrial Areas

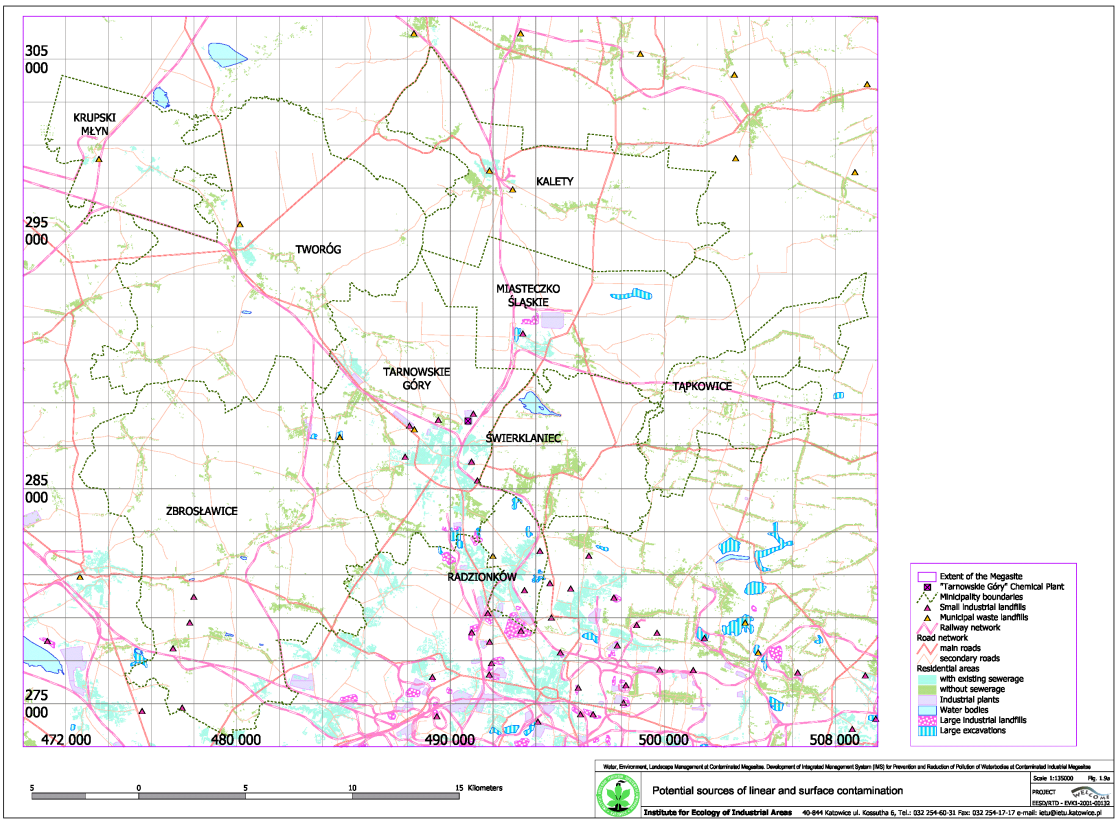

KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Municipality boundaries
Interpolated Cd concentration
less than 1 mg/kg Cd
1 - 3
3 - 10
10 - 20
above 20 mg/kg Cd
No Data
2 0 2 4 6 8 10 Kilometers
Contamination of the top soil with cadmium
Institute for Ecology of Industrial Areas

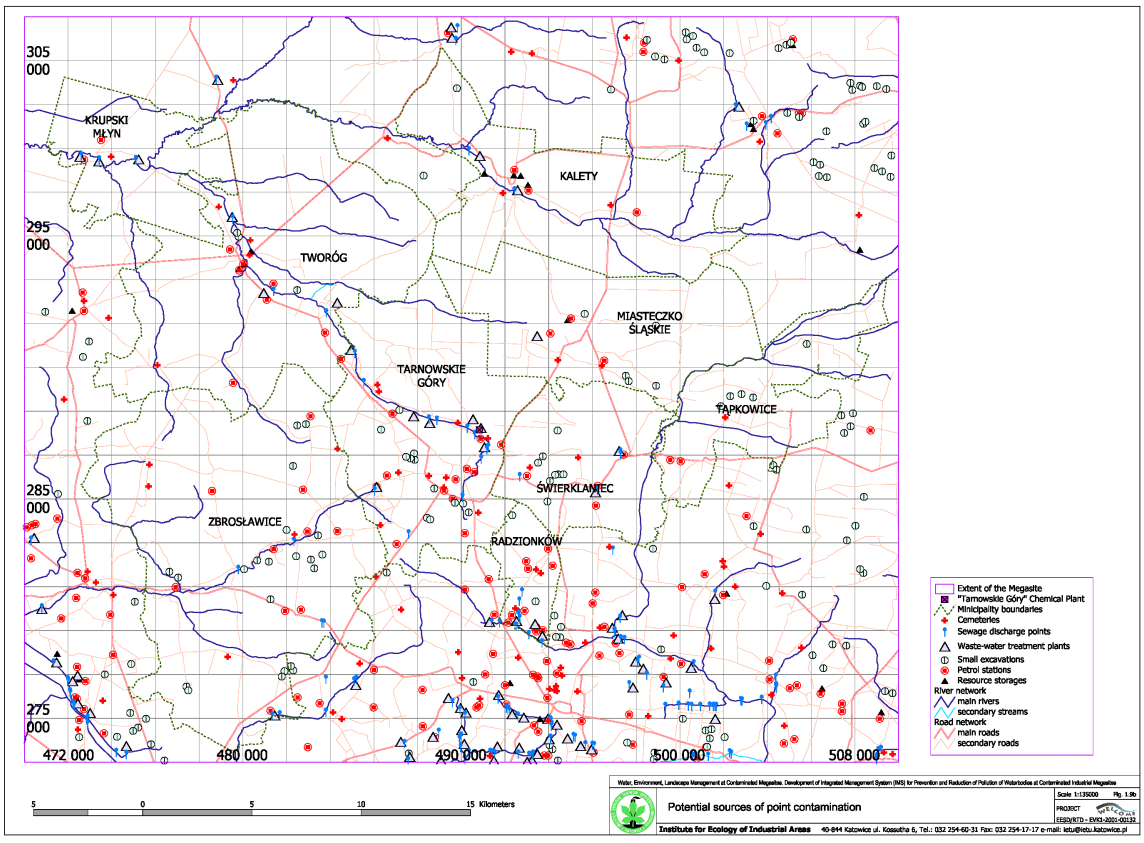

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KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Municipality boundaries
Interpolated Pb concentration
less than 50 mg/kg Pb
50 - 100
100 - 200
200 - 400
above 400 mg/kg Pb
No Data
2 0 2 4 6 8 10 Kilometers
Contamination of the top soil with lead
Institute for Ecology of Industrial Areas

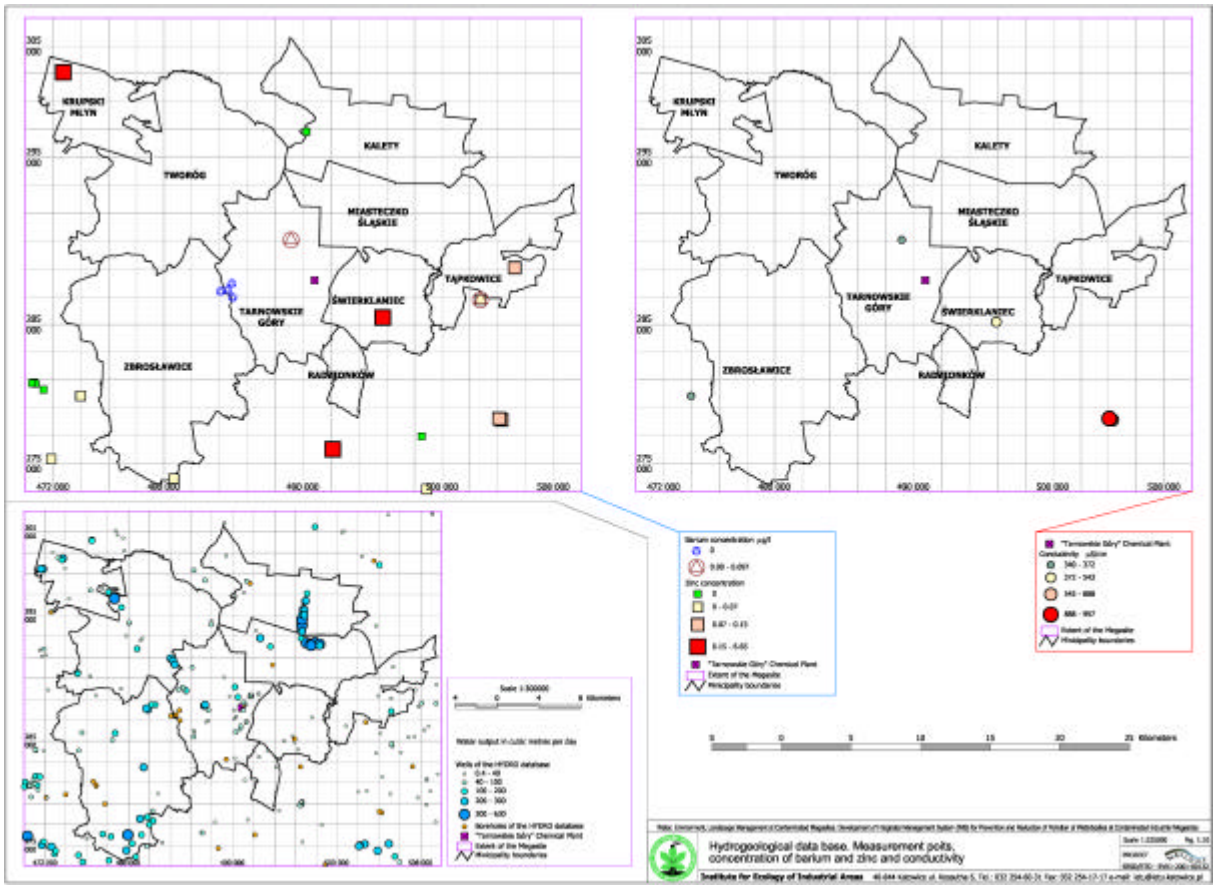

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KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWICE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Municipality boundaries
Interpolated Zn concentration
less than 70 mg/kg Zn
70 - 140
140 - 420
420 - 1000
above 1000 mg/kg Zn
No Data
2 0 2 4 6 8 10 Kilometers
Contamination of the top soil with zinc
Institute for Ecology of Industrial Areas

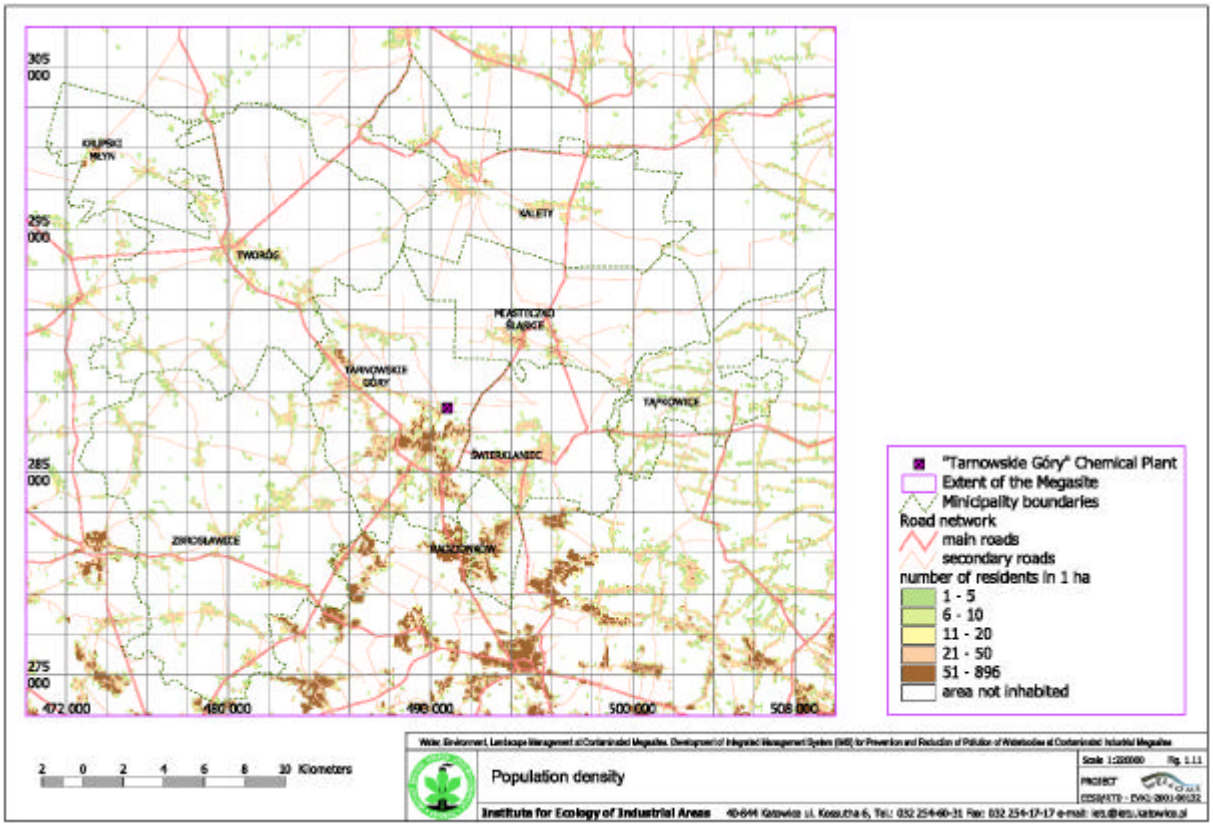

KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
OŻAROWICE
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
Legend
Quaternary
anthropogenic formation
Quaternary not diversified - sands
Qh peat
Qh sands
Qh silts
Qh alluvial formations and sands
Qh sands, gravels and clays
Qp sands
Qp4 loams
Qp4 silt loams
Qp4 clayey silts
Qp4 sands
Qp4 sands and gravels
Qp4 sands, gravels and clays
Qp4 gravelly sands
Qp4 gravels
Qp3 loams
Qp3 clays
Qp3 sands
Qp3 sands and loams
Qp3 sands and gravels
Qp3 gravelly sands
Qp3 gravelly sands and loams
Qp2 silt loams
Tertiary
Tertiary
Jurassic
J13to sandstones
J11h loams
J11h gravelly sands
J11h gravelly sands and loams
Triassic
T3k clays, sandstones and limestones
T3k clays
T3k clays and marls
T3k limestones
T2w limestones
T2w dolomites
T2w clays
T2w dolomites and limestones
T2w limestones and dolomites
T2p limestones and marls
T2p limestones and dolomites
T2p limestones
T1p clayey sands
Carboniferous
C3n shales, sandstones and hard coal
C3n sandstones, shales and hard coal
C3n sandstones, shales, conglomerates and hard coal
C1/3 w/n shales, mudstones and sandstones
Others
water bodies
"Tarnowskie Góry" Chemical Plant
municipalities boundaries
1:50 000
Geology of The Tarnowskie Góry Megasite
Institute for Ecology of Industrial Areas
40-832 Katowice ul. Kossutha 6, tel.: +48 32 2546031, fax: +48 32 2541717 e-mail: ietu@ietu.katowice.pl
Katowice, 2002

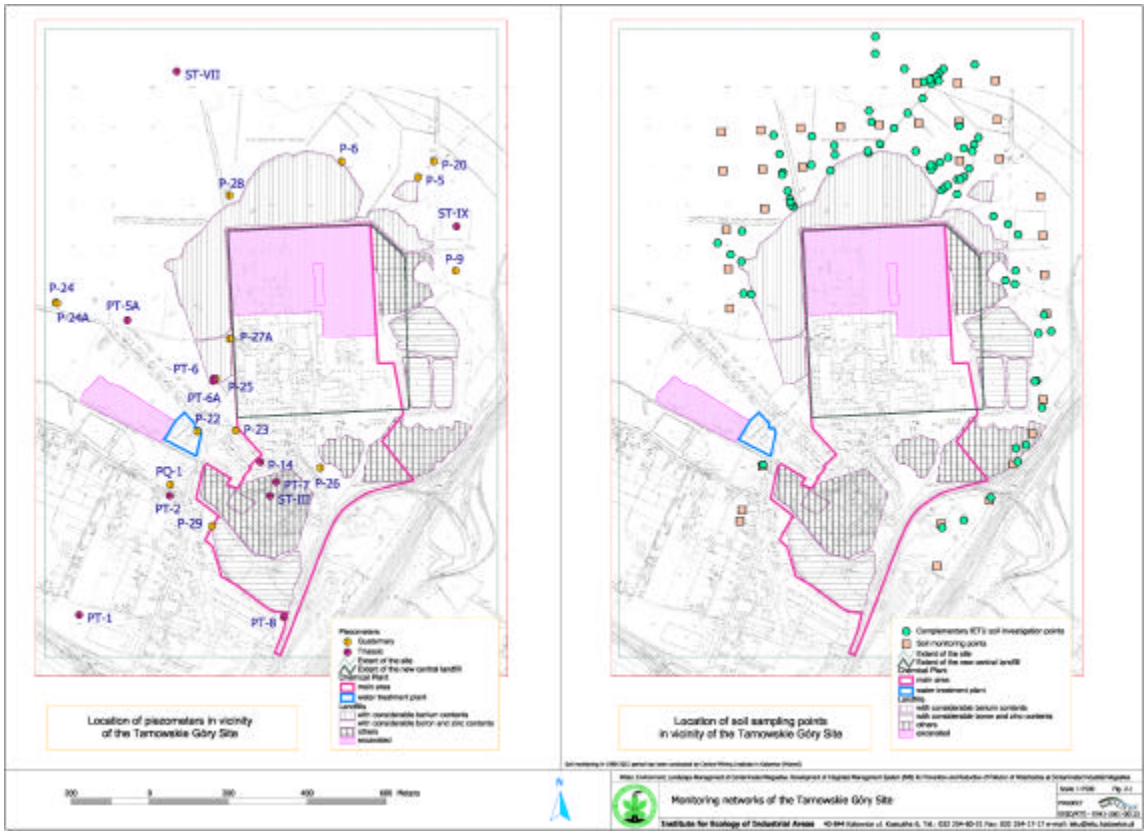

Mała Panew River
Lubliniec - Myszków
Gliwice
Kłodnica River (Pyskowice)
Olkusz - Zawiercie
Bytom
Będzin
KALETY
TWORÓG
TARNOWSKIE GÓRY
TARNOWSKIE GÓRY
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
2 0 2 4 6 8 10 Kilometers
Boundaries of ground water protection due to the forecasted time of water flow from surface to the Main Groundwater Basins
Boundaries of Main Groundwater Basins
Institute for Ecology of Industrial Areas

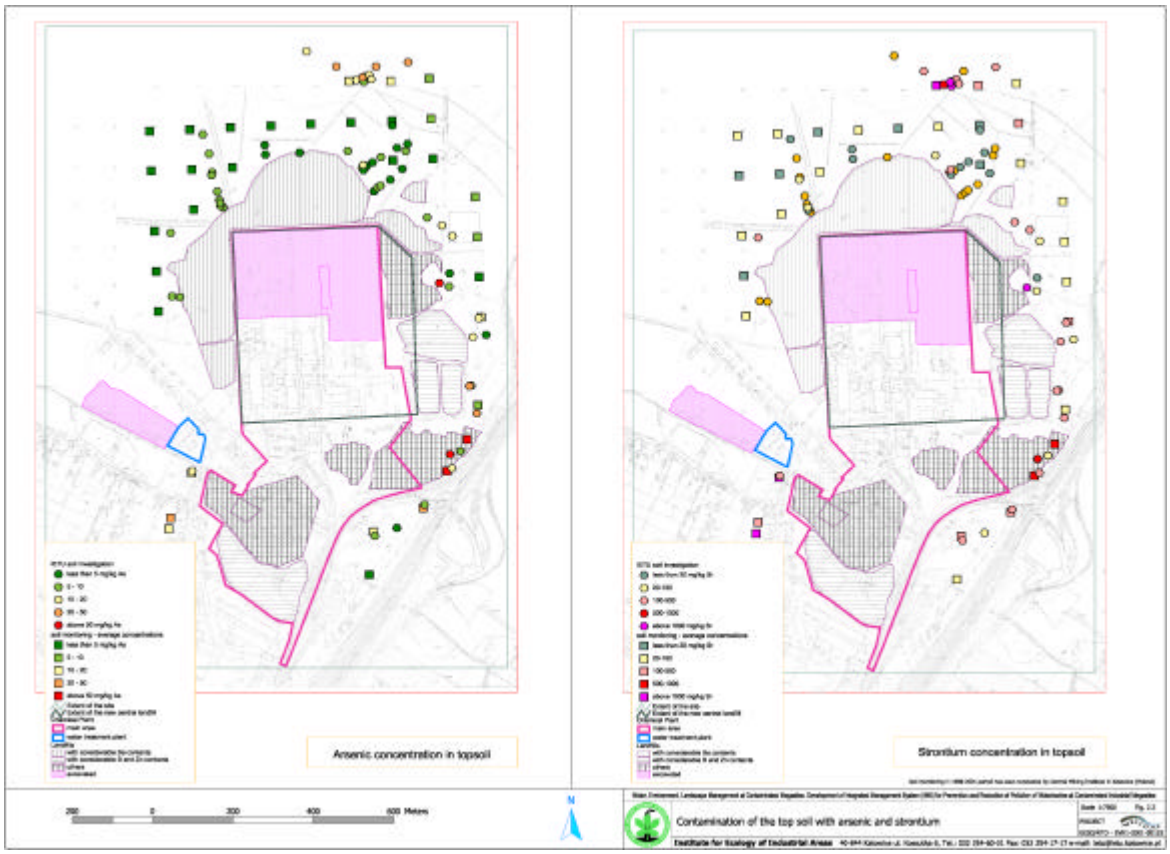

305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
TĄPKOWICE
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
Extent of the Megasite
"Tarnowskie Góry" Chemical Plant
Minicipality boundaries
Small industrial landfills
Municipal waste landfills
Railway network
Road network
main roads
secondary roads
Residential areas
with existing sewerage
without sewerage
Industrial plants
Water bodies
Large industrial landfills
Large excavations
5 0 5 10 15 Kilometers
Potential sources of linear and surface contamination
Institute for Ecology of Industrial Areas

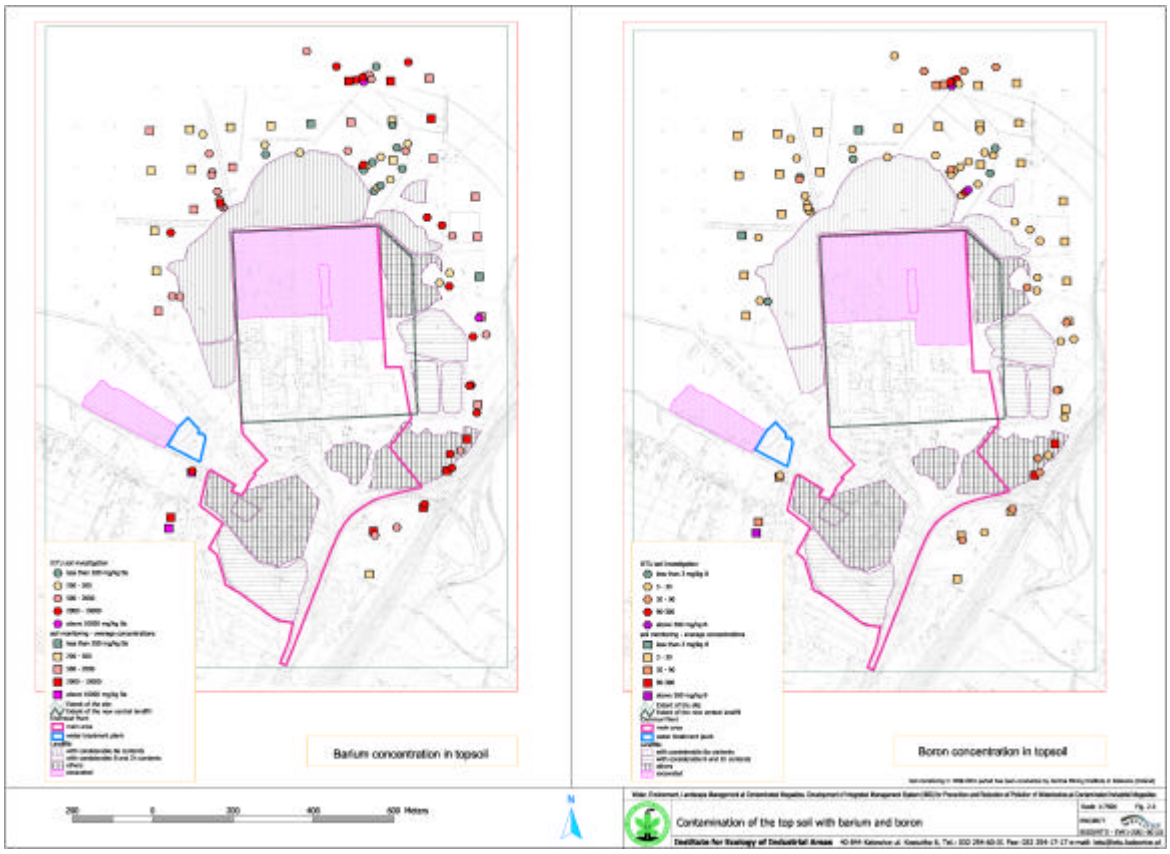

305 000
295 000
285 000
275 000
472 000
480 000
490 000
500 000
508 000
KRUPSKI MŁYN
KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
TĄPKOWICE
ŚWIERKLANIEC
ZBROSŁAWICE
RADZIONKÓW
Extent of the Megasite
"Tarnowskie Góry" Chemical Plant
Minicipality boundaries
Cemeteries
Sewage discharge points
Waste-water treatment plants
Small excavations
Petrol stations
Resource storages
River network
main rivers
secondary streams
Road network
main roads
secondary roads
5 0 5 10 15 Kilometers
Potential sources of point contamination
Institute for Ecology of Industrial Areas

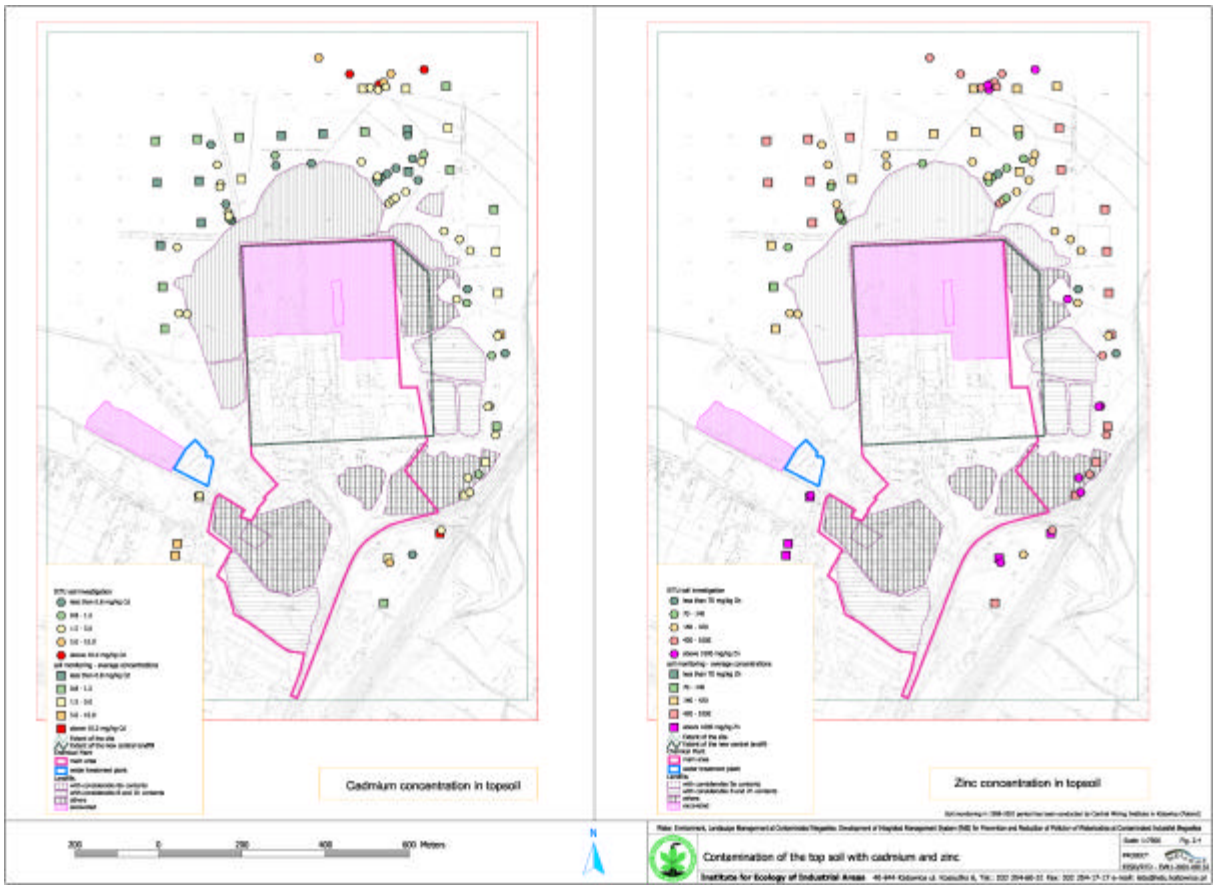

KALETY
TWORÓG
MIASTECZKO ŚLĄSKIE
TARNOWSKIE GÓRY
ŚWIERKLANIEC
TĄPKOWICE
ZBROSŁAWICE
RADZIONKÓW
Hydrogeological data base. Measurement polts, concentration of barium and zinc and conductivity

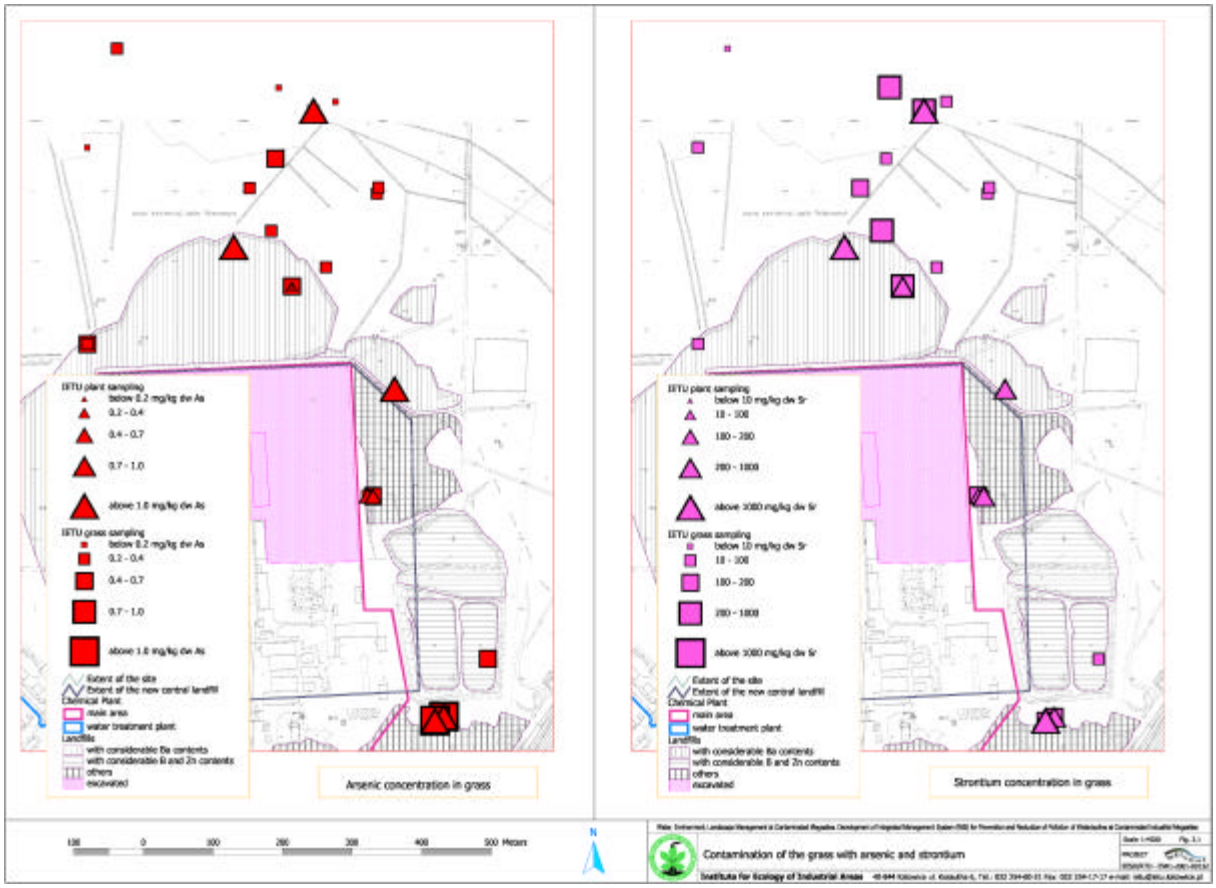

"Tarnowskie Góry" Chemical Plant
Extent of the Megasite
Minicipality boundaries
Road network
main roads
secondary roads
number of residents in 1 ha
1 - 5
6 - 10
11 - 20
21 - 50
51 - 896
area not inhabited
Population density
Institute for Ecology of Industrial Areas

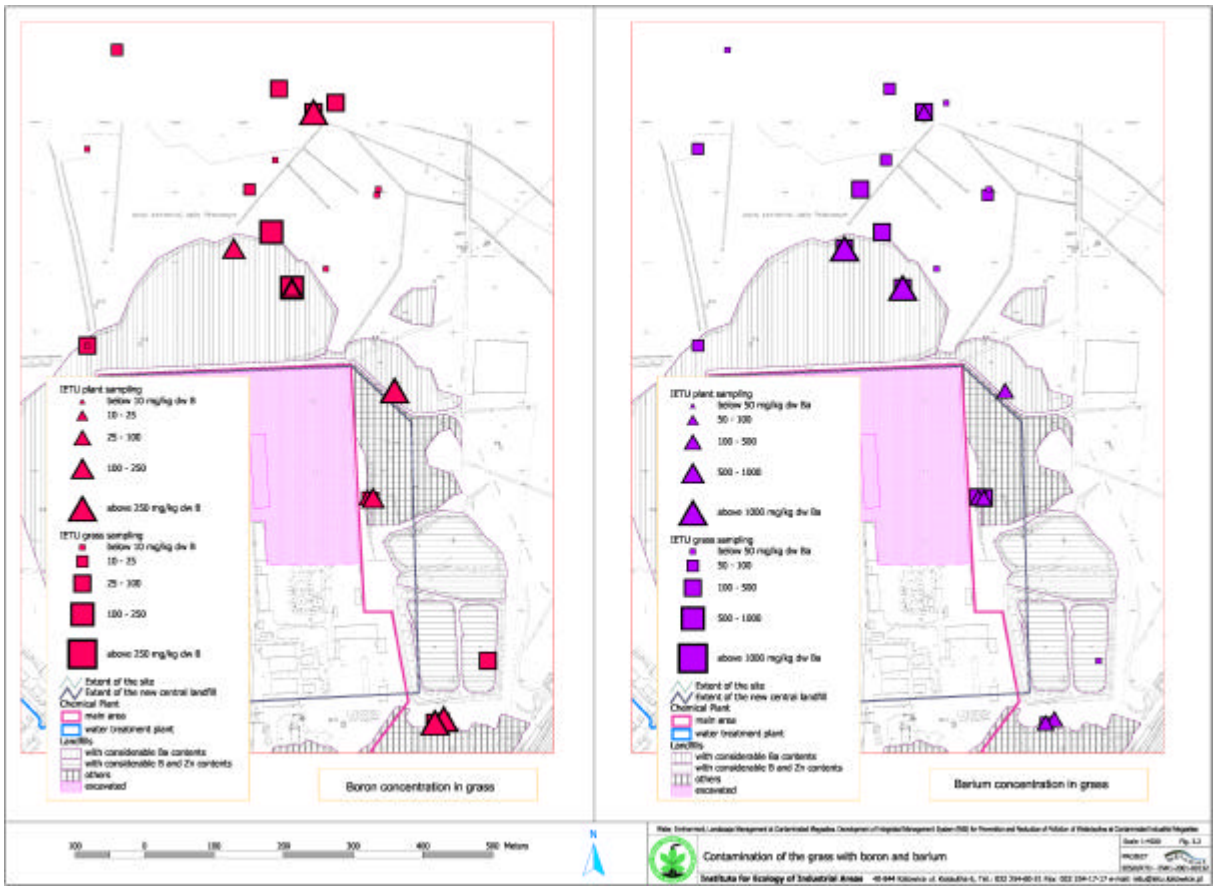

ST-VII
P-6
P-20
P-5
P-28
ST-IX
P-9
P-24
P-24A
PT-5A
P-27A
PT-6
P-25
PT-6A
P-22
P-23
P-14
PQ-1
PT-7
P-26
ST-III
PT-2
P-29
PT-1
PT-8
Location of piezometers in vicinity of the Tarnowskie Góry Site
Location of soil sampling points in vicinity of the Tarnowskie Góry Site
Monitoring networks of the Tarnowskie Góry Site

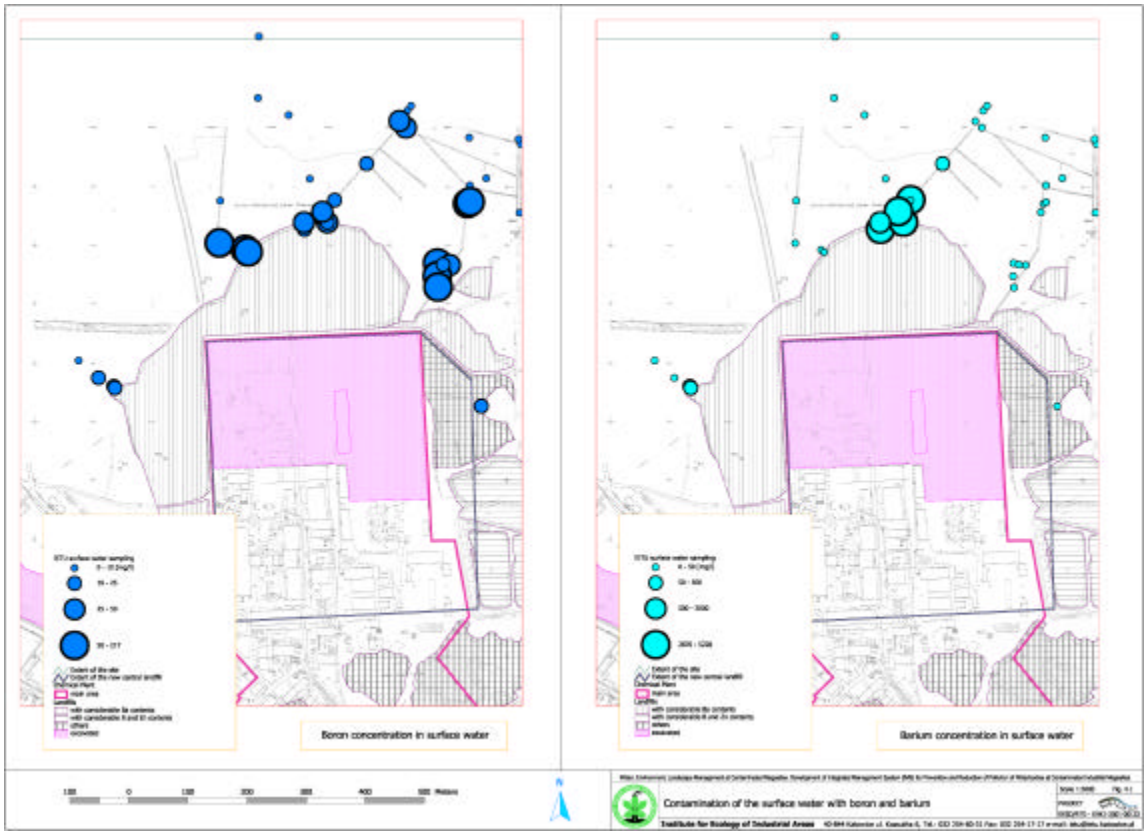

Arsenic concentration in topsoil
Strontium concentration in topsoil
Contamination of the top soil with arsenic and strontium

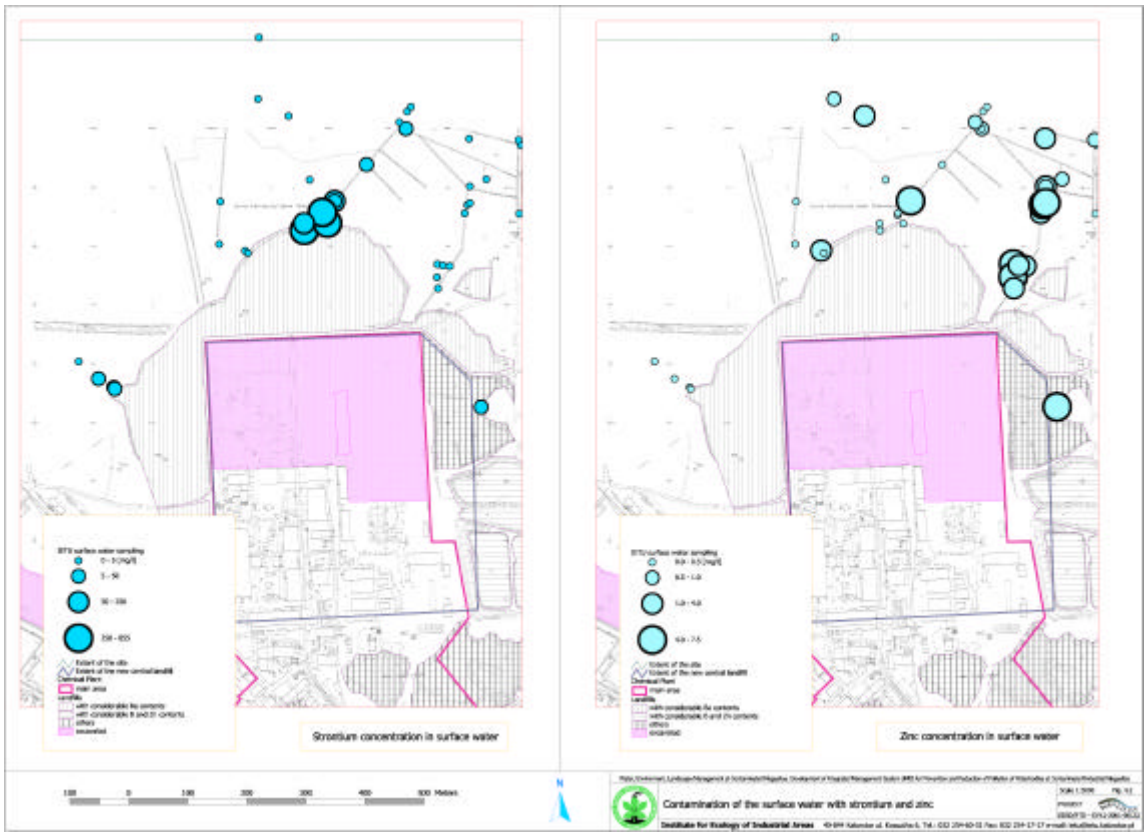

Barium concentration in topsoil
Boron concentration in topsoil
Contamination of the top soil with barium and boron


Cadmium concentration in topsoil
Zinc concentration in topsoil
Contamination of the top soil with cadmium and zinc


Arsenic concentration in grass
Strontium concentration in grass
Contamination of the grass with arsenic and strontium
Institute for Ecology of Industrial Areas


Boron concentration in grass
Barium concentration in grass
Contamination of the grass with boron and barium
Institute for Ecology of Industrial Areas


Boron concentration in surface water
Barium concentration in surface water
Contamination of the surface water with boron and barium


Strontium concentration in surface water
Zinc concentration in surface water
Contamination of the surface water with strontium and zinc