MODELLING OF WALLS FOR REDUCING CONTAMINATION THAT IS CAUSED BY A FORMER DUMP SITE IN RIGA CITY, LATVIA

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ABSTRACT

Building of a shopping center was planed in Riga city, Latvia. Unfortunately, the center was located in the former dump site place where the about eight meters thick waste body contained an irregular mixture of oil products, Phenols, Detergents and metals: Copper, Lead and Chromium. It was expected that these dissolved in groundwater contaminants entered the nearby lake and dich. It was found out that cleaning of the place was not time and cost effective. It was necessary to reduce the concentration of these pollutants before they entered the both surface water objects. To find the proper walls for reduction of the contaminated groundwater concentration, the local hydrogeological model (HM) was built. The Groundwater Vistas (GV) program was used to run HM. The primary data for HM were provided by the HM of Latvia LAMO4. It was found out that immobilization of the contamination body by using an enclosing impermeable wall was not practicable, because the valid wall there must cover there the 37m thick sand layer. Results of modelling proved that to reduce the contaminant concentration, the permeable reactive wall that cleans groundwater must be established before the lake. No wall is necessary for protecting the ditch, because its discharge flow is small. Results of modelling may be useful for specialists dealing with impermeable and reactive walls for reducing harmful effects of contaminated groundwater.

Keywords: appliance of passive and active walls, groundwater contamination, hydrogeological model

INTRODUCTION

In the paper, the case is considered when building of a shopping center was planned in Riga city, Latvia (see Fig. 1). Unfortunately, the center was situated in the former dump site area (see Fig. 2).

It was found out that the soil and groundwater of the place up to the 8m depth were contaminated by oil products (OP), Phenols, Detergents and metals: Copper (Cu), Lead (Pb) and Chromium (Cr) [1]. Cleaning of the place was not time and cost effective. It was expected that contaminated groundwater flows entered the nearby lake and ditch.

Fig. 1. The study area location

It was necessary to find effective walls for reducing the contaminant concentration of these flows. Additional investigations on groundwater contamination were carried out along the coastlines of these surface water objects [2]. It was found out that the concentrations of OP, Phenols and Detergents only for the lake exceed the standards of Regulations [3]

To investigate walls of reducing the contaminant concentration below the standards, it was necessary to find spatial distributions of the groundwater heads φ [m asl] and flows q [m^3/day]. To find these distributions, the local hydrogeological model (HM) was established. The primary data for HM were provided by the HM of Latvia LAMO4 [4].

The model was run by the (GV) program [5] where the GV module MODPATH [6] modelled groundwater pathlines. The SURFER [7] program was applied for preparing data for HM and for visualization of modelling results.

Appliance of passive and active reactive walls [8] was modelled. It was found out that reactive wall that cleans groundwater must be established before the lake. No wall is necessary to protect the ditch. [9].

THE HYDROGEOLOGICAL MODEL

The steady state local HM provides computed distributions of the groundwater head φ [m asl] and flows q [m^3/day] in nodes of the HM spatial grid. The HM area size was 800m×800m (see Fig. 2). The plane approximation step h=1.0m. The model included 11 grid planes. Therefore, the spatial HM grid contained 7.04×10^6 nodes.

The HM vertical schematization is presented in Table 1.

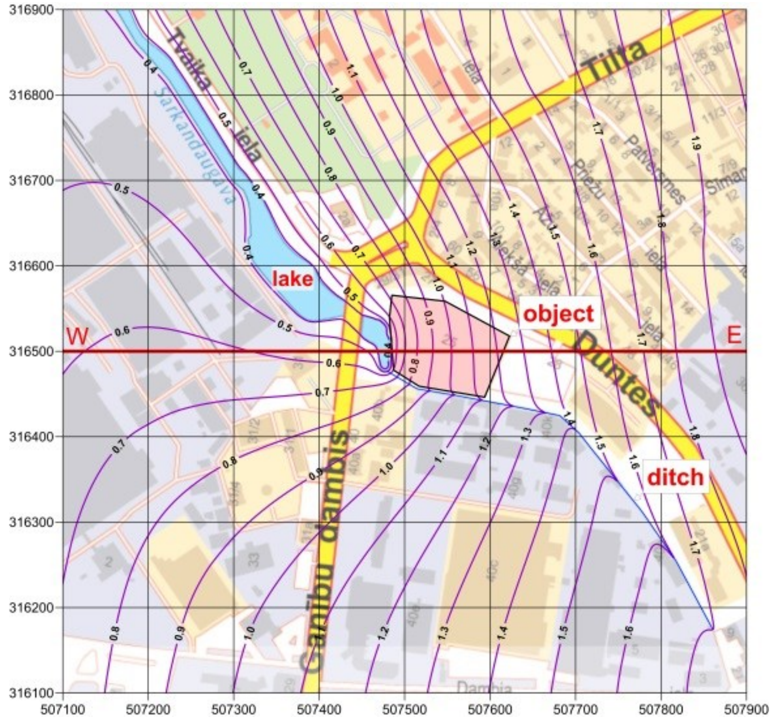

Fig. 2. The groundwater head isolines [m asl] of the layer Q27. The cross section W-E location is shown

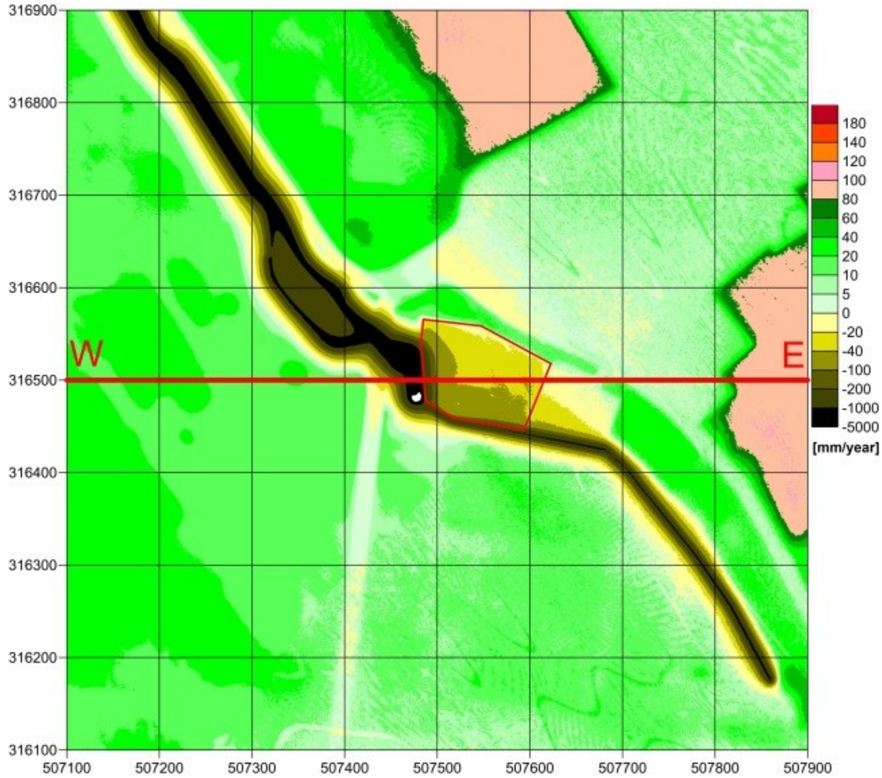

Fig. 3. The infiltration flow [mm/year] distribution of the layer Q26. The cross section W-E location is shown

Table 1

The vertical schematization of the hydrogeological model

No	Name of layer	Layer code	Thickness in object [m]	Thickness in HM [m]	Permeability [m/day]	Notes
1.	Relief	rel	0.02	0.02	10.0	ψ_{rel}- boundary condition
2.	Aeration zone	aer	1.5-2.5	0.2-6.6	10^{-5} -10^{-3}	contaminated
3.	Sand	Q27	2.5	2.5	0.5	contaminated, lake and ditch as boundary conditions
4.	Sand	Q26	2.5	2.5	0.5	contaminated
5.	Sand	Q25	2.5	2.5	0.5	contaminated
6.	Sand	Q24	2.5	2.5	0.5	
7.	Sand	Q23	5.0	5.0	0.5	
8.	Sand	Q22	10.0	10.0	0.5	
9.	Sand	Q21	9.8	6.5-24.5	0.5	
10.	Aquitard	gQ	24.2	15.5-28.5	2×10^{-4}	
11.	Aquifer D3gj2	D3gj2	2.0	2.0	10.0	Ψ_{D3gj2}–boundary condition

The first and the eleventh planes of HM serve as the locations for fixing the GV constant head boundary conditions ψ_{rel} and ψ_{D3gj2}, accordingly. The aeration zone aer (layer No 2.) as the aquitard controls the infiltration flow in the HM top. The seven HM layers No 3.– No 9. approximate the Quaternary sand body. The layers No 2.-No 5. are contaminated. The layer No 3. is joined with the lake and the ditch that represent the GV boundary conditions “Lake” and “River”, respectively. The thickness of the aquifer Q2 (including the aer zone) in the object area is 37m.

The GV tool “Mass balance” was applied for obtaining data on the spatial groundwater flows q in the HM layers (see Fig. 5).

RESULTS OF MODELLING

By using local HM, the groundwater head φ flow q distributions were obtained for the cases when the infiltration flow in the building area was blocked. Blocking of the

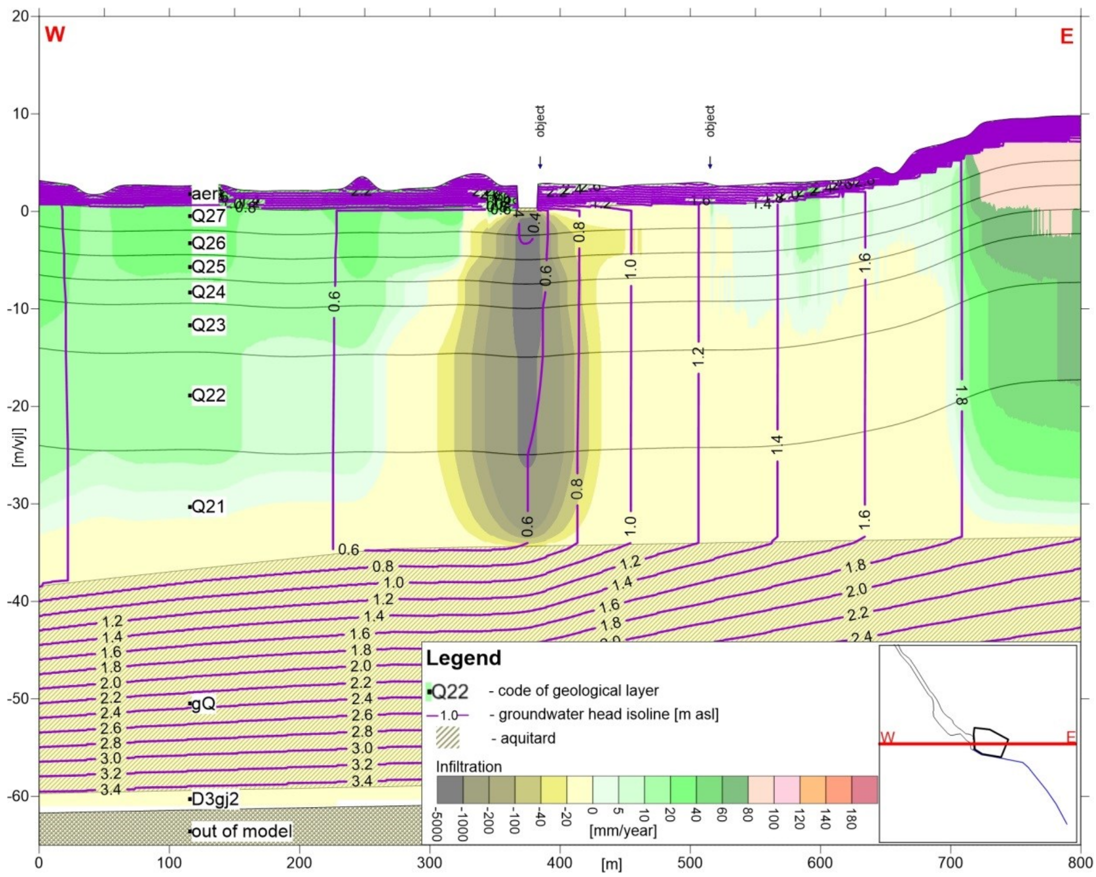

Fig. 4. The groundwater head isolines [m asl] and the infiltration flow [mm/year] in the cross section W-E

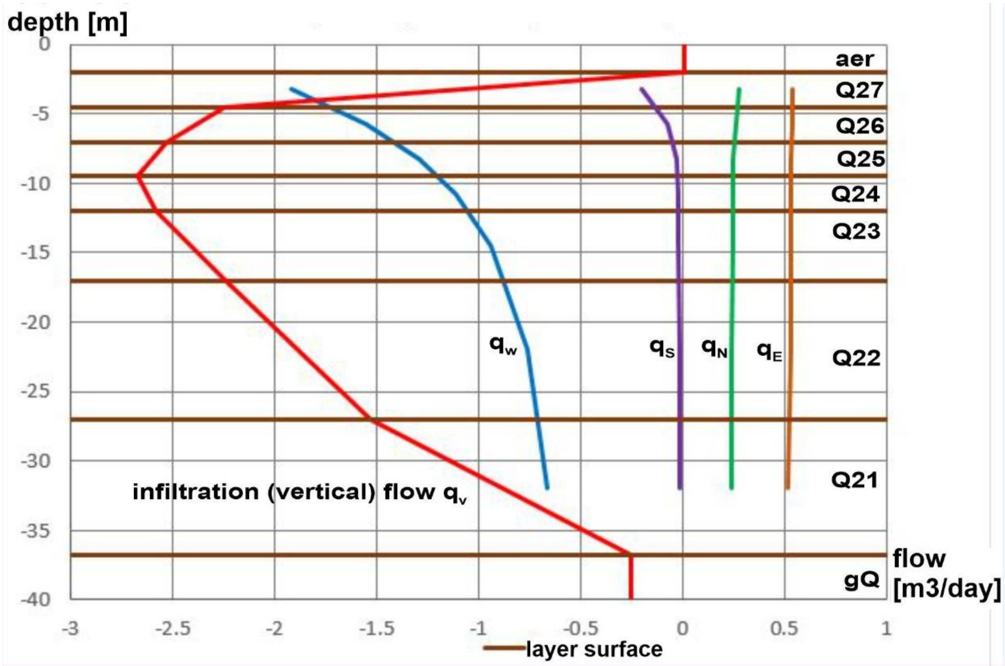

Fig. 5. Distribution of the spatial groundwater flows [m^3/day] within the object body

flow prevents the downward movement of contaminants in the aeration zone aer. The results on φ and infiltration distributions q_v are presented in Fig. 2, Fig. 3, accordingly.

In Fig.4, the groundwater head and infiltration flow distributions in the vertical section W-E of Fig. 2 and Fig. 3 confirm the spatial nature of the modelled groundwater system.

In Fig. 5, the groundwater spatial flow distribution for the object layers is shown. There q_w, q_s, q_n, q_e are the lateral flows through the western, southern, northern, eastern sides of the object layers.

The flow q_w that enters the lake is much larger than the flow q_s that discharges into the ditch. The flows q_n, q_e stream into the object area where $q_n \sim 2q_e$.

The MODPATH program was used for creating of the groundwater flow pathlines that intersect the object area. In Fig. 6, the four pathlines are shown. The pathlines No 2., No 3. and No 4. confirm that groundwater passes the object area during ~16 years. Groundwater does not enter the dich (pathline No 4). because, the flow q_s is not large enough. Therefore, it is not necessary to protect the ditch.

In Fig. 7, the vertical section along the pathline No 3. is presented when the enclosing impermeable wall is used for the layers aer, Q27, Q26, Q25, Q24 and Q23. It is obvious that the wall provides no immobilization of the contamination, because groundwater avoids the wall.

For the considered case, the valid wall bottom must enter the aquitard gQ. Only then the contaminant body can be immobilized. Unfortunately, the thickness of the aquifer Q2 there is 37m. For this reason, establishing of the wall is not practicable.

In the report [9,] it was recommended that contamination of groundwater entering the lake, can be reduced by establishing the permeable reactive wall of the depth 8m and the length 56m before of the lake. To match the standards of the regulations [3], the wall must reduce OP, Phenols and Detergent concentration 2.7, 5.2 and 4.3 times, accordingly.

CONCLUSIONS

Building of a shopping center was planed in the Riga city, Latvia. The center was located in the former dump site place. It was expected that the dissolved in groundwater contaminants entered the nearby lake and dich. The local HM was created for investigation of appliance of impermeable and permeable reactive walls

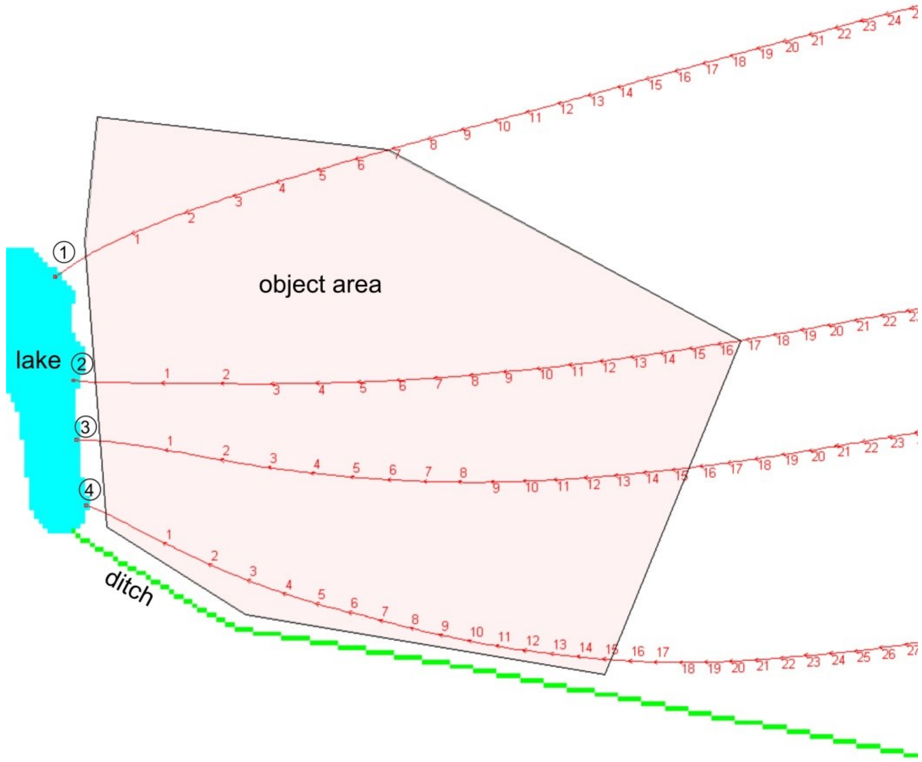

Fig. 6. The x-y projections of pathlines in the object area. The groundwater particle movement time from the lake is traced in years

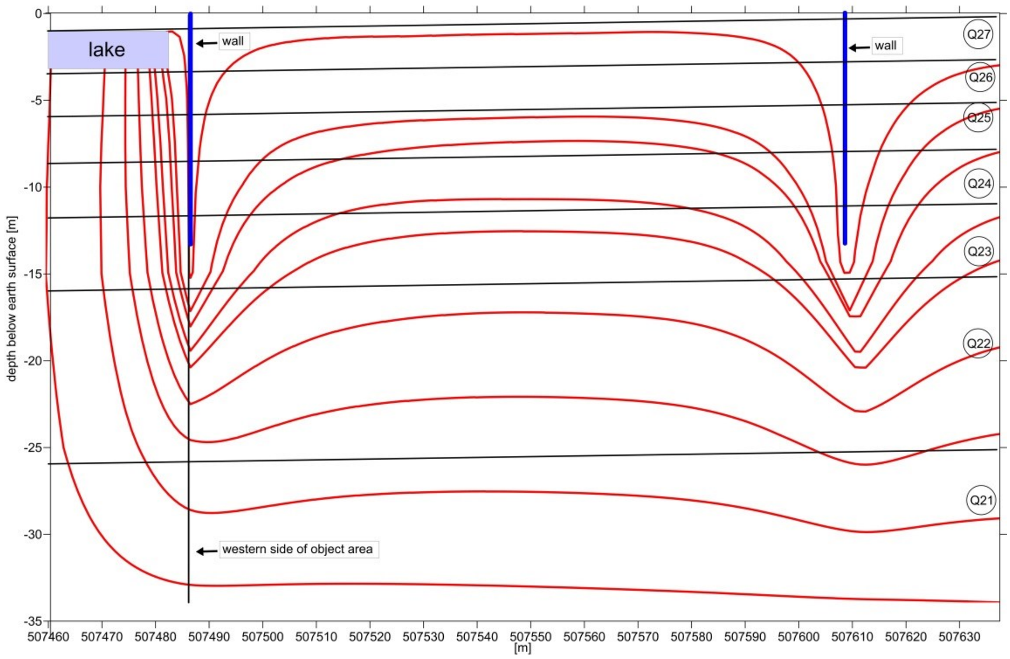

Fig. 7. The z-projections of tracers along the pathline No 3 if the enclosing impermeable wall of the depth 14.5m is established,

for cleaning contaminated groundwater. It was found out that because of the large thickness of the sand layer there (~37m) building of the valid impermeable wall was notpracticable. Contamination of the lake can be reduced by establishing permeable reactive wall. No protection is necessary for the ditch, because of its small groundwater discharge flow.

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