Project Investor: CITY OF BYDGOSZCZ
BYDGOSZCZ CITY COUNCIL
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CONCEPT OF RECLAMATION THE COBRAMAN PROJECT TERRAIN IN BYDGOSZCZ

Output 5.2.2

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INTRODUCTION

The subject of the feasibility study is the analysis of the concept of reclamation the COBRAMAN project terrain in Bydgoszcz.

From several years Poland is being a part of international reclamation projects and programs. The reclamation programs prepared by gminas (communes) should more, than so far, cover the areas degraded by industrial activity, in order to rename their functions.

Among this kind of programs is project COBRAMAN "Manager Coordinating Brownfield Redevelopment Activities", supporting reclamation of post-industrial areas in Central Europe.

Neglected post-industrial areas are located in each European city. Researches in about 500 polish cities showed, that almost 80% of urban centres with about 100 000 of citizens, administrate this type of grounds. Local administration representatives have problems with finding ideas, how to restore the attractiveness. Only 6 polish institutions are running financial projects of COBRAMAN for Central Europe (Central Europe Program).

In this small group has its place Bydgoszcz, where a team of City Council workers is managing COBRAMAN project. This international project is concentrating on reclamation post-industrial areas in Central Europe and is co-financed by European Union.

Project COBAMAN in Bydgoszcz has been selected in the firs call competition in year 2008.

The subject of the projects is i.a. reclamation of terrain located in Bydgoszcz, on 36-38 Jagiellońska Str.

The reclamation process is going to be realized in period from January to November 2011.

The project realization will bring solutions of problems resulting from harmfulness of polluting substances in soil of the area covered by reclamation, causing danger for townsfolk, and also will help in improving the environment, by cleaning and developing wastelands in Bydgoszcz city.

2. BASIC INFORMATIONS REGARDING THE PROJECT

2.1. Project location

The reclamation terrain covered by COBRAMAN project is located in Kujawskie-Pomeranian Voivodeship, in city centre of Bydgoszcz, on 36-38 Jagiellońska Street, plot no. 2/4, 3/4, 3/6, district 149, register unit – 3 – in the Land Register no. KW 3268.

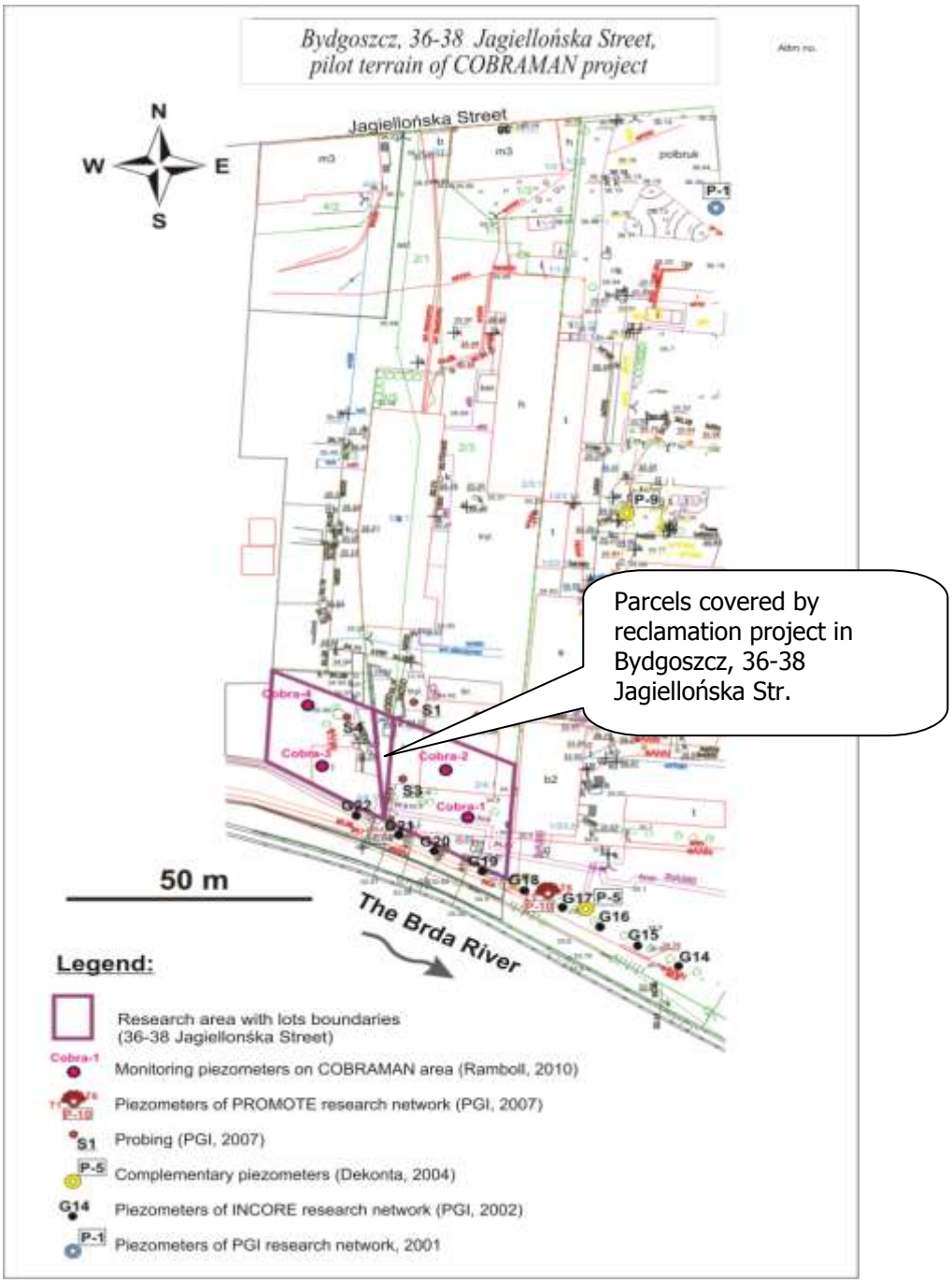


Fig. 1 Map with indication of the area covered by the project COBRAMAN

The area covered by researches is located in city of Bydgoszcz, by the Brda River, on its left bank. According to the partition of Poland by J. Kondracki (1998), area of research is located in centre zone of Torun-Eberswalde Ice-Marginal Valley (Torun-Bydgoszcz Valley) nearby Lower Vistula Valley (Fordon Valley).

2.2. Analysis of the project surroundings

City of Bydgoszcz is a metropolis with 400.000 citizens, the capital of Kujawskie-Pomeranian Voivodeship, located by the estuary of the Brda River into Vistula River and on of the biggest economic hubs in Poland. It is headquarter of many known international corporations, especially representing high technology industry.

Location of Bydgoszcz City in direct neighbourhood of large forest complexes, in valley of Vistula and Brda Rivers and in company of the Bydgoszcz Canal, near the Koronowski Lagoon, gives the greenery sites of Bydgoszcz a particular role of the regional „Green Gate" and the city of transit, a role of the last stop for those, heading towards for the rest in the Tuchola Woods, neighbouring woods or by the Koronowski Lagoon, or other open water.

Rivers Brda and Vistula and also the Bydgoszcz Canal are a very important element of the Bydgoszcz landscape and also associated with each water system. Through the city flows the Brda River, which flows into the Vistula, in place called „Brdyujście" *(the Brda estuary*), and the Bydgoszcz Canal leads to the Noteć River and next do the Odra River. Within the city there are three antique locks of the Old Canal, constructed in 1773, two locks of the new canal, build in years 1910-15, including the City Lock located in the Old Town, three locks on Brdyujście, including only one in Poland roller gate dam, sub staging weirs in the Old Town and the dam on the Brda in Smukała, sub staging the river and forming the Smukała Lagoon. In the city and its surroundings are a few other channels cross-cut in the eighteenth and nineteenth centuries, which are together called the Bydgoszcz Water Junction.

The diverse topography and vast areas of surrounding forest make the existing and planned green spaces in Bydgoszcz possible to be both rich in biodiversity as well as attractively prepared.

The authorities of Bydgoszcz, in the interests of the natural environment of the City, carry out many projects related to environmental protection and improvement of life in friendly surroundings.

The green areas are part of the environment surrounding Bydgoszcz by a green ring. For the enrichment of natural life they are combined with the neighbouring areas by creating ecological corridors. Leading tending economy, that is flora and fauna friendly, allows the repopulation of green areas for any species of animal, by leaving the natural enclaves and safe refuge.

In the city of Bydgoszcz are 83 nature monuments (recognized under the regulations of the Bydgoszcz Voivode), including 78 monuments of the animated nature (single trees, tree groups, an alley) and 5 monuments of the inanimate nature (erratic boulders, a spring).

The Green areas are so located and designed to decrease negative effects of the traffic, also environmental nuisance of the production, trade, industry and services, fulfilling the role of the green buffer. They are an integral part of residential, cultural, and service development and with it are designed to improve the quality of life and health in the city. Those areas are the background for a wide range of leisure offer, providing space for each inhabitant of the different requirements and preferences

Taking into consideration development of the City, the authorities are preparing the Bydgoszcz City Greenery Development Strategy, which is an instrument necessary for taking decisions that are long-term and directed, in order to effectively manage and care of green spaces and improve the quality of life in the city. Strategy, in accordance with the principles of sustainable development, is intended to lead in the spatial order, legibility of the urban space, harmonizing the city with the natural, culture and landscape environment, but mainly intended to improve quality of life in the city and increase its aesthetic value.

2.3. Description of the project site and current status

The terrain, that is intended to be rehabilitated, is an undeveloped wasteland, located in city centre, qualified as „Bz” - recreation and leisure area. It is owned by the commune of Bydgoszcz. It is surrounded by a wall from the eastern and southern side. To this wall is attached ground heat pipeline. On mentioned above area are located tree and bush plantings. In present, the area is not used. It’s surface measures 1 130 m^2. The project area is separated from the Brda River by small, undeveloped greenery.

The course of borders of relevant terrain is a result of cadastral division in this part of the City and only from south side, the natural border is determined by The Brda River. From the east side it borders on the terrain of former city gasworks and from the west with office buildings, among others CTO headquarters, and from the north with construction investment terrain (apartment building) belonging to company OG-BUD. Additionally analyzed area is neighbouring with „The Bydgoszcz Water Junction – revitalization of the boulevards and wharfs", covering reconstruction and building banks protection, reconstruction of lightning, rebuilding of bicycle and walk paths and construction of small architecture objects – project financed by the EU.

Area covered by mentioned above investment and the COBRAMAN project plots are neighbouring with each other.

The Brda Wharf, in place covered by project, has 150 year history of development. In past were located here numerous private companies and workshops in buildings, roof shelters and warehouses, which have been demolished. Earlier, was located here city tram depot, and before that - Bydgoszcz Building Paper Plant E. Aron and Co. Limited Partnership, formerly Robert Aron Bydgoszcz and Bydgoszcz Gasworks, which functioned in the years 1860-1973, supplied tar for the saturation of paper and cardboard in that paper factory.

Fig. 2 General view from the other side of the Brda on the Old Gasworks terrain and the neighbouring area covered by COBRAMAN project

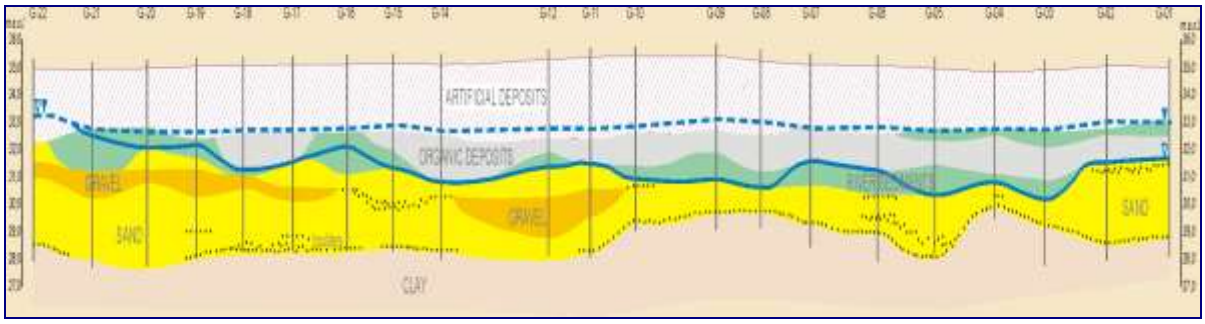


Fig. 3 Geological cross-section along the control plain of the INCORE project

The authorities of Bydgoszcz, realizing a threat, have taken decisions to exclude this area and submit it to the treatment (rehabilitation). Based on Ground Changes Register (Wykaz Zmian Gruntowych) on 27.09.2007 was drawn, and accepted by Magistrate Centre of Geodesy and Cartography Documentation in Bydgoszcz on 04.10.2007, a change in register of grounds and buildings for plots 2/4, 3/4, 3/6 regarding the type of use from „Bi" - other built up areas to „Bz" - recreational areas.

From the geological angle the area covered by researches (COBRAMAN pilot terrain), is localized mostly in embankment grounds, which thickness reaches 3m. These are located in sands and mud, genetically related to development of the Brda, and in fluvioglacial sands. The whole set of this permeable sediments, with thickness to 7m, is located in Tertiary motley clays, often interbedded by layers or focuses of brown coal. On boarder of Tertiary and Quaternary deposits, in drillings, can be often found residual pavement, also the analysis of the depth of clay roof location has shown, that fluvioglacial deposits in the region of ice-marginal valley of the Brda, were heavily eroded, up to the erosion of clay and coal. Those processes had effected with formation of characteristic gutters in clays, which came to the glacial trough of the Brda.

In 2007 field works and observation of profiles were conducted. During the stay in the field, there could be organoleptic sensed smells (odours) of water and ground, which indicated to very heavy contamination with organic compounds (mainly by-products of coal gasification) in embankment layer, which ranges from 1.2m to 3m of thickness. Water permeable deposits, i.e. variable-grained sands, gravels and mud, with average filtration ratio k=1x10-7, which are located deeper, also had shown contamination by hydrocarbons. By the preparation of the construction investment project, was i.a. excavated a trench to a depth of 2,5m, in order to remove located in ground foundations, probably remnants of former tram workshops and foundations of the former building paper plant. The excavation had revealed macroscopic contaminations in embankment and natural sediments – the last ones were uncovered during the foundation removal.

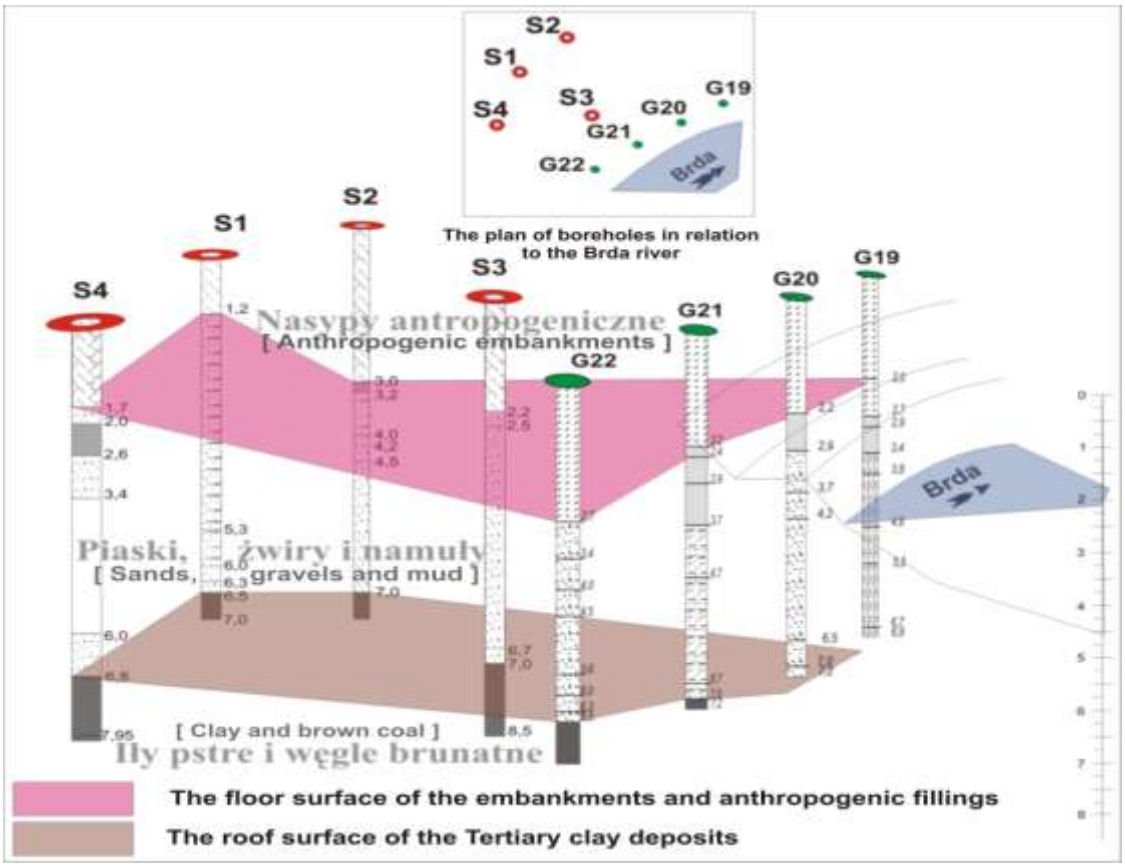


Fig. 4 Results of the researches of the city grounds, next to the Old Gasworks, XII.2007 - geology

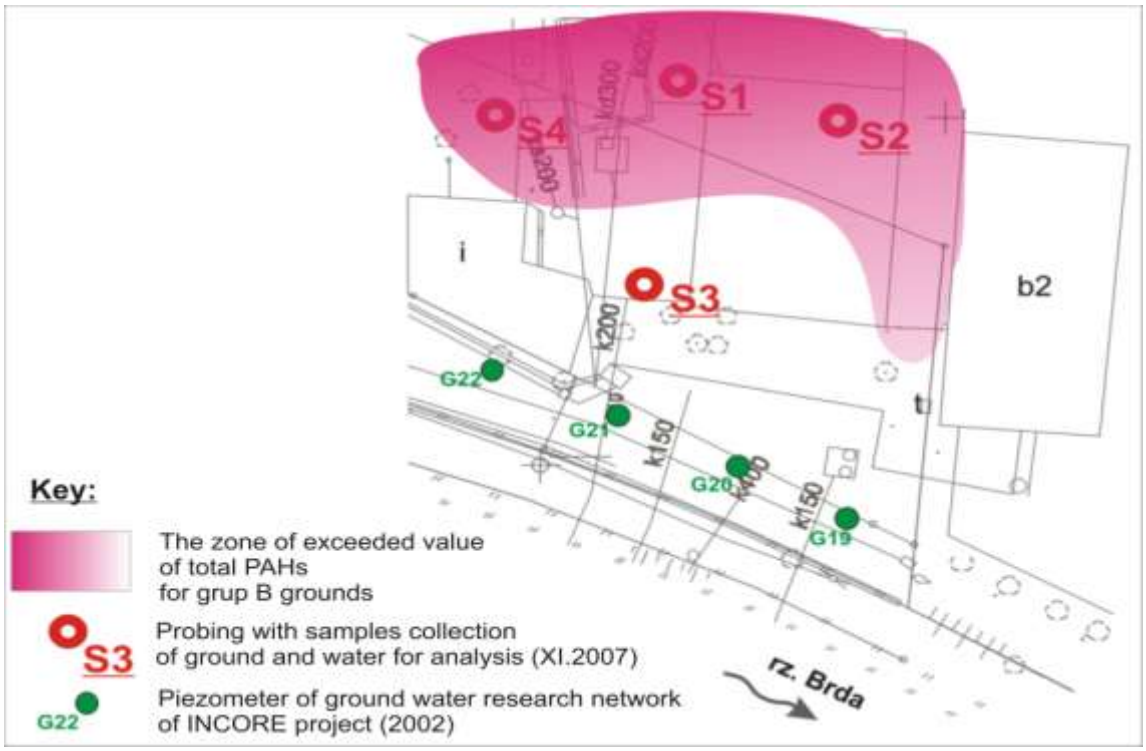


Fig. 5 Results of the researches of the city grounds, next to the Old Gasworks, XII.2007 – geochemistry (PAHs in ground)

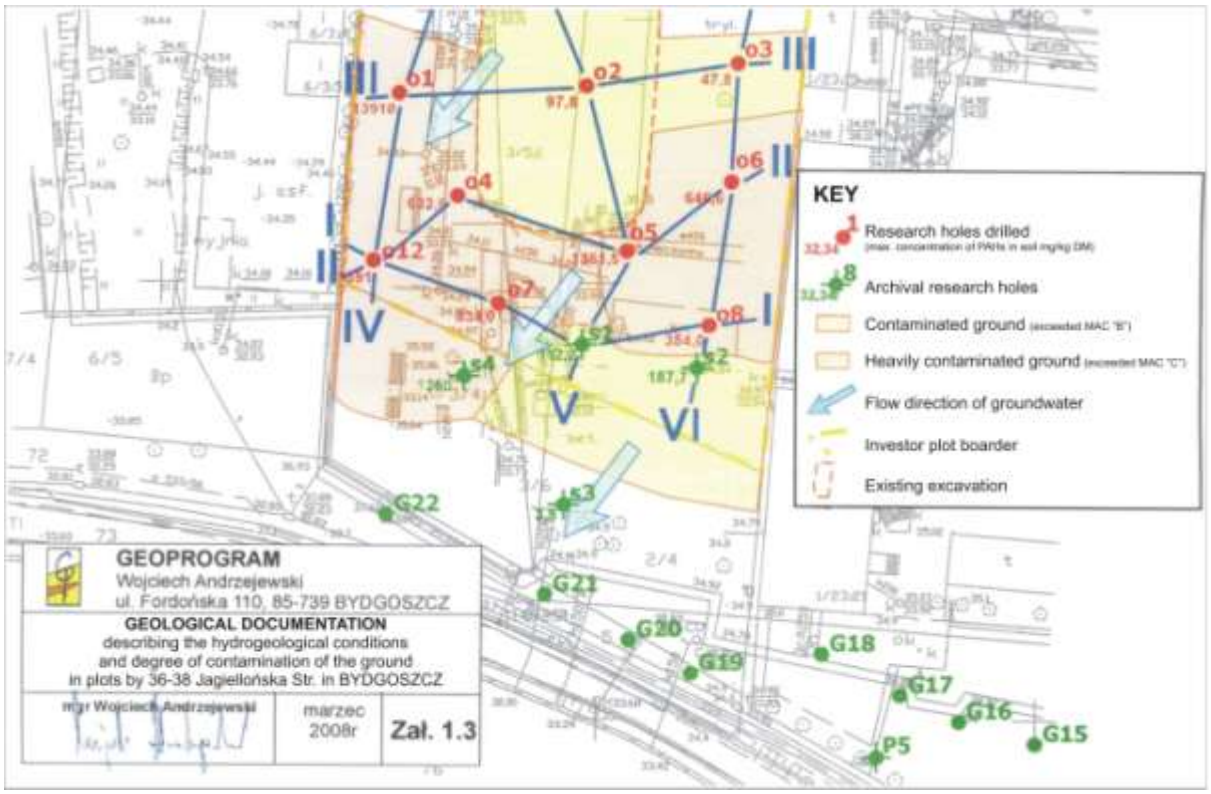


Fig. 6 Results of the investment area researches next to the Old Gasworks, II. 2008 – geochemistry (PAHs in ground)

Conducted researches of soil and underground water, supported by comparisons with underground water researches on neighbouring areas (by the INCORE project) in years 2002 – 2003, had shown, that in terms of quality of the ground, the area is:

1. Heavily contaminated with polycyclic aromatic hydrocarbons (PAHs). The contamination have significant horizontal range, the vertical range is up to 2-3m, and in places even 4m. The concentration of PAHs exceeds the limit values for areas type „B", 5 times, 9 times and even 600 times;
2. Moderately-contaminated with aromatic hydrocarbons (volatile compounds) – contamination has limited range, only in the more thick zone, on 3m of embankment, the concentration stated exceeds limits 5 times;
3. Moderately and incidental contaminated by phenols – point wise, small thickness of polluted embankment, limited value of contamination exceeded 50 times;
4. Moderately and incidental contaminated by mineral oils – point wise, few places, small thickness of the contaminated embankment, concentration exceeded 6-8 times.

In terms of the quality of underground water, researched zone requires reclamation activities – remediation of underground water - due to heavy contamination of PAHs, benzene and other aromatic hydrocarbons.
(„ Research and evaluation of ground quality on property by 36-38 Jagiellońska Street in Bydgoszcz", project no. 95.3200.0732.33.2, executed by PGI on commission of City Council in Bydgoszcz)

In 2010 were conducted re-researches of the grounds, by execution of 4 sounding samplings.

Below is shown the map of research boreholes, drilled during researches in years 2002-2003, 2007-2008 and 2010.

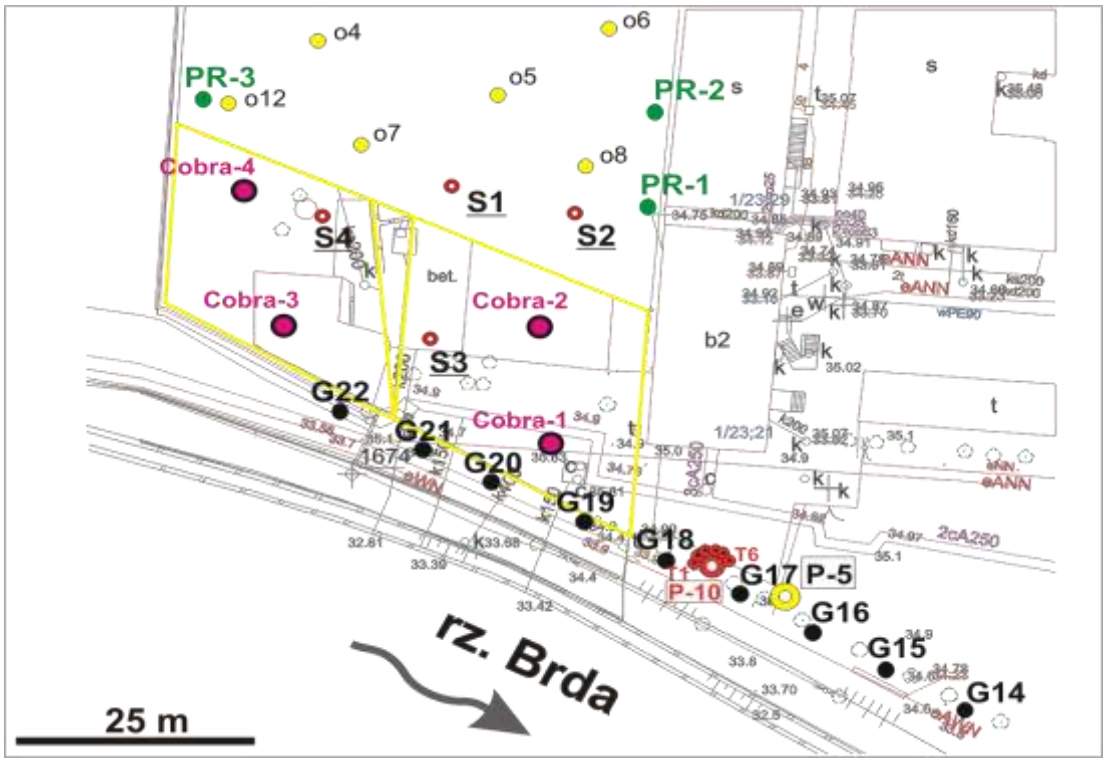
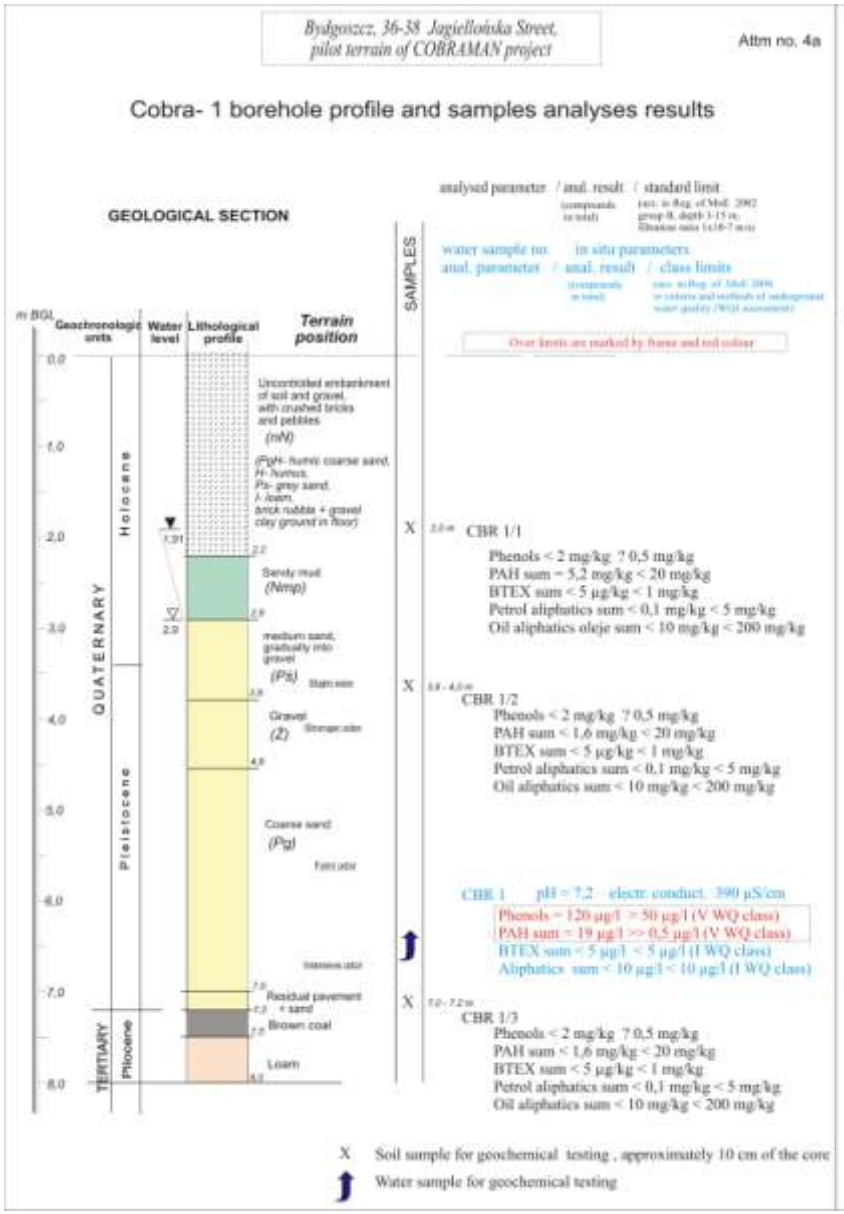
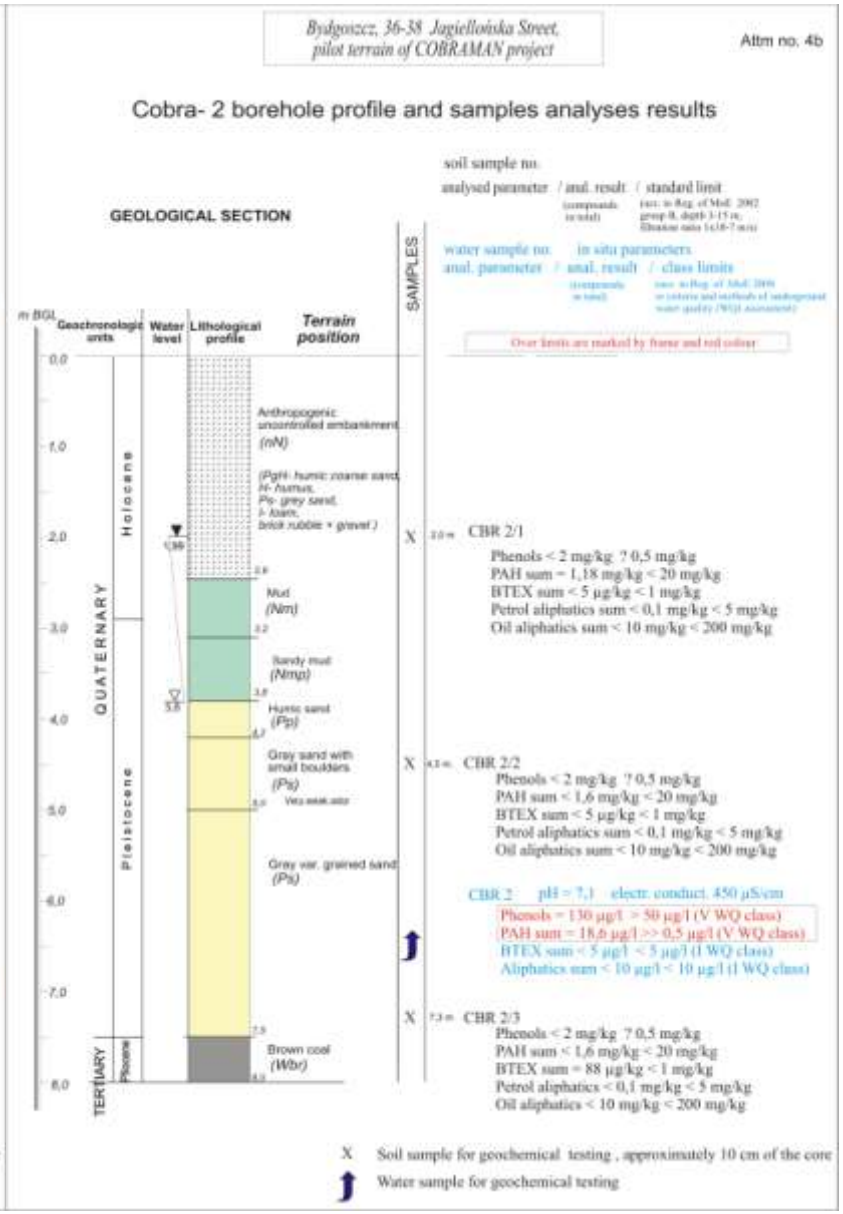


Fig. 7 Research boreholes map, drilled in the area of covered by COBRAMAN project terrain, years 2002-2010

The situation was analogical in probing. Those last researches confirmed the contamination of the ground covered by pilot program COBRAMAN. Below are shown profiles of the boreholes from research probing, executed in 2010 and the results of the samples analysis.





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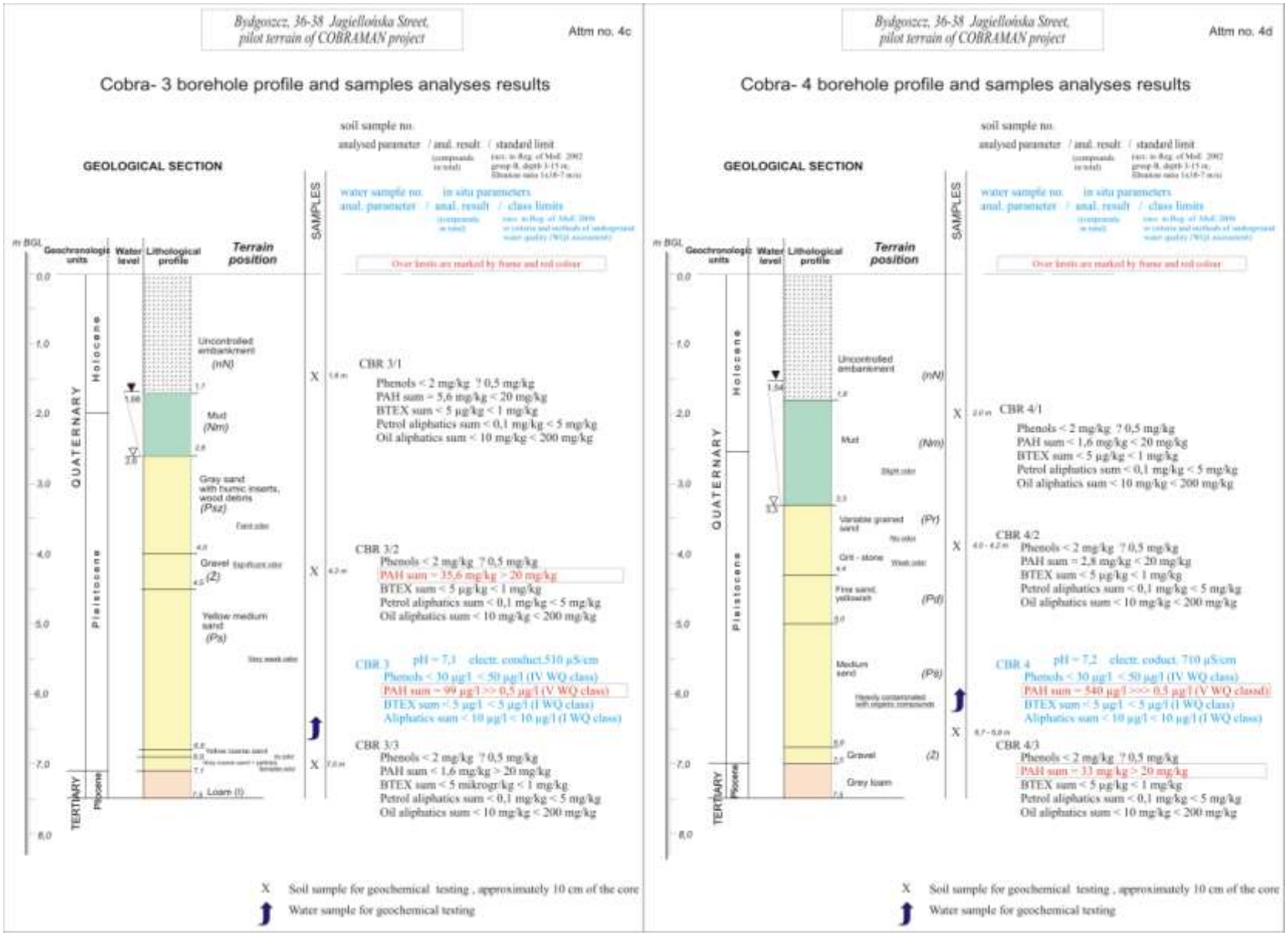

Based on conducted research and samples analysis, a compilation of the data collected was made, which is illustrated on maps below.

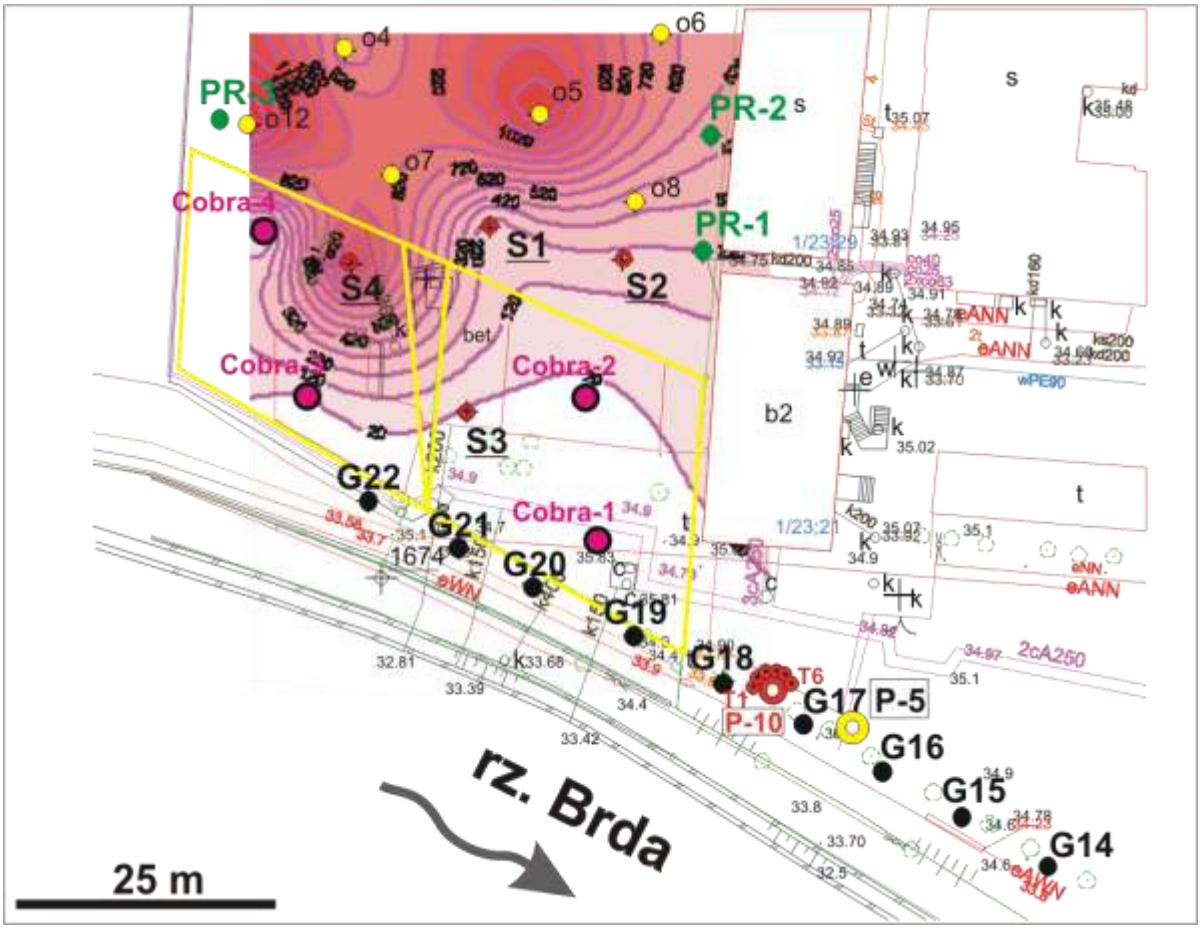

Fig. 8 The map of PAHs values on level I (depth c.a. 1-2-m) in the area of COBRAMAN terrain (compilation of archival data)

On map shown above, in the embankment zone (so called level I, which is 1-2m BGL) about half of the ground have exceeded maximum allowable concentration, (MAC) for PAHs for type B grounds (20 mg/kg DM).

In lower saturation zone, at the interface with tertiary loam is located a small spot of contamination near the western boarder (a derivative of the bigger focus located above and on the north), recognizable are also heavy contaminations along whole boarder with the Old Gasworks – this is the effect of influence, fractionation and migration non-aqueous phase in the floor of the aquifer area.

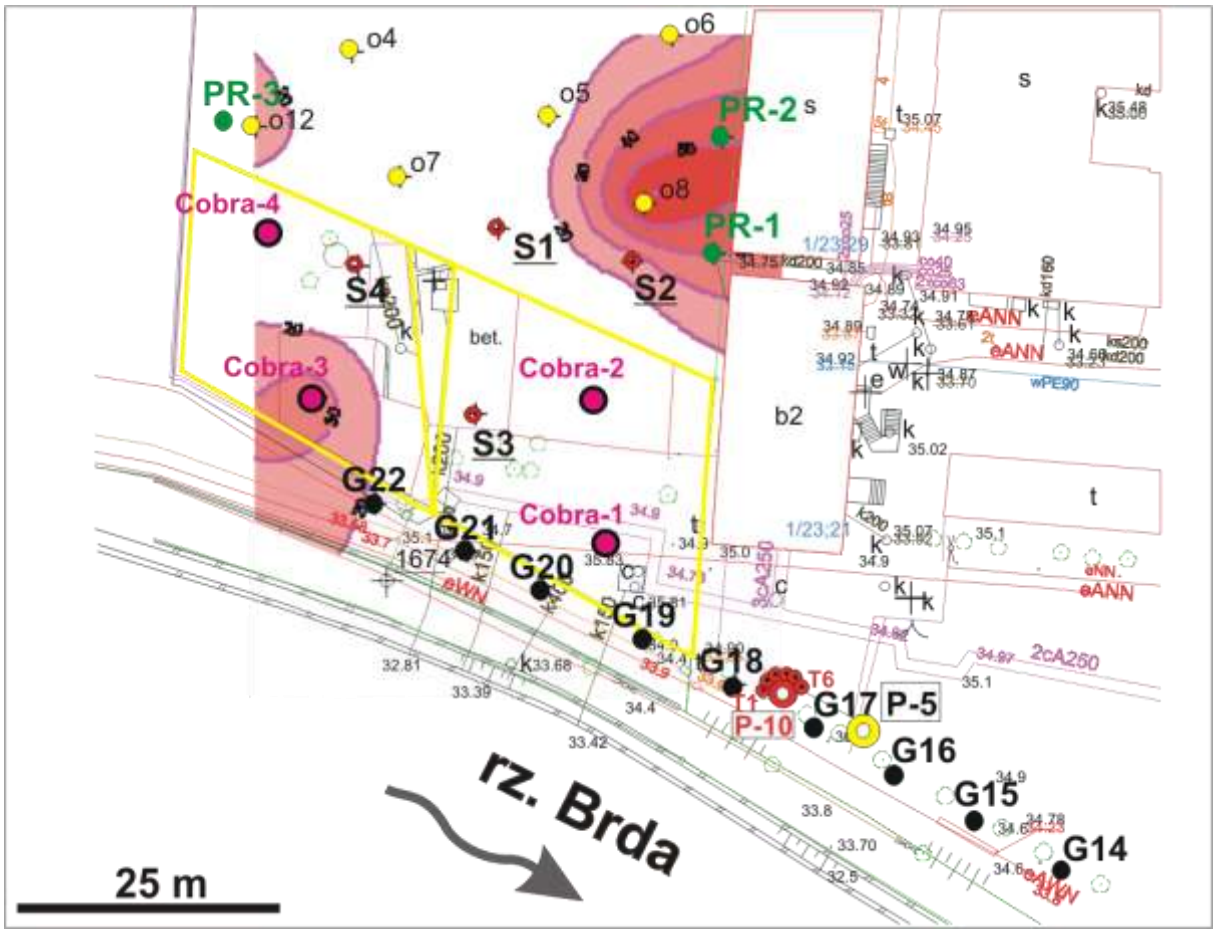

Fig. 9 The map of PAHs values on level II (depth c.a. 4-m) in the area of COBRAMAN terrain (compilation of archival data)

On the map shown above, in upper saturation zone, located under mud (so called level II, which is about 4m BGL) recognizable is a small area, secondary contaminated grounds (gravels zone). PAHs are migrating probably from focus located originally by the OGBUD and NOT properties boarder or (which is more probable) glacial gravel outwash („praodsyp") from very heavy focus of contamination localized primarily on OGBUD terrain, by the boarder with the Old Gasworks.

On below shown map, in lower saturation zone, at the interface with tertiary loam, is located a small spot of contamination by western boarder (derivative of bigger focus located above and on the north), at the same map are also marked heavy contaminations along whole boarder with the Old Gasworks - this is the effect of influence, fractionation and migration non-aqueous phase in the floor of the aquifer area.

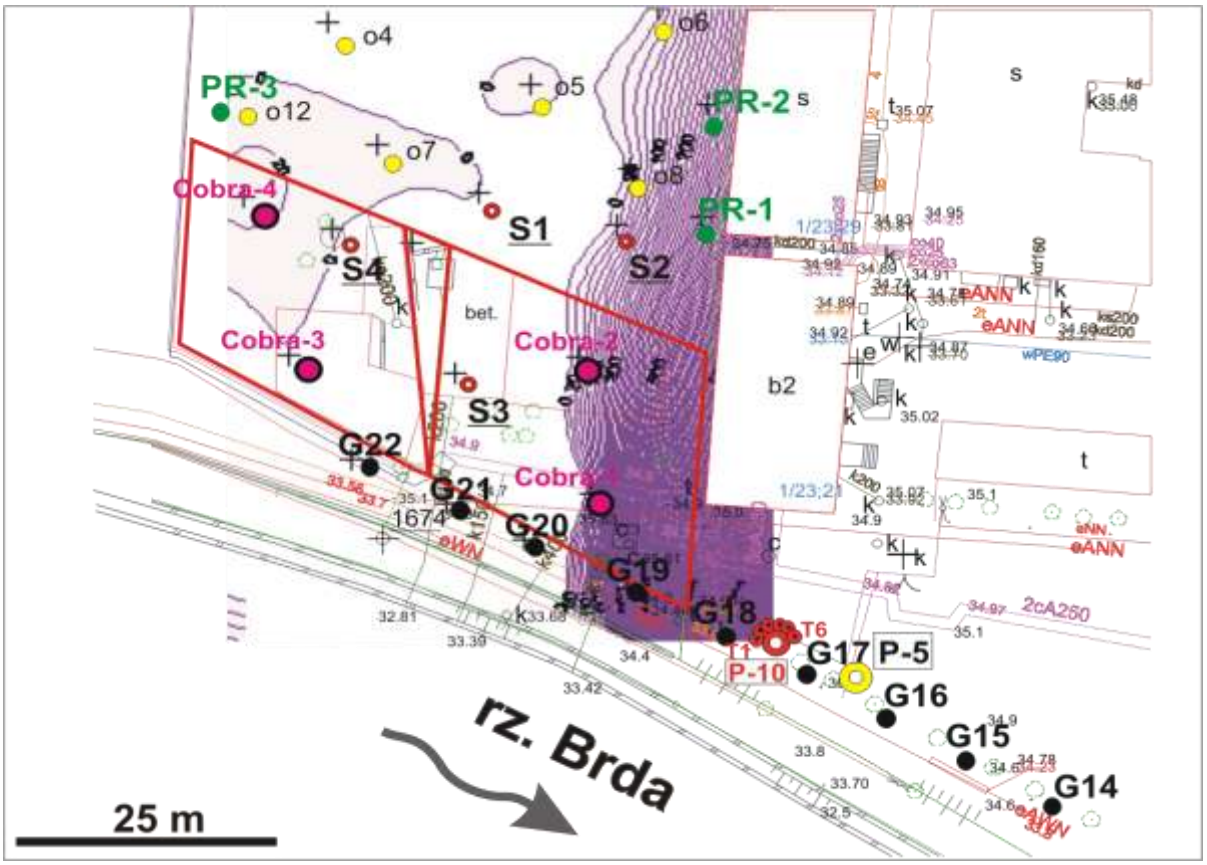

Fig. 10 The map of PAHs values on level III (depth c.a. 6-7 m) in the area of COBRAMAN terrain (compilation of archival data)

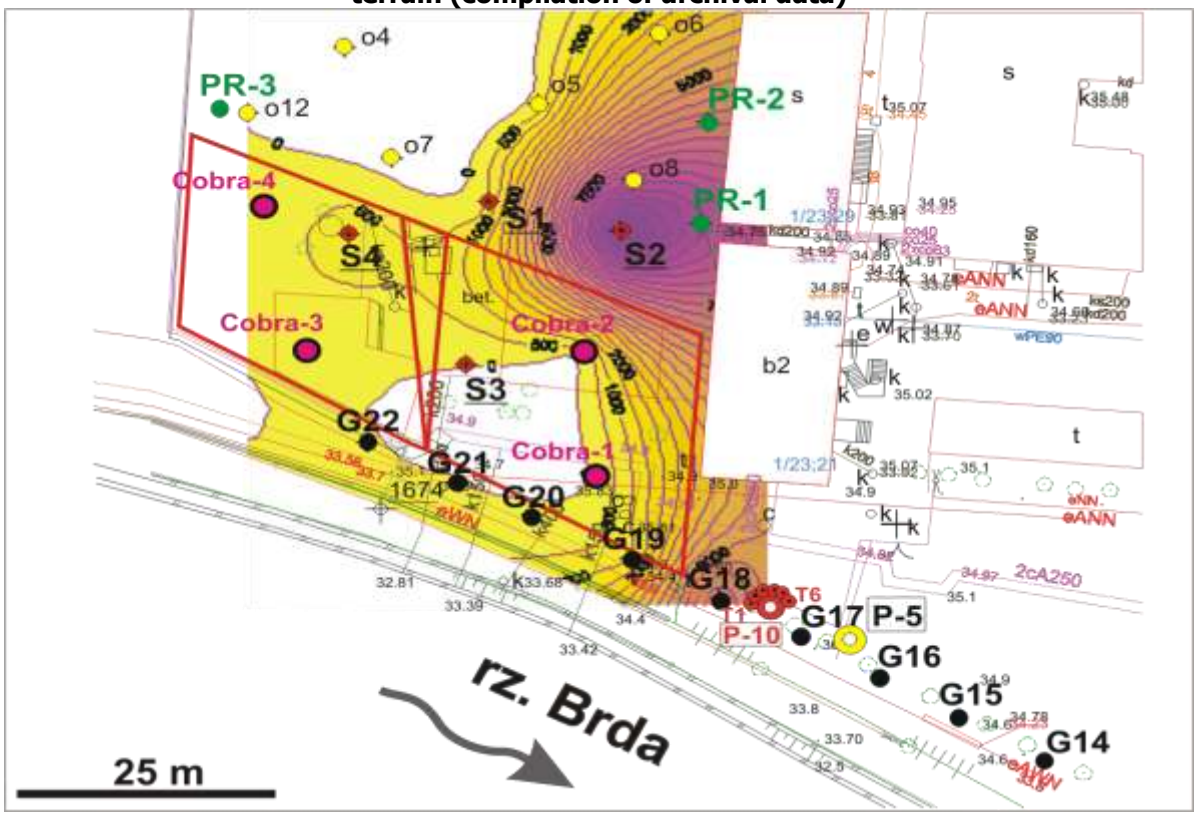

Fig. 11 The map of PAHs values in the ground water in the area of project (compilation of archival data, values in micrograms/litre)

The diagnosis regarding contamination of water-ground environment for the area covered by COBRAMAN project had shown that on analyzed terrain occurs a contamination of compounds resistant to destruction: aliphatic compounds (petrol, oils), phenols, BTEX and PAHs.

The neutralization of these compounds should be the priority of (bio) degradation.

The analysis of several contaminants have shown, that:

- Oils in samples from 2007 were detectable also in zones of boreholes S1 and S4. At present non-detectable;
- BTEX was detectable – in 2007 in embankment in the area of borehole s2 (concentration was 5.28 mg/kg) and in the area of s4 borehole (concentration was 0.684 mg/kg), in 2008 in the area above the S2 hole (point o8) concentration was 0.5 mg/kg, in 2010 in the sample from Cobra-2 borehole concentration was 130 microgram/litre and in the sample from Cobra-1 concentration was120 microgram/litre;
- Phenols – in 2007 in the sample from S2 hole was 30 microgram/litre, in 2010 in the sample from Cobra-2 – concentration was 130 microgram/litre, and in the sample from Cobra-1 – 120 microgram/litre.

Analyses regarding PAHs values in the area covered by the project are shown above.

3. OPTIONS OF RECLAMATION OF THE SITE COVERED BY THE PROJECT

Preliminary assumptions:

1) None of the included in ground reclamation concepts of the Cobraman project terrain, will be effective and long lasting in time, if the contaminants transportation by underground water from neighbouring areas (mainly Old Gasworks) won't be stopped.
2) The acceleration of reclamation and faster planned developing of the area, can be achieved, if the Investor removes the substantial part of contaminated grounds from the embankment and improve the mineral isolation of the base, and in consequence saturation zone.
3) In each case, at the beginning of works removal of old underground installations, tanks etc. and liquidation of the wall from western and The Brda side is necessary. Burial of existing heat pipeline is also necessary.
4) Each of the concepts involves saving necessary, non-collision, protected boreholes in order of underground water monitoring
5) Each of the concepts consists of the following elements:

- works making the area accessible - as described in the paragraph. 1 - 4 identical for each concept,
- the actual remediation works - a specific range for each of the concepts,
- adaptation and arrangement works - are generally similar in each of the concepts and depend upon the surface preparation of the terrain for needs of the target site development.

3.1. Concept I

This concept involves removing part of the embankment, bioremediation and filling the excavations.

Works, which are necessary to conduct in terms of the concept:

1. Moving into the underground channel the heat pipeline part, currently hanging on the wall from the western side and part from the side of the Brda running on the surface. Responsible for the action: Municipal Heat Power Plant (costs cover by MHPP)

Grounds: ”hiding” the pipeline will allow an access to the area and „set free” the wall, which is the main part of the plot enclosure. It will allow the execution of demolition works of the walls and former pavement and flooring left after demolished garages and also removal remnants of inventory controlled underground facilities (storage tank from reinforced concrete, sewage system).

Hint: time for the moving the pipeline and its deactivation can be correlated with its uninstallation by the boarder with the Old Gasworks terrain on the conflict section with designed barrier (dense wall), and next, after construction the barrier, re-instalment of the heat pipeline.

2. Construction of a temporary access road to the work area from the west. The minimum option is to use travel through parking lot of NOT + 50 m of road with a surface from aggregate 0.2 m thick and a width of 4 m.

   Grounds: the reason for implement the shortest route paved way - through the parking lot of NOT – is to avoid the devastation of trees and lawns along the boulevard between the Brda River and NOT terrain. The minimum to construct section is about 50 m, and it may have a width of 4 m, which is sufficient for the regulated one-way traffic. The road surface must allow access of excavators, trucks and possibly self-propelled crawling paler or cutter of loam barriers. Designed is a construction of the road from ferroconcrete slabs, placed on natural aggregate foundation or recycled one.

   Hint: If agreed before with Municipal Heat Power Plant, which will be earlier deconstructing the heat pipeline and excavate and construct the heat channel, it is possible to construct the road with sharing the costs on both investors.

3. Demolition of the walls and pavement and flooring – remnants of former garages, warehouses and workshops. Removing remains of underground infrastructure (storage tank from reinforced concrete, sewage system).

   The demolition of the wall length of approximately 80 m, a width of about 0.4 m high along with the foundation on average 4 m - this gives a volume of about 128 m^3 of demolition and crushing. Removal of old concrete pavements: about 250 m^2, the average thickness of about 0.2 m - this gives a volume of c.a. 50 m3 to remove and crushing.

   Removal of underground reinforced concrete facilities (the same as the liquidation of the foundations of the building) of approximately 15 m^3 to remove and crushing.

4. Construction of dense wall limiting the flow of contaminated water from the site of the Old Gasworks. Length approx. 50 m, depth of 7.5 m (the need to anchor the wall in the Pliocene clays), the width approx. 0.4 m (the barrier of clay-cement) or a Larsen wall. Preferred is a mill cut barrier of clay-cement.
   Hint: after construction of the barrier or the wall it's possible to re-install the heat pipeline section.

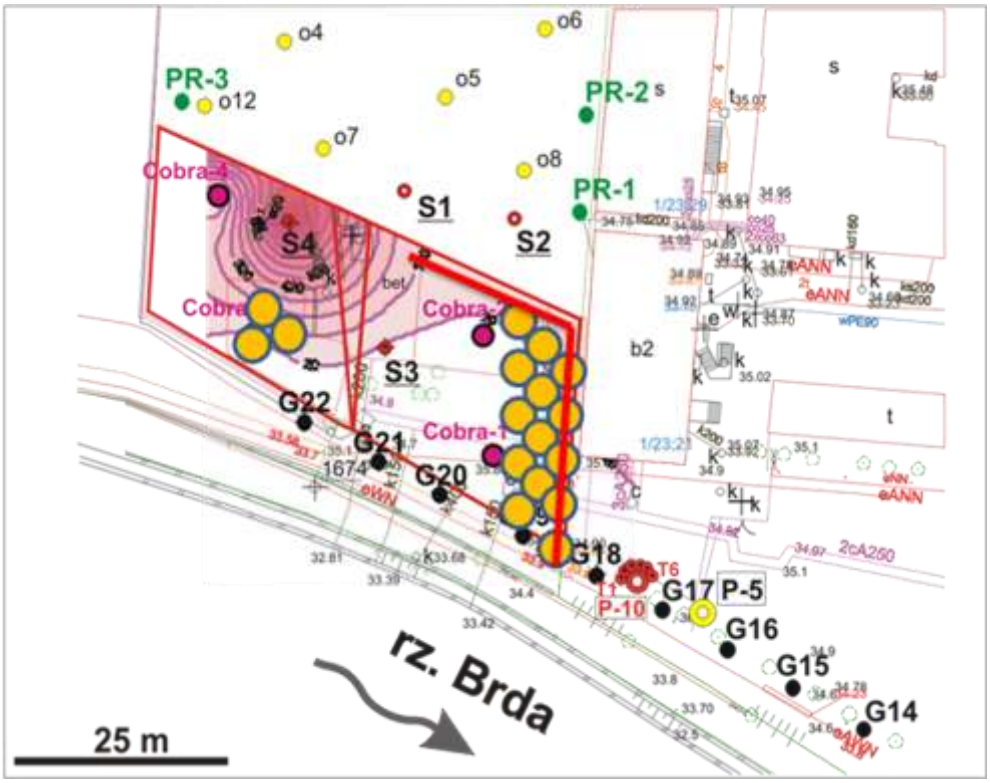

Fig. 12 The map of rehabilitation with the marked barrier limiting the inflow of contaminated water

5. Earthworks involving the removal of the embankment (partly heavily contaminated post-gasification tars) to an average depth of about 2m (storage / remediation of contaminated ground: 1320m^3 - about 2 376 tons of soil) and importing clean ground (loam material clean aggregate or soil). Anticipated soundings will be taken to a depth of 2.5m with the macroscopic evaluation of the profile on grid 5 x 5m.

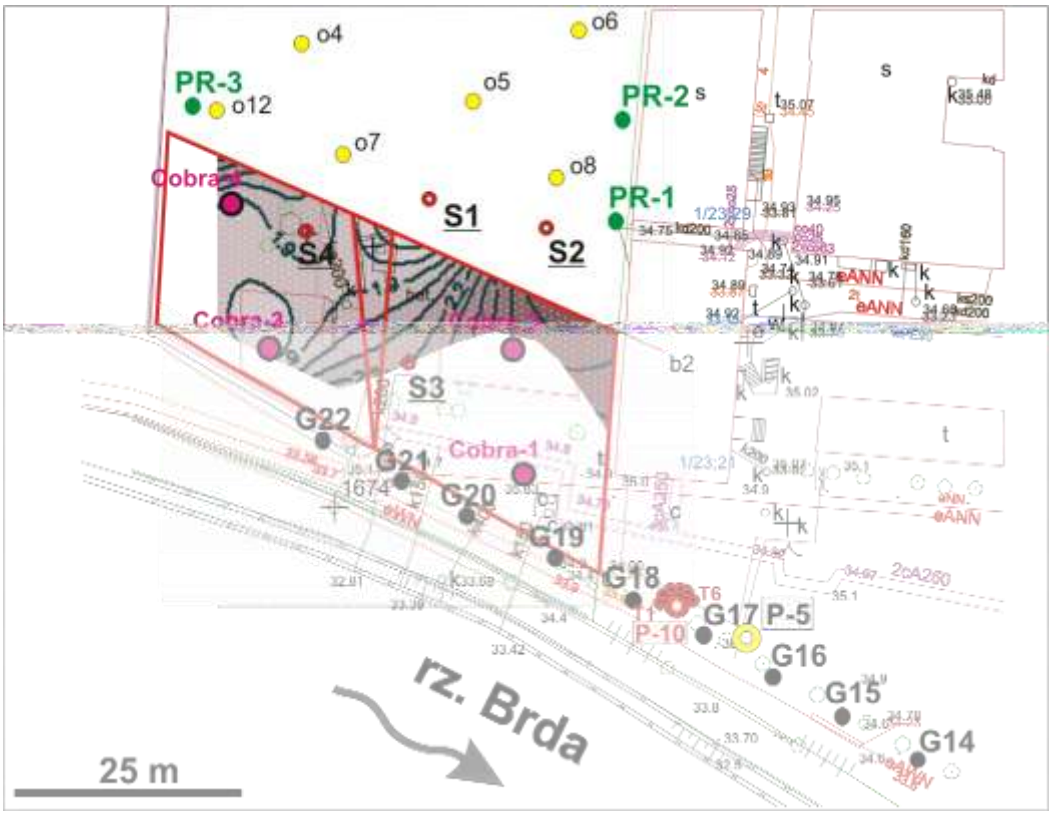

Fig. 13 Map of the concept of removing part of the embankment, bioremediation and filling the excavations

- Exchange of the ground: 660 m^2 x 2 m = 1320 m^3, which is moving out the soil from contaminated with tar compounds zones (preliminary assumptions are, that removal of about 2/3 area covered by the embankment to an average depth of 2m will be necessary). Before filling, the excavation should be saturated with bio preparation mixture (inoculation of bacteria) and „padded" with a 0.5 thick loam layer in order improving the natural horizontal isolation, which currently is formed with sandy mud.
- The probings with macroscopic evaluation and embankments classification map: 30 probings to 3 meters.

6. Before performing the loam isolation, the bottom of the pit should be inoculated with bacterial preparations (preferably by spraying from the tank with diluted bio preparation). Estimated at 1 m^2, should be used 1 / 3 of dose per 1 m^3 of soil.
   Hint: excavation must be left open for about a week in order to better proliferation of bacteria in aerobic conditions. Next should be performed the clay layer and filling the excavation with clean soil, while on the surface of the ground use humic soil appropriate to the needs of greening plan for the area.

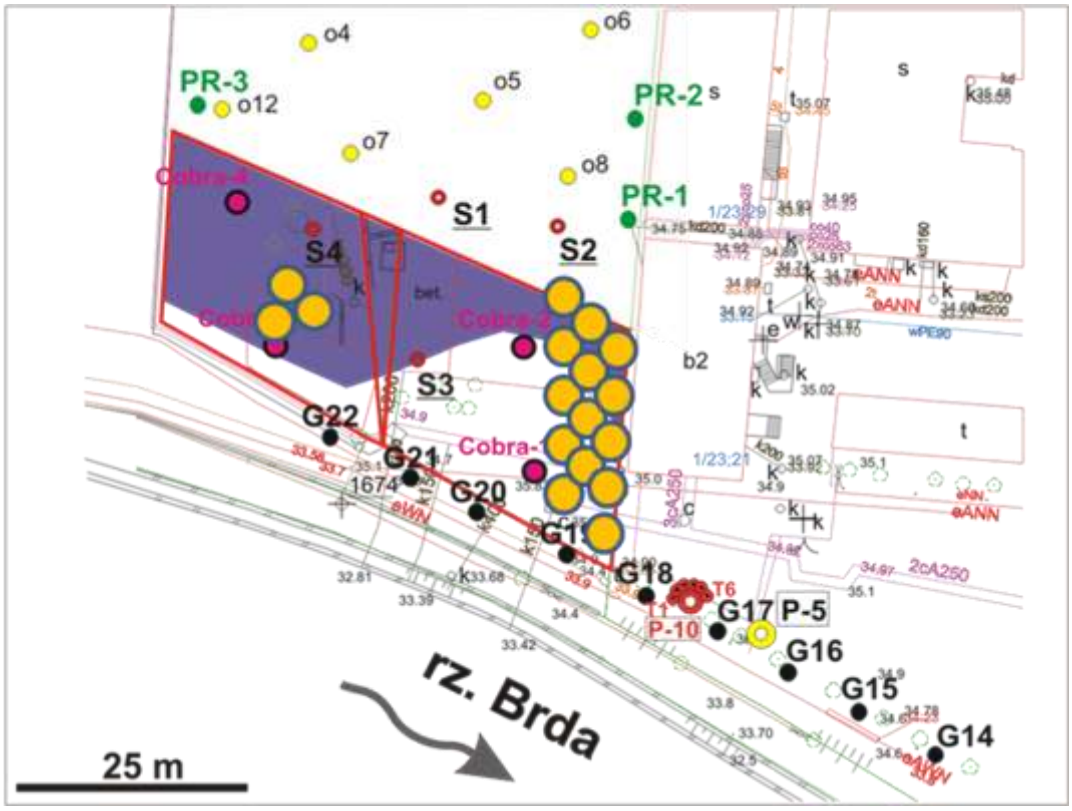

Fig. 14 The area after removal of part of the embankment to a depth of about 2m. Conducting the injections of bio preparation into the polluted zones at levels II and III

7. Drilling the injection holes and the application of bio preparation at level II and III. Due to the concentration of PAHs found in these levels, it is estimated that at the level II just a one-time application is necessary, while level III injections, must be repeated or injections concentration must be increased, by additional drilling and injection into holes the bio preparation. The volume of soil to bioremediation in the level II is estimated at 50 m^3, while in level III at 250 m^3.

   Hint: increasing the number of holes in level III theoretically accelerate the remediation process, because the microorganisms will quickly reach the contaminated zones, however, it does not require increasing doses. The holes should be done after the filling of the excavation and forming the surface layer and completed in way that it will be possible to carry out their research in monitoring or possible additional application of bio preparation.
8. 4-fold performance of the monitoring, testing bio preparation work at the level II and III (preferably every 3 months). Monitoring involves collecting samples of each of the 4 selected piezometers (one of the level II and 3 of the level III) and analyze them for content and composition of PAHs.

Hint: The last series of monitored water should have full range of chemical markers used in this project, which are BTEX, PAH, phenols, petrol and oils. At the end of the project should be officially, by that mean with presence of the Investor and controllers representing Regional Environmental Protection Officer, collected by the probe soil samples from zones, recognized as primary contaminated. The probing in distance of about 2 – 2.5m from the injection borehole. The analysis of soil samples should be performed by certified laboratory in the same range as primary in research project, which are contents of single BTEX, PAHs, phenols, petrol and mineral oils. This test could proof the degree of effectiveness of bioremediation treatment.

Table no. 1 Schedule of material and financial for the concept I

No.	Activity / Period of realization	1st quarter 2011	2nd quarter 2011	3rd quarter 2011	4th quarter 2011
1.	Construction of the temporary road	6 000,00			
2.	Demolition of walls	10 200,00			
3.	Removal of old concrete pavements	2 700,00			
4.	Removal of underground reinforced concrete facilities	1 200,00			
5.	Construction of dense barrier		290 000,00		
6.	Probing		4 500,00		
7.	Soil exchange		58 080,00		
8.	Purchase of loam material		40 000,00		
9.	Storage of contaminated soil *		792 000,00		
10.	Application bio preparation**		40 400,00		
11.	Monitoring research		1 500,00	1 500,00	2 000,00
	Total net	20 100,00	1 226 480,00	1 500,00	2 000,00
	VAT	4 422,00	269 825,60	330,00	440,00
Total Gross		**1 525 097,60**			

Source: own study based on an estimate (an estimate made for the lowest prices)

* cost of this process is estimated from 792 000 PLN net to 1 056 000 PLN net.

The volume of exported soil can be reduced by doing more probing and chemical analysis of soil samples (up to 3 m maximum), the costs can be reduced if positive results of the soundings of contaminated soil. In addition, the Investor may decide to build-in pure crushed demolition material into the resulting excavation and formed clay layer. This would drastically reduce costs of transportation and getting the new aggregate. Replacing the contaminated parts of the embankment significantly

accelerate the process of environmental remediation in the relevant area and will allow for rapid adoption of destination management.

** optional for the performance of 18 injection holes costs could increase by 8 000 PLN net.

3.2. Concept II

This concept is based on bioremediation without removal of contaminated grounds from the embankment.

Works, necessary to conduct in terms of the concept:

1. Moving into the underground channel the heat pipeline part, currently hanging on the wall from the western side and part from the side of the Brda running on the surface. Responsible for the action: Municipal Heat Power Plant (costs cover by MHPP)

   Grounds: ”hiding” the pipeline will allow an access to the area and „set free” the wall, which is the main part of the plot enclosure. It will allow the execution of demolition works of the walls and former pavement and flooring left after demolished garages and also removal remnants of inventory controlled underground facilities (storage tank from reinforced concrete, sewage system).

   Hint: time for the moving the pipeline and its deactivation can be correlated with its uninstallation by the boarder with the Old Gasworks terrain on the conflict section with designed barrier (dense wall), and next, after construction the barrier, re-instalment of the heat pipeline.

2. Construction of a temporary access road to the work area from the west. The minimum option is to use travel through parking lot of NOT + 50 m of road with a surface from aggregate 0.2 m thick and a width of 4 m.

   Grounds: the reason for implement the shortest route paved way - through the parking lot of NOT – is to avoid the devastation of trees and lawns along the boulevard between the Brda River and NOT terrain. The minimum to construct section is about 50 m, and it may have a width of 4 m, which is sufficient for the regulated one-way traffic. The road surface must allow access of excavators, trucks and possibly self-propelled crawling paler or cutter of loam barriers. Designed is a construction of the road from ferroconcrete slabs, placed on natural aggregate foundation or recycled one.

Hint: If agreed before with Municipal Heat Power Plant, which will be earlier deconstructing the heat pipeline and excavate and construct the heat channel, it is possible to construct the road with sharing the costs on both investors.

3. Demolition of the walls and pavement and flooring – remnants of former garages, warehouses and workshops. Removing remains of underground infrastructure (storage tank from reinforced concrete, sewage system).

   The demolition of the wall length of approximately 80 m, a width of about 0.4 m high along with the foundation on average 4 m - this gives a volume of about 128 m^3 of demolition and crushing. Removal of old concrete pavements: about 250 m^2, the average thickness of about 0.2 m - this gives a volume of c.a. 50 m3 to remove and crushing.

   Removal of underground reinforced concrete facilities (the same as the liquidation of the foundations of the building) of approximately 15 m^3 to remove and crushing.

4. Construction of dense wall limiting the flow of contaminated water from the site of the Old Gasworks. Length approx. 50 m, depth of 7.5 m (the need to anchor the wall in the Pliocene clays), the width approx. 0.4 m (the barrier of clay-cement) or a Larsen wall. Preferred is a mill cut barrier of clay-cement.

   Hint: after construction of the barrier or the wall it's possible to re-install the heat pipeline section.

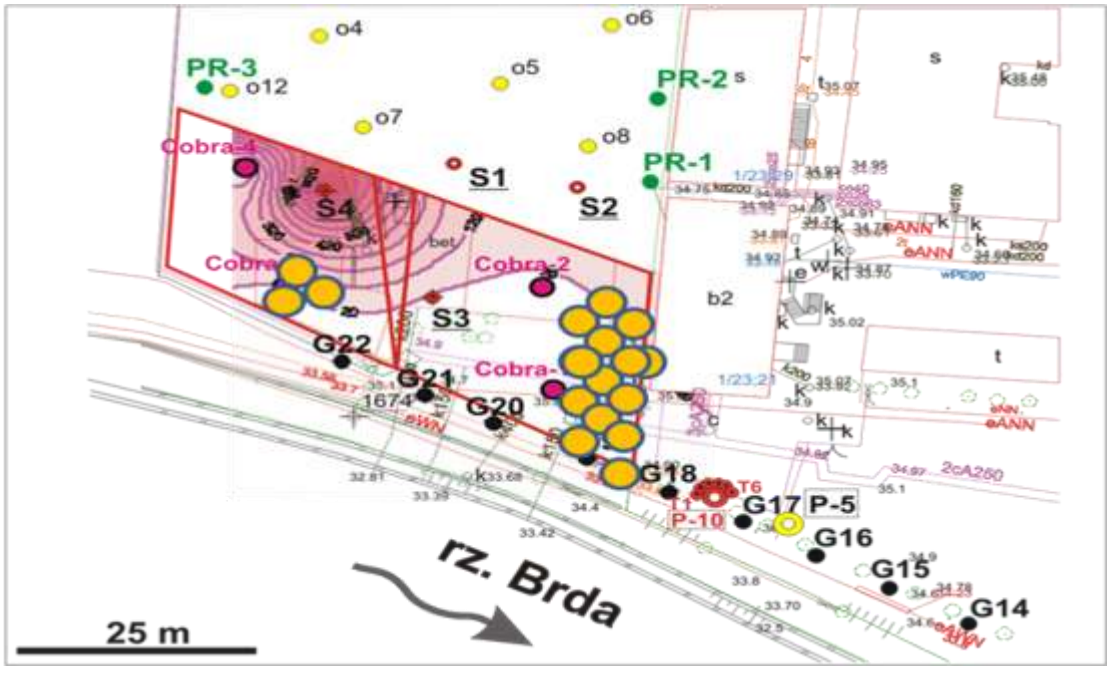

Fig. 15 Map with marked places of bio preparation injections into the levels II and III.

5. Drilling the injection holes and the application bio preparation at level II and III. Due to the concentration of PAHs found in these levels, it is estimated that at the level II just a one-time application is necessary, while level III injections, must be repeated or injections concentration must be increased, by additional drilling and injection into holes the bio preparation. The volume of soil to bioremediation in the level II is estimated at 50 m^3, while in level III at 250 m^3. Drilling injection holes: 13 pieces (optional 18 pcs.)

   It is recommended a deep embankment plowing in order of its fluffing and aeration.

   Hint: increasing the number of holes in level III theoretically accelerate the remediation process, because the microorganisms will quickly reach the contaminated zones, however, it does not require increasing doses. The holes should be done after the filling of the excavation and forming the surface layer and completed in way that it will be possible to carry out their research in monitoring or possible additional application of bio preparation.

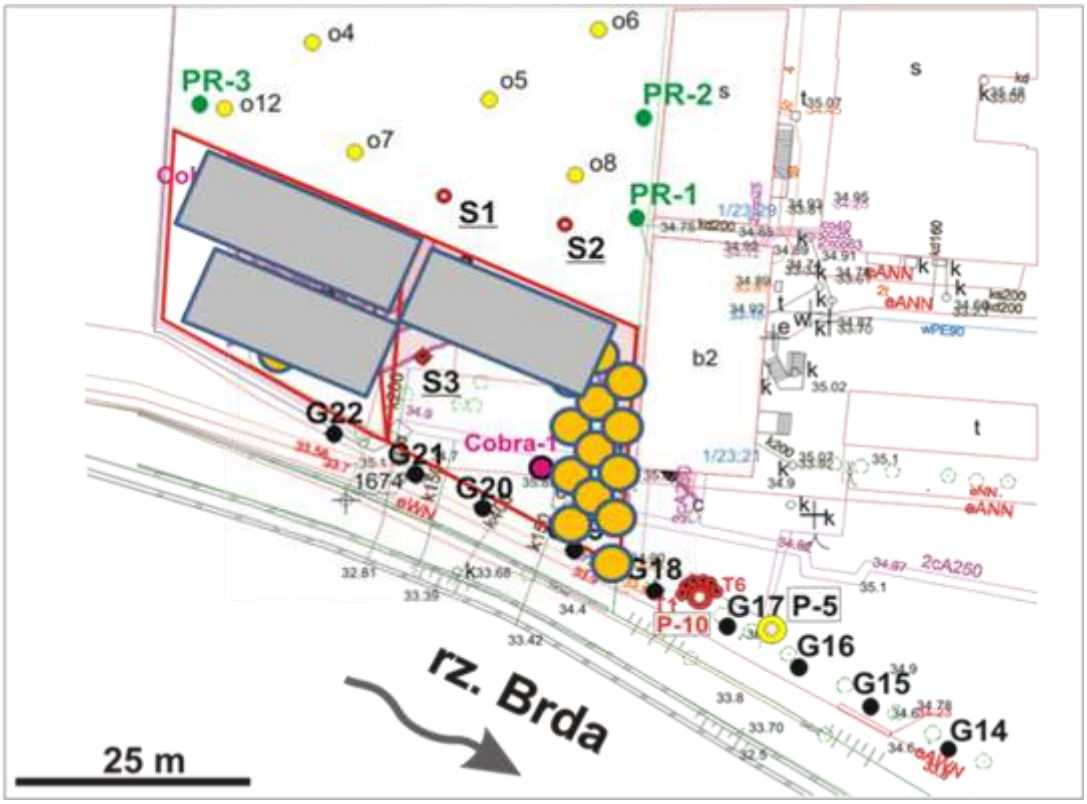

Fig. 16 Map of selected ponds of bioremediation on the levelled terrain

6. Levelling of the terrain and forming of several (4-6), shallow (up to 20 cm in depth.) remediation ponds. The easiest way to form ponds is to rise on levelled terrain small dikes. At the bottom of ponds should be rolled-down the geotextile mat to ensure the percolation, but also an even soaking and protection of the substrate from washing out.

   Hint: conducting ground levelling by grader or bulldozer, the application holes should be marked and protected.

7. Application of bio preparation in a dilution with water into the remediation ponds.

   The liquid should be dosed evenly and slowly to allow the soaking, and not overflowing the ponds. The preparation can be prepared in the tank, i.e. 5-7 m^3, on-site or delivered. Amount of concentrated bio preparation should be adjusted to the volume of soil below the ponds and above the mud. Estimated should be assumed 1320m^3.

   Hint: ponds, after inoculation of bacteria should be left open for a period of about a week, depending on weather conditions, such as high temperature and drought, surface should be sprinkled. If needed, conduct aeration and re-application of bio-preparations for the deeper levels. Should be executed a control of the effectiveness of microorganisms activity.

8. Fertilization and the closure of bioremediation ponds.

   After about 7-10 days should be carried out the fertilization in ponds using diluted soil nitrogen fertilizers, the best solution is slurry manure. Then, to avoid unpleasant for the residents of the central part of the city smells, ponds should be filled up by prepared or delivered humic soil (at least with a layer of 0.4 m thickness). There is about 7 m^3 of liquid manure and approximately 280 m^3 of soil needed.

   Grounds: microorganisms will proliferate faster in conditions of good soil fertilization. The layer of the soil will eliminate odour complaints and allow the immediate land use in the planned target.

   Hints: manure can not be applied in the level II and III. It is only possible to use the aeration by the compressed air through sealed application openings. In order to fill the ponds and levelling the ground should be used unpolluted, fertile garden soil.

9. 4-fold performance of the monitoring, testing bio preparation work at the level I, II and III (preferably every 3 months). Monitoring involves collecting soil samples

each time from level I (4 samples) and groundwater samples from 4 selected piezometers (one of the level II and level three of level III), analysing samples for content and composition of PAHs.

The last series of monitored soil and water should have full range of chemical markers used in this project, which are BTEX, PAH, phenols, petrol and oils. At the end of the project should be officially, by that mean with presence of the Investor and controllers representing Regional Environmental Protection Officer, collected by the probe soil samples from zones, recognized as primary contaminated. The probing in distance about 2 – 2.5m from the injection borehole and control samples from the embankment level, representatively for the entire area, by that means evenly placed. The analysis of soil samples should be performed by certified laboratory in the same range as primary in research project, which are contents of single BTEX, PAHs, phenols, petrol and mineral oils. This test could proof the degree of effectiveness of bioremediation treatment.

This method is cheaper but the reclamation process takes much longer in time.

Table no. 2 Schedule of material and financial for the concept II

No.	Activity / Period of realization	1st quarter 2011	2nd quarter 2011	3rd quarter 2011	4th quarter 2011
1.	Construction of the temporary road	6 000,00			
2.	Demolition of walls	10 200,00			
3.	Removal of old concrete pavements	2 700,00			
4.	Removal of underground reinforced concrete facilities	1 200,00			
5.	Construction of dense barrier		290 000,00		
6.	Drilling injection holes and the application bio preparation*		20 500,00		
7.	Terrain levelling and forming the bioremediation ponds		5 000,00		
8.	Application of bio preparation into the bioremediation ponds		60 000,00		
9.	Fertilization and the closure of bioremediation ponds**			22 800,00	
10.	Monitoring research		3 000,00	3 000,00	4 000,00
	Total net	20 100,00	378 500,00	25 800,00	4 000,00
	VAT	4 422,00	83 270,00	5 676,00	880,00
Total Gross		**522 648,00**			

Source: own study based on an estimate (an estimate made for the lowest prices)

* optional for the performance of 18 injection holes costs could increase by 8 000 PLN net,

** cost of materials: 11 800 PLN net, cost of the earthwork (transportation - assuming a radius of 20 km and the final levelling): 11 000 PLN net.

3.3. Concept III

This concept is based on mechanical-flotation treatment of land and in-situ immobilization of contaminants.

Works, necessary to conduct in terms of the concept:

1. Moving into the underground channel the heat pipeline part, currently hanging on the wall from the western side and part from the side of the Brda running on the surface. Responsible for the action: Municipal Heat Power Plant (costs cover by MHPP)

   Grounds: ”hiding” the pipeline will allow an access to the area and „set free” the wall, which is the main part of the plot enclosure. It will allow the execution of demolition works of the walls and former pavement and flooring left after demolished garages and also removal remnants of inventory controlled underground facilities (storage tank from reinforced concrete, sewage system).

   Hint: time for the moving the pipeline and its deactivation can be correlated with its uninstallation by the boarder with the Old Gasworks terrain on the conflict section with designed barrier (dense wall), and next, after construction the barrier, re-instalment of the heat pipeline.

2. Construction of a temporary access road to the work area from the west. The minimum option is to use travel through parking lot of NOT + 50 m of road with a surface from aggregate 0.2 m thick and a width of 4 m.

   Grounds: the reason for implement the shortest route paved way - through the parking lot of NOT – is to avoid the devastation of trees and lawns along the boulevard between the Brda River and NOT terrain. The minimum to construct section is about 50 m, and it may have a width of 4 m, which is sufficient for the regulated one-way traffic. The road surface must allow access of excavators, trucks and possibly self-propelled crawling paler or cutter of loam barriers.

Designed is a construction of the road from ferroconcrete slabs, placed on natural aggregate foundation or recycled one.

Hint: If agreed before with Municipal Heat Power Plant, which will be earlier deconstructing the heat pipeline and excavate and construct the heat channel, it is possible to construct the road with sharing the costs on both investors.

3. Demolition of the walls and pavement and flooring – remnants of former garages, warehouses and workshops. Removing remains of underground infrastructure (storage tank from reinforced concrete, sewage system).

   The demolition of the wall length of approximately 80 m, a width of about 0.4 m high along with the foundation on average 4 m - this gives a volume of about 128 m^3 of demolition and crushing. Removal of old concrete pavements: about 250 m^2, the average thickness of about 0.2 m - this gives a volume of c.a. 50 m3 to remove and crushing.

   Removal of underground reinforced concrete facilities (the same as the liquidation of the foundations of the building) of approximately 15 m^3 to remove and crushing.

4. Construction of dense wall limiting the flow of contaminated water from the site of the Old Gasworks. Length approx. 50 m, depth of 7.5 m (the need to anchor the wall in the Pliocene clays), the width approx. 0.4 m (the barrier of clay-cement) or a Larsen wall. Preferred is a mill cut barrier of clay-cement.

   Hint: after construction of the barrier or the wall it's possible to re-install the heat pipeline section.

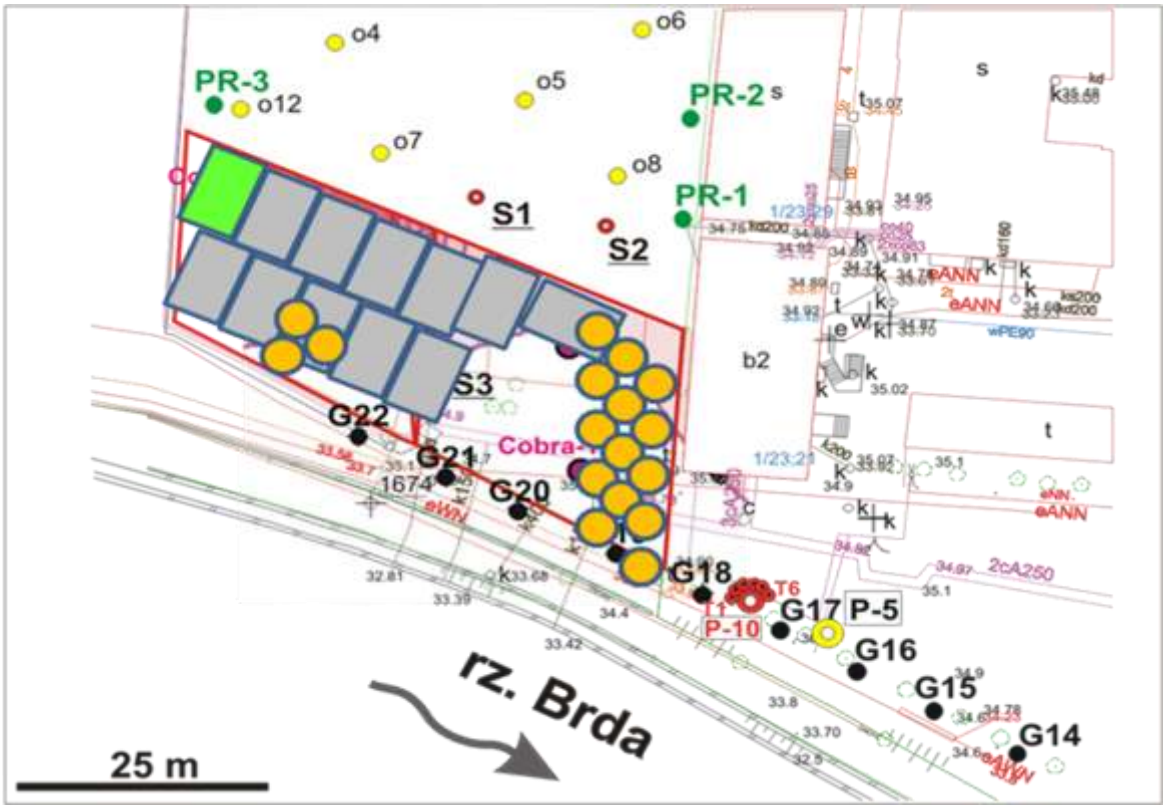

Fig. 17 Map with selected areas of gradual purification of the Embankment soil in the so-called ground washing sections

5. The injection of activated carbon to a level II and III. The density of injection must be greater than in the case of techniques based on bioremediation, but the diameter of the holes may be less. The volume of contaminated soil to be blocked with activated carbon on the level II (more accurately in the gravel layer between 4 and 4.5m of depth.) is estimated at 50 m^3, and on level III (between 6 and 7.5 m) is 250m^3.

   Hint: this part must be executed by specialized company, equipped with professional hardware to perform injections under high pressure

6. The macroscopic diagnosis of the profile in the embankment by sounding to a depth of 2.5 m, at density of 2 x 5 m. An indication of sectors to choose and purification. Performing cuts in designated sectors with the trawl wall excavation technique (as in the construction of sewers). Ground selected from the first sector would be temporarily postponed and moved to a heap. To reduce the nuisance of the scent and the evaporation, the heap can be covered tightly with a thick construction film.

From other sectors selected output will be subjected to screening for grid and sieve to separate the scrap, debris, stones and bricks greater than 50 mm. Soil after loading to the container with water and strong detergent will be subjected to stirring and aeration (blowing air from the nozzle at the bottom of the container). Produced in this way emulsion of water, detergents and organic compounds of carbon and foam will be mechanically scraped to a second container with a water clarifier.

Hint: Sludge and thickened emulsion will be treated as hazardous waste – after thickening can be used as additional fuel to cement kilns installations. The volume of resulting in this process waste is very difficult to assess without testing. In accepted to direct "washing" the soil volume of about 1320 m^3, can be located more than 670 kg of pure organic compounds in sort of PAHs (supposing the average concentration in soil of 280 mg / kg of dry matter for PAHs), which together with other compounds (phenols, BTEX and mineral oils) can give about 1 000kg. In the form of emulsified and with detergents can give respectively 2 to 3 tons of hazardous waste, depending on the degree of obtained separation from the water.

The ground from the container after washing would be moved on to the next container in order to flush the remaining detergent, and then deposited in the open trench. At the same time soil from the next sector, would be put on the screen and into the „washing" container. It is assumed to make about 70 such sectors.

Hazardous waste will be exported by ADR transport within a radius of 300 km (cement plant) and thermally recycled.

The Amount of necessary detergents is without local testing is very difficult to assess, it can only be estimated at range of 180-240kg of the preparation with a concentration of 70%. It is also necessary to provide power connections and by that electrical energy to the process (it is assumed the work of 6 engines with power of 4 kWh for 6 months of the task duration, which is clearing the embankment ground by "washing" the soil).

For macro-levelling the site should be used unpolluted, fertile garden soil.

7. Conducting the research of activated carbon effectiveness in the level II and III.
   .At the end of the project should be officially, by that mean with presence of the Investor and controllers representing Regional Environmental Protection Officer, collected by the probe soil samples from zones, recognized as primary contaminated. There can be randomly performed 2-3 probing together with

collecting soil samples from „after washing" ground. From deeper levels 4 water samples should be in general collected each time 4-fold during one year period from the moment of activated coal application. The analysis of the soil and water samples should be performed by certified laboratory and in range of primary assumed in the project individual markers: BTEX, PAHs, phenols, petrol and mineral oils. This test could proof the degree of effectiveness of bioremediation treatment.

Table no. 3 Schedule of material and financial for the concept III

No.	Activity / Period of realization	1st quarter 2011	2nd quarter 2011	3rd quarter 2011	4th quarter 2011
1.	Construction of the temporary road	6 000,00			
2.	Demolition of walls	10 200,00			
3.	Removal of old concrete pavements	2 700,00			
4.	Removal of underground reinforced concrete facilities	1 200,00			
5.	Construction of dense barrier		290 000,00		
6.	Drilling holes and injection of activated carbon*		65 000,00		
7.	Starting a container soil washing station, including the mobilization of equipment **, electric connection and energy		25 000,00		
8.	Electric connection and energy costs	10 000,00	25 000,00	26 200,00	
9.	Export and thermal utilization of hazardous waste		2 550,00	2 550,00	
10.	Monitoring research			3 140,00	3 140,00
	Total net	30 100,00	407 550,00	31 890,00	3 140,00
	VAT	6 622,00	89 661,00	7 015,80	690,80
Total Gross		**576 669,60**			

Source: own study based on an estimate (an estimate made for the lowest prices)

* cost of drilling 25-28 openings, and activated carbon injection,

** detergents cost is about 10 PLN for purchase from the manufacturer in its original packaging (this, however causes the need for individual preparation of the formulation).