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PARDES BEHISAHON

RISK EVALUATION

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Order	**Pardes BeHisahon – Risk evaluation**
Order No.:	
Type of message:	**Simplified risk assessment**
Prepared by:	**Mgr. Daniel Světlík** **RNDr. Ondřej Urban, Ph.D.** Authority of the Ministry of environment (MŽP) to conduct and evaluate geological work in areas of hydrogeological rehabilitation geology
Approved by:	**Ing. Jan Vaněk, MBA** Head of Environmental Rehabilitation and Ecological Projects
Prepared on:	17. 10. 2017
Distribution list:	Windex, DEKONTA
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CONTENTS

1. Specification of the subjected site

The Pardes BeHisahon plan – Or Yehuda is located north to road 461, south and east to the Tel Hashomer army base, west to an agricultural area belonging to Kiryat Ono. The area of the subjected site is app. 340 dunams (Fig. 1).

The site is located in an agricultural area, where in its center there are trees on top of a seasonal stream. The area of the site is mixed between an open area and a build area which includes from its northern and western sides an army base (Tel Hashomer), a neighborhood from its southern side (south to road 461), and agricultural areas from its eastern side.

The site is in good condition with no neglecting signs or garbage, except for a single pile of dry organic waste (pruned branches), which does not impose any potential for soil pollution.

At the center of the site there is an open drainage canal – the Kiryat Ono canal which flows from southern Kiryat Ono through the army base (Tel Hashomer) and connects to the Ayalon River, south-west to Or Yehuda.

A few facilities were identified at the site (Fig. 2):

1. A cellular antenna, located at the center of the site.
2. A temporary building located close to road 461 at the western part of the site.
3. Electricity poles located across the vertical line at the eastern part of the site.

1.1. Existing and planned use of the site

The site is a part of the "Pardes BeHisahon" project from 1955. The country invited people to purchase leasing rights at the land, for yield. The designation of the site in about to be changed (waiting for permits). Most of the area is an agricultural land, except for a single use of cellular antennas.

The plan of future utilization of the site includes residencies (app. 2,350 apartments in 11-14 levels building with 3 basement levels), public institutions (elementary school, high school, kindergartens, dorms, synagogue, etc.), a commerce front looking at road 461, a commerce front in the first few levels on the western side and an open public area.

2. Natural relations in the site of interest

2.1. Geology and hydrogeology

The site is located in the central part of the shore aquifer from the Pleistocene age. The shore aquifer is one of the main water sources of Israel. The shore basin is made of layers of sand, sandy loam and conglomerates which are conducting rocks and between them layers of mud, clay and marlstone. At the base of the aquifer there is a thick sequence of sealed layers, composed mainly of clay and marlstone from the Saqiya formation, yet certain fractures across the aquifer allow the passage of salty water from the bottom of the aquifer. The aquifer is blocked by sealed soils at its eastern border and by the ocean at its western border. The natural drainage of the aquifer is the ocean, although today the water of the aquifer are exploited by suction drillings preventing the flow to the sea.

Fig. 1: The area of interest - situation in a traffic map.

Fig. 2: Detailed site situation.

The area of Gush Dan, where the site is located, includes mainly red loams and alluvium soils. Ground level at the site is 35-42 meters above sea level. According to level maps prepared by the water authority in 2010, groundwater level at the site is 6 - 8.5 meters above sea level.

3. Soil survey

The soil survey included sampling from 8 boreholes situated in two clusters, one in the northern half of the subjected area, the other on SW border of the site (Fig. 3). 16 samples were taken from various depths ranging from 0.2 to 5 m b. t. (Tab. 3-1). Active soil gas sampling included collecting of gas samples from 18 double boreholes spread-over the whole site area where sampling was performed from 2 levels at 2 and 9.5 m b. t.

Table No. 3-1: Laboratory results, soil survey.

PAH (mg/kg)	VOC (mg/kg)	TPH (mg/kg)	Depth (m)	Sample	Borehole	Date
N.D	N.D	<50	0.3	C-1	S1	7.5.17
N.D	N.D	<50	0.9	C-2		
N.D	N.D	<50	0.2	C-3	S2	7.5.17
N.D	<0.01	<50	0.4	C-4		
N.D	N.D	<50	1	B-17	S3	27.4.17
N.D	N.D	<50	5	B-21		
N.D	N.D	<50	0.3	C-5	S4	7.5.17
N.D	N.D	<50	0.9	C-6		
N.D	N.D	<50	0.2	C-7	S5	7.5.17
N.D	N.D	<50	0.8	C-8		
N.D	N.D	<50	1	A-1	S6	24.4.17
N.D	N.D	<50	5	A-5		
N.D	N.D	<50	1	B-3	S7	27.4.17
N.D	N.D	<50	5	B-7		
N.D	N.D	<50	1	B-10	S8	27.4.17
N.D	N.D	<50	5	B-14		
7	-	100	Screening levels for residential area			
-	-	100	Screening levels according to hydrological sensitivity			

Table No. 3-2: Laboratory results, soil survey.

מתכות - מיצוי חומצי																			
Screening level according to hydrological sensitivity	Screening level for residential area	S8		S7		S6		S5		S4		S3		S2		S1		Substance	
		B-14	B-10	B-7	B-3	A-5	A-1	C-8	C-7	C-6	C-5	B-21	B-17	C-4	C-3	C-2	C-1		
		מ"ג/ק"ג																	
100	20	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	Ag	כסף
45	17	<2	<2	<2	8.2	<2	3.3	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	As	ארסן
150	-	<2	3.9	7.1	<2	6.6	4.2	4.8	4.5	3.8	3.9	2.2	<2	2.8	2.4	3.7	4.2	B	בורון
750	500	<15	20	60	16.8	57	45	57	79	68	83	39	39	76	56	63	65	Ba	בריום
15	10	<1	<1	<1	<1	<1	3.2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	Cd	קדמיום
250	150	7.7	10.5	44	12.1	37	25	22	30	26	30	18.4	16.7	21	18.3	26	30	Cr	כרום
14	150	4.5	6.2	17.4	27	13.8	50	14	16.5	20	14.1	10	7.7	8.1	7.4	9.5	10.8	Cu	נחושת
20	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	Hg	כספית
3,500	2,000	154	136	488	81	384	215	274	298	268	297	263	181	327	184	385	467	Mn	מנגן
300	130	3.6	5.4	27	6.2	20	16.6	15.2	18.4	17	21	13.7	9.9	15.5	12.5	18.4	20	Ni	ניקל
500	250	<3	4.4	15.8	5.1	<3	12.2	16.2	18	24	14.1	7.1	5.8	8.3	7.9	9.3	10.3	Pb	עופרת
100	5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	Se	סלניום
1,000	300	<15	<15	34	17.8	30	78	36	51	74	41	15.2	<15	18	18	22	24	Zn	אבץ

Fig. 1: The situation of 8 boreholes for soil survey.

Fig. 3: The situation of 8 boreholes for soil survey.

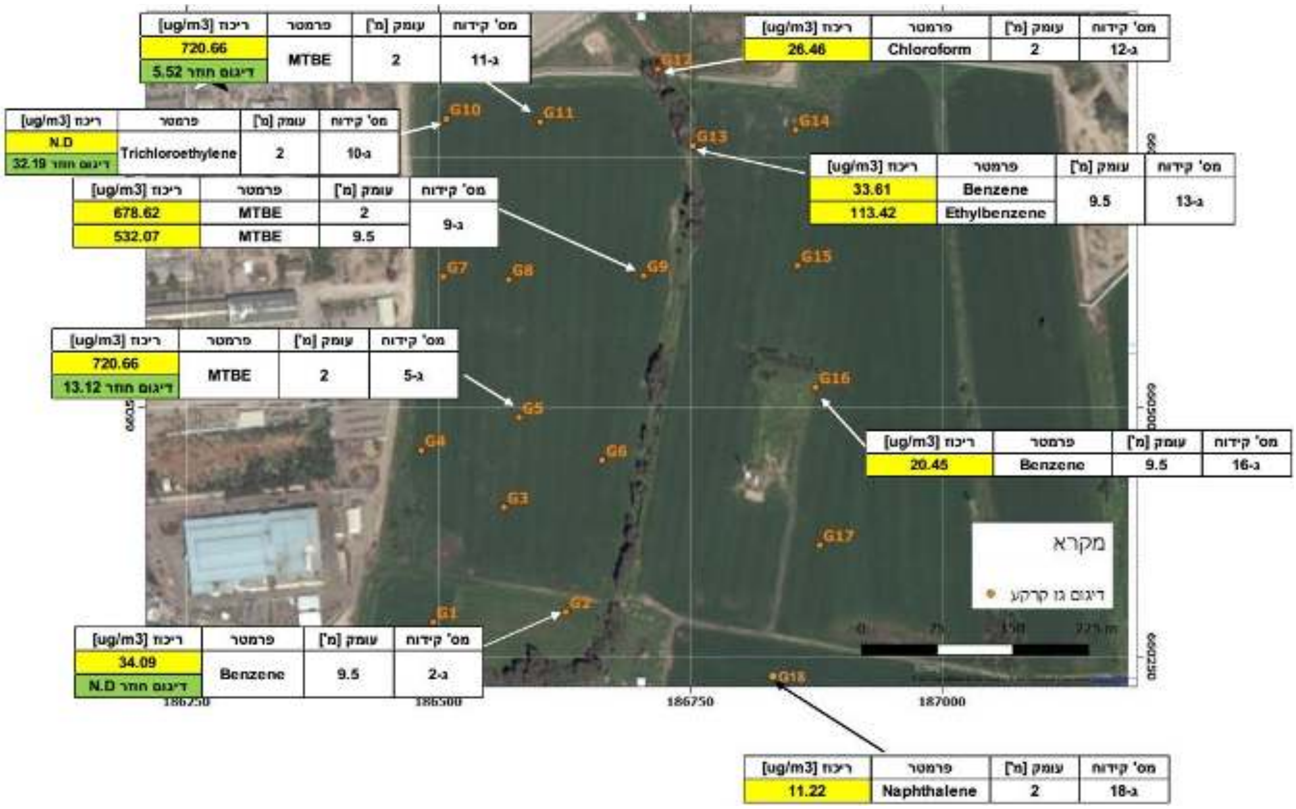

Fig. 4: The situation of 18 boreholes for active gas soil survey with marking out the exceeding values.

Table No. 3-3: Laboratory results, active soil gas survey results.

דיגום גז אקטיבי [ug/m3]																																						
ג- 18		ג- 17		ג- 16		ג- 15		ג- 14		ג- 13		ג- 12		ג- 11		ג- 10		ג- 9		ג- 8		ג- 7		ג- 6		ג- 5		ג- 4		ג- 3		ג- 2		ג- 1		ערכי ייחוס		מס' קידוח
9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2	9.5	2			עומק [מ']
1913	5511	5197	8633	4850	4851	5193	5542	5195	5538	4350	4848	4879	1914	5510	4593	4595	5543	4351	4856	6836	4357	4352	6825	5509	5171	6815	6826	5197	4594	5537	5505	4598	5199	4857	4349	Tier 1	NJDEP	מס' קניסטר
תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	חורג	תקין	חורג	תקין	תקין	תקין	חורג	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין	תקין			IPA
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	10.64	N.D	N.D	N.D	N.D	N.D	N.D	N.D	676,000	260,000	1,1,1- trichloroethane
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	4.96	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	41.99	N.D	N.D	N.D	N.D	N.D	-	76	1,1-dichloroethene
N.D	27.43	N.D	22.81	10.81	6.78	N.D	7.42	N.D	N.D	148.31	N.D	10.91	N.D	N.D	N.D	5.51	N.D	N.D	N.D	N.D	N.D	N.D	16.71	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	13.96	N.D	21.09	N.D	946	-	1,2,4-trimethylbenzene
N.D	10.81	N.D	7.47	6.19	N.D	N.D	9.34	N.D	N.D	45.87	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	-	1,3,5-trimethylbenzene
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	29.84	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	-	1,4- dioxane
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	55.35	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	11.75	N.D	N.D	N.D	-	-	1-ethyl-4-methyl-Benzene
N.D	9.02	N.D	25.24	51.81	N.D	4.69	N.D	N.D	N.D	40.31	N.D	N.D	N.D	6.28	13.18	12.92	N.D	N.D	4.19	N.D	N.D	N.D	N.D	N.D	7.82	N.D	12.39	N.D	6.81	N.D	N.D	3.69	N.D	7.28	N.D	-	260,000	2-butanone
N.D	N.D	N.D	22.41	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	68.25	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	-	2-hexanone
N.D	33.87	N.D	39.34	N.D	N.D	N.D	N.D	N.D	N.D	109.48	N.D	N.D	N.D	41.67	98.75	65.44	43.11	N.D	N.D	N.D	39.17	N.D	N.D	N.D	33.14	N.D	48.48	N.D	43.61	69.17	N.D	N.D	N.D	N.D	N.D	-	1,600,000	Acetone
N.D	N.D	N.D	N.D	20.45	4.34	N.D	N.D	N.D	N.D	33.61	N.D	N.D	4.7	N.D	N.D	9.81	N.D	N.D	N.D	N.D	N.D	N.D	12.4	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	34.09	N.D	N.D	N.D	40.4	16	Benzene
N.D	16.13	N.D	17.68	N.D	27.6	N.D	28.74	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	46.7	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	287	110	Bromoform
N.D	N.D	N.D	N.D	18.99	N.D	N.D	N.D	N.D	N.D	73.45	N.D	4.33	N.D	N.D	3.92	N.D	N.D	6.13	N.D	15.67	5.17	N.D	N.D	5.73	16.47	N.D	3.67	N.D	49.63	14.39	N.D	47.55	N.D	N.D	N.D	-	36,000	Carbon disulfide
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	31.76	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	2,600	Chlorobenzene
N.D	N.D	N.D	N.D	5.37	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	26.46	N.D	N.D	N.D	N.D	N.D	N.D	6.15	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	13.7	24	Chloroform
N.D	N.D	N.D	N.D	4.56	N.D	N.D	N.D	N.D	N.D	N.D	N.D	4.79	N.D	N.D	3.49	2.33	N.D	N.D	N.D	N.D	2.09	N.D	N.D	N.D	2.87	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	4,700	Chloromethane
N.D	N.D	N.D	4.56	4.2	4.08	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	5.04	N.D	N.D	N.D	N.D	N.D	4.28	N.D	N.D	N.D	N.D	N.D	N.D	-	-	Cis-1,2-dichloroethene
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	46.85	N.D	N.D	N.D	811,000	310,000	Cyclohexane
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	22.76	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	-	Ethanol
N.D	N.D	N.D	10.17	13.11	N.D	N.D	N.D	N.D	N.D	113.42	N.D	16.28	N.D	N.D	N.D	6.34	N.D	N.D	N.D	N.D	N.D	N.D	19.97	N.D	4.82	N.D	N.D	N.D	N.D	N.D	N.D	32.74	N.D	N.D	N.D	126	49	Ethylbenzene
5.67	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	7.92	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	11.29	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	36,000	Freon-11
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	13.56	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	51.35	7.97	61.54	N.D	N.D	N.D	N.D	N.D	-	1,600,000	Freon-113
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	4.99	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	4.99	N.D	N.D	7.57	5.24	N.D	N.D	N.D	N.D	N.D	N.D	-	5,200	Freon-12
N.D	N.D	N.D	N.D	36.68	N.D	N.D	N.D	N.D	N.D	207.58	N.D	N.D	N.D	N.D	N.D	5	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	4.34	N.D	N.D	N.D	N.D	N.D	94,600	-	Heptane
N.D	N.D	N.D	3.81	205.13	N.D	N.D	N.D	N.D	N.D	448.58	N.D	50.93	6.13	N.D	N.D	24.95	9.06	N.D	N.D	N.D	N.D	N.D	N.D	N.D	8.07	N.D	N.D	N.D	59.71	64.85	N.D	233.36	N.D	N.D	N.D	-	36,000	Hexane
N.D	N.D	N.D	433.29	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	17.41	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	1,600,000	Methyl isobutyl ketone
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	29.36	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-	-	Methyl methacrylate
N.D	25.6	N.D	14.24	9.52	9.81	N.D	4.72	N.D	N.D	N.D	N.D	15.5	12.26	N.D	676.64	29.64	32.81	532.07	678.62	9.77	86.63	N.D	30.21	14.42	322.67	3.71	720.66	N.D	170.13	133.58	23.83	26.64	N.D	N.D	N.D	1,210	470	Methyl tert-butyl ether
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	15.42	N.D	N.D	5.59	10	N.D	5.21	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	25.15	N.D	5.7	N.D	N.D	N.D	-	4,800	Methylene chloride
N.D	11.22	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	6.24	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	9.28	26	Naphthalene
N.D	10.76	8.47	29.86	782.64	14.25	N.D	N.D	2.34	N.D	1387.57	3.18	108.31	8.38	2.34	75.76	294.01	134.61	N.D	37.28	N.D	181.75	N.D	9.41	4.97	102.8	N.D	59.26	N.D	892.4	571.85	2.22	682.72	N.D	N.D	N.D	-	-	Propene
N.D	N.D	N.D	190.52	N.D	N.D	34.66	N.D	17.91	N.D	N.D	N.D	N.D	9.63	39.61	N.D	104.93	17.16	29.37	N.D	N.D	N.D	12.01	N.D	N.D	N.D	N.D	N.D	N.D	8.89	N.D	N.D	18.99	11.6	N.D	N.D	1210	470	Tetrachloroethylene
4.94	22.8	14.47	50.61	443.82	74.5	N.D	162.31	45.34	19.71	376.85	90.71	62.82	55.17	44.02	69.68	117.09	82.27	22.95	31.84	31.05	89.65	26.3	89.13	27.96	24.65	51.93	61.77	22.95	27.92	119.2	43.6	245.9	84.38	25.14	N.D	676,000	260,000	Toluene
N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	9.62	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	9.83	N.D	N.D	N.D	N.D	N.D	N.D	N.D	76.9	27	Trichloroethylene
N.D	23.45	N.D	44.16	56.54	20.19	N.D	7.82	N.D	N.D	598.75	N.D	65.48	22.23	N.D	4.65	40.04	N.D	8.81	11.68	N.D	N.D	7.03	86.24	N.D	15.71	N.D	N.D	N.D	N.D	N.D	14.24	179.24	N.D	N.D	N.D	13,500	5,200	Xylenes (total)

Exceeding values in case of NJ DEP

Exceeding values in case of Tier 1 RBTL

Table No. 3-4: Laboratory results, summary of important active soil gas survey results.

Active soil gas sampling (ug/m3)											
G18	G16	G13	G12	G11	G9		G5	G2	Screening levels		Borehole
2	9.5	9.5	2	2	9.5	2	2	9.5			Depth (m)
5511	4850	4350	1914	4593	4351	4856	6826	4598	Tier 1	NJDEP	Canister
Proper	Proper	Proper	Proper	Improper	Proper	Proper	Proper	Proper			IPA
N.D	20.45	33.61	4.7	N.D	N.D	N.D	N.D	34.09	40.4	16	Benzene
N.D	5.37	N.D	26.46	N.D	N.D	N.D	N.D	N.D	13.7	24	Chloroform
N.D	13.11	113.42	N.D	N.D	N.D	N.D	N.D	32.74	126	49	Ethylbenzene
25.6	9.52	N.D	12.26	676.64	532.07	678.62	720.66	26.64	1,210	470	Methyl tert-butyl ether
11.22	N.D	N.D	N.D	N.D	N.D	N.D	6.24	N.D	9.28	26	Naphthalene

3.1. Soil / Soil Gas survey results summary

The soil survey results can be summarized as follows:

- PID field results were between 0-5.1 ppm.
- TPH (8015): concentrations in all samples were lower than 50 mg/kg (detection limit).
- PAHs: concentrations in all samples were lower than 0.01 mg/kg (detection limit).
- VOCs: concentrations in all samples were lower than 0.003 mg/kg (detection limit) except for sample C-4 (borehole S2) where methylene chloride was identified in a concentration lower that the quantitative limit of 0.01 mg/kg.
- Heavy metals: concentrations in all samples were lower than screening levels (compared to NJDEP values).

The soil gas survey results can be summarized as follows:

- Screening levels for benzene, MTBE, chloroform, naphthalene and ethylbenzene were exceeded in comparison with NJDEP values. Exceeded values were determined in 9 samples in total, 8 boreholes respectively, of which in case of chloroform, ethylbenzene and naphthalene the occurrence of exceeding value was unique. Benzene exceeding value was discovered in 3 samples, MTBE in 4 (Fig. 4).

Table No. -35: Results of laboratory analyses of soil and comparison with the Tier 1 RBTL.

Borehole ID	Tier 1 Risk-Based Target Level - Residential Land Use (IRBCA)1 (mg/kg)	S8		S7		S6		S5		S4		S3		S2		S1	
Sample ID		B-14	B-10	B-7	B-3	A-5	A-1	C-8	C-7	C-6	C-5	B-21	B-17	C-4	C-3	C-2	C-1
Ag	3,80E+02	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
As	16	<2	<2	<2	8,2	<2	3,3	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
B		<2	3,9	7,1	<2	6,6	4,2	4,8	4,5	3,8	3,9	2,2	<2	2,8	2,4	3,7	4,2
Ba		<15	20	60	16,8	57	45	57	79	66	83	39	39	76	56	63	65
Cd	6,83E+01	<1	<1	<1	<1	<1	3,2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr		7,7	10,5	44	12,1	37	25	22	30	26	30	18,4	16,7	21	18,3	26	30
Cu	3,04E+03	4,5	6,2	17,4	27	13,8	50	14	16,5	20	14,1	10	7,7	8,1	7,4	9,5	10,8
Hg	5,36E+00	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mn	1,80E+03	154	135	486	81	384	215	274	298	256	297	263	181	327	184	385	467
Ni	1,51E+03	3,6	5,4	27	6,2	20	16,6	15,2	18,4	17	21	13,7	9,9	15,5	12,5	18,4	20
Pb	80	<3	4,4	15,8	5,1	<3	12,2	16,2	18	24	14,1	7,1	5,8	8,3	7,9	9,3	10,3
Se	3,80E+02	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Zn	2,28E+04	<15	<15	34	17,8	30	78	36	51	74	41	15,2	<15	18	18	22	24

<u>Comparison with Tier 1 Risk-Based Target Levels - Residential Land Use (IRBCA)</u>

Soil:

- No concentrations exceeding threshold values were found during the soil survey.

Soil gas:

- In borehole G-12 the **chloroform** concentration exceeded Tier 1 RBTL (of 13,7 $\mu g/m^3$) and in borehole G18 the **naphthalene** RBTL value (9,28 $\mu g/m^3$) was exceeded as well - see Tab. 3-3.

4. Risk assessment

Before the quantification of risks, it is necessary to specify scenarios for the exposure of possible threatened recipients. This information, which is the subject of the identification of risks, is derived from data about the character and scope of contamination.

4.1. The determination and the justification of risks of priority contaminants

As has been already described above the soil gas survey confirmed the exceeding of the Tier 1 RBTL values in single cases of chloroform (borehole G12) and naphthalene (borehole G18). Although the other boreholes for active gas sampling didn't capture exceeding values of chloroform and naphthalene in this study we will consider these the priority contaminants.

In a further step the intrusion of chloroform and naphthalene through the soil profile and foundation construction layer and potential health risks resulting from contact with human organism is to be evaluated. As there are no technical information about the building’s foundation design for the parameters of the foundational structure will be used the suggested values in IRBCA methodology.

4.2. Toxicological properties of priority contaminants

Chloroform

Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste. It will burn only when it reaches very high temperatures. In the past, chloroform was used as an inhaled anesthetic during surgery, but it isn't used that way today. Today, chloroform is used to make other chemicals and can also be formed in small amounts when chlorine is added to water. Other names for chloroform are trichloromethane and methyl trichloride.

Chloroform may be released to the air as a result of its formation in the chlorination of drinking water, wastewater and swimming pools. Other sources include pulp and paper mills, hazardous waste sites, and sanitary landfills. The major effect from acute (short-term) inhalation exposure to chloroform is central nervous system depression. Chronic (long-term) exposure to chloroform by inhalation in humans has resulted in effects on the liver, including hepatitis and jaundice, and central nervous system effects, such as depression and irritability. Chloroform has been shown to be carcinogenic in animals after oral exposure, resulting in an increase in kidney and liver tumors. EPA has classified chloroform as a Group B2, probable human carcinogen.

Under the Proposed Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1996; U.S. EPA, 1999), chloroform is likely to be carcinogenic to humans by all routes of exposure under high-exposure conditions that lead to cytotoxicity and regenerative hyperplasia in susceptible tissues (U.S. EPA, 1998a,b). Chloroform is not likely to be carcinogenic to humans by any route of exposure under exposure conditions that do not cause cytotoxicity and cell regeneration. This weight-of-evidence conclusion is based on: 1) observations in animals exposed by both oral and inhalation pathways which indicate that sustained or repeated cytotoxicity with secondary regenerative hyperplasia precedes, and is probably required for, hepatic and renal neoplasia; 2) there are no epidemiological data specific to chloroform and, at most, equivocal epidemiological data related to drinking water exposures that cannot necessarily be negative, although there are some scattered positive results that generally have limitations such as excessively high dose or with confounding factors. Thus, the weigh-of-evidence of the genotoxicity data on chloroform supports a conclusion that chloroform is not strongly mutagenic, and the genotoxicity is not likely to be the predominant mode of action underlying the carcinogenic potential of chloroform. Although no cancer data exist for exposures via the dermal pathway, the weight-of-evidence conclusion is considered to be applicable to this pathway as well, because chloroform absorbed through the skin and into the blood is expected to be metabolized and to cause toxicity in much the same way as chloroform absorbed by other exposure routes.

Naphthalene

Naphthalene a white solid with a characteristic odor of mothballs, is a polycyclic aromatic hydrocarbon composed of two fused benzene rings. The principal end use of naphthalene is as a raw material for the production of phthalic anhydride. It is also used as an intermediate for synthetic resins, celluloid, lampblack, smokeless powder, solvents, and lubricants. Naphthalene is used directly as a moth repellant, insecticide, anthelmintic, and intestinal antiseptic (ATSDR, 1990; U.S. EPA, 1986).

Naphthalene can be absorbed by the oral, inhalation, and dermal routes of exposure and can cross the placenta in amounts sufficient to cause fetal toxicity. The most commonly observed effect of naphthalene toxicity following acute oral or inhalation exposure in humans is hemolytic anemia associated with decreased hemoglobin and hematocrit values, increased reticulocyte counts, presence of Heinz bodies, and increased serum bilirubin levels (ATSDR, 1990). Hemolytic anemia has been observed in an infant dermally exposed to naphthalene (Schafer, 1951) and in infants whose mothers were exposed to naphthalene during pregnancy (Anziulewicz et al., 1959; Zinkham and Childs, 1958). Infants and individuals having a congenital deficiency of erythrocyte glucose-6-phosphate dehydrogenase are especially susceptible to naphthalene-induced hemolytic anemia (Wintrobe et al., 1974).

Acute oral and subchronic inhalation exposure of humans to naphthalene has resulted in neurotoxic effects (confusion, lethargy, listlessness, vertigo), gastrointestinal distress, hepatic effects (jaundice, hepatomegaly, elevated serum enzyme levels), renal effects, and ocular effects (cataracts, optical atrophy). Cataracts have been reported in individuals occupationally exposed to naphthalene (Ghetti and Mariani, 1956) and in rabbits and rats exposed orally to naphthalene (Van Heyningen and Pirie, 1976; Fitzhugh and Buschke, 1949). A number of deaths have been reported following intentional ingestion of naphthalene-containing mothballs (ATSDR, 1990). The estimated lethal dose of naphthalene is 5-15 g for adults and 2-3 g for children. Naphthalene is a primary skin irritant and is acutely irritating to the eyes of humans (Sandmeyer, 1981).
Table No. 4-1: Values of toxicological parameters of priority contaminants used in this assessment.

Substance	Carcinogenicity by IARC[2]	Carcinogenicity by U.S.EPA[1]	IUR* (Inhalation Unit Risk) $[\mu g.m^{-3}]^{-1}$
Chloroform	2B	B2	2,3E-05
Naphthalene	2B	C	3,4E-05

*source: database www.epa.gov, http://www.iarc.fr/

[1]) EPA WOE (2005 Guidelines) = weight of evidence for carcinogenicity under 2005 EPA cancer guidelines: C (Possible human carcinogen), B2 (Probable human carcinogen - based on sufficient evidence of carcinogenicity in animals)

[2]) 1 – carcinogenic to humans,
2A – probably carcinogenic to humans,
2B – possibly carcinogenic to humans,
3 – can not yet be assessed in terms of carcinogenicity,
4 - probably not carcinogenic to humans.

Inhalation unit risk (IUR) is an estimate of the increased cancer risk from inhalation exposure to a concentration of 1 $\mu g/m^3$ for a lifetime. The IUR can be multiplied by an estimate of lifetime exposure (in $\mu g/m^3$) to estimate the lifetime cancer risk.

Table No. 4-2: List of usable reference doses for calculations of health risks.

Effects	Noncancerous	Carcinogenic
Exposure	$RfC_{inhalation}$ $[mg.kg^{-1}.day^{-1}]^{-1}$	$SF_{inhalation}$ $[mg.kg^{-1}.day^{-1}]^{-1}$
Chloroform	9,8E-02	10,73E-02
Naphthalene	3,0E-03	15,87-02

* source: epa.gov.cz – composite sl table -05/2016

Note: $SF_{inhalation}$ was derived from equation: $SF_{inhalation}$ =(IUR*1000*70)/15

Reference concentration for inhalation ($RfC_{inhalation}$) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

4.3. Summary of transport methods and real exposure scenarios

According to the client's requirement only the risks resulting from soil gases intrusion will be evaluated.

The potential group of human health risks recipients was identified as the r**esidents (adults and children),** who will live inside the planned buildings and who might face risks from inhalation of gases intruding through the foundation constructions.

Other exposure scenarios linked especially with any contact with the contaminated soil including among others dermal contact with contaminated soil, accidental ingestion, inhalation of contaminated soil particles etc. can not be included in the risk assessment because of the lack of appropriate data.

Risks for the construction workers are not evaluated as these workers have to use personal protective equipment during the construction works at the site that mitigate all the potential health risks.

4.4. Assessed exposure scenario and its parameters

The considered exposure scenario is only one – **Residents (adults and children)** living in the buildings and using its basement levels as underground garages for car parking. The parameters of exposure used in our calculations are summarized in the following tables together with the exposure parameters identified in the exposure scenario. The values of these parameters were estimated on the basis of expectations about the movements of inhabitants. No engineering plans are available at the moment for the buildings yet a proper ventilation system installation in the underground levels is expected. Therefore the advancement of gases intruded through the foundational layer to higher levels of the building (possibly with apartments, shops etc.) is not expected and only the exposition of the residents during their short term stay in the underground garages is evaluated.

The two representative age groups of residents were selected with respect to various values of exposure parameters. With calculations of exposure doses and health risks, they are combined with the maximum concentration of contaminants discovered which served for modelling of indoor concentration (see next chapter).

In the estimate of health risks, following exposition parameters values were chosen: exposure of adults with the average length of life of 70 years with the body weight of 72 kg during maximum 25 years with the frequency of exposure of 350 days in one year for exposure by inhalation which includes only the indoor air exposure of 1 hour per day. In the case of the child population, children up to 6 years old with the body weight of 19 kg are considered, the time of exposure is considered as a maximum of 6 years. Within the scenario, **the acceptable value of risk at the level of 1.10^{-6} for the group of up to 10 - 100** threatened people is considered as that which corresponds to the probability of the origination of cancer for 1 person in 1 million.

Table No. 4-3: Exposure scenario Residents - list of exposure methods and risk recipients.

Environmental element	Exposure method	Recipient of risks
Soil gas intruded into the basement levels of the buildings	**Inhalation**	**Residents (children 1-6 years, adults 18 – 70 years);**

Table No. 4-4: Exposition scenario Residents (using the underground garages) - list of exposure parameters used.

Exposure parameter	Symbol	Adults	Children
Duration of exposure [year]	ED	25	6
Averaging period [day] - for non-carcinogenic : ED (year) x 365 days.year-1	AT	9125	2190
Averaging period [day] - for carcinogenic : 70 years x 365 days.year^{-1}	AT kar.	25550	
Average weight of the individual [kg]	BW	72	19
Inhalation rate (medium activity) [m3.hour-1]	InhR	0,625	0,35
Frequency of exposure [hour.year-1]	EF	350	350

4.5. The methodology of quantitative assessment and soil gas intrusion modelling

For the evaluation of exposure by contaminated soil gas of indoor air a software tool Risk 5.0 was used. In the software the Johnson-Ettinger model is integrated which enables modelling of the vapor intrusion pathway into buildings trough the soil and foundational structure based on pre-adjusted settings/parameters of soil, building structures and the contaminant. For intrusion modelling as an input the maximum concentration of contaminant in the soil gas was used. All input parameters that were used in the model are summarized in following tables.

Table No. 4-5: Unsaturated zone properties beneath building used in the Johnson-Ettinger model.

Parameter	Unit	Value
Total porosity	cm3/cm3	4,0E-01
Water content	cm3/cm3	1,0E-01
Air content	cm3/cm3	3,0E-01
Distance from source to building	m	1,0E-03
Bioattenuation factor	-	1,0E+00

Table No. 4-6: Building parameters used in the Johnson-Ettinger model.

Parameter	Unit	Value
Foundation thickness	cm	1,5E+01
Fraction of cracks	-	2,0E-03
Porosity in cracks	cm3/cm3	4,0E-01
Water content in cracks	cm3/cm3	1,0E-01
Enclosed space floor length	m	1,0E+01
Enclosed space floor width	m	1,0E+01
Enclosed space height	m	2,0E+00
Number of air changes per hour	1/hr	5,0E-01
Foundation thickness	cm	1,5E+01
Fraction of cracks	-	2,0E-03

Table No. 4-7: Soil gas source concentration for vapor model.

Chemical	Units	Concentration
Chloroform	mg/m3	2,6E-02
Naphthalene	mg/m3	1,1E-02

Table No. 4-8: Chemical properties of contaminant soil gases used in the Johnson-Ettinger model.

Chemical Properties	Units	Chloroform	Naphthalene
Diffusion coefficient in air	cm2/s	1,0E-01	5,9E-02
Diffusion coefficient in water	cm2/s	1,0E-05	7,5E-06
Solubility	mg/l	7,9E+03	3,1E+01
Kd (total soil partition coefficient)	L/kg	ND	ND
KOC (organiChem carbon partition coefficient	L/kg	4,0E+01	2,0E+03
Henry's Law coefficient	(m3-H2O)/(m3-air)	1,5E-01	2,0E-02
Molecular weight	g/mol	1,2E+02	1,3E+02

4.6. Evaluation of health risks

During the evaluation of health risks, it is necessary to distinguish between the evaluation of substances with carcinogenic (stochastic) effects and non-carcinogenic (systematic) effects. Mechanisms of the affection of these two types of contaminants are different. In the case of substances with a carcinogenic effect event, a small number of changes at the molecular level may cause uncontrolled cell proliferation, or the development of malignancies. It is derived from the existing idea about the origination of malignancies, when the initiating moment may be any contact with carcinogenic substances. Because theoretically there is no safe level of exposure to such substances, the mechanism of the action is described as a non-threshold. In the case of systemic toxicity, the toxic effect of pollutants must overcome at first some (threshold) physiological detoxification capacity, compensation and the defense mechanisms of the body. So, it is possible to identify the rate of exposure which is safe for the human body and does not cause any negative effects under normal circumstances. For the evaluation of the chronic influence of contaminants from the environment on the human body, the fact is characteristic that as a rule it concerns the affection of very low concentrations whose toxic effect must be extrapolated from areas of high concentrations.

For the evaluation of the systematic toxic substances with non-cancer effects , US EPA introduces the so-called reference doses of RfD [$mg.kg^{-1}.day^{-1}$], whereas The world health organization WHO uses a system of acceptable daily doses (ADI). The value of RfD represents the level of the everyday exposure dose of the contaminant which the population (including sensitive groups) may face during the whole length of life without the reflection of any unfavorable effects. Doses varying under the level of RfD cannot be considered with the highest probability as risky. Values of RfD are, as a rule, obtained from toxicological tests on animals, from the so-called NOAEL values (the highest levels of exposure and no negative influence was observed), which are reduced by one or more orders of factors of uncertainty expressing uncertainty resulting from semi-kind extrapolation and extrapolation from the area of high into the area of low doses.

At present, there are more organizations stating RfD values, which are regularly published and updated. For the calculation of the risks in this work, the values of RfD will be used from updated databases US EPA and IRIS, and also from the database RAIS, which summarizes the knowledge from the database US EPA (United States Environmental Protection Agency), IRIS (Integrated Risk Information System), PPRTVs (EPA Provisional Peer Reviewed Toxicity Values) and others.

The purpose **of the evaluation of exposure** is deriving / calculating the average daily intake or the lifelong intake of the monitored contaminant. As a rule, long-term, (chronic) exposure with low doses of the contaminant from the environment is considered. If the concentration of the contaminant in the monitored medium during the exposure is constant, the volume of the substance entering into the organism can be expressed as the average daily intake [$mg.kg^{-1}.day^{-1}$], which can be calculated by the following equation:

CADD = C . IR FI . EF . ED / BW . AT

CADD	Chronic Average Daily Dose [$mg.kg^{-1}.day^{-1}$]
C	concentration of the contaminant in the monitored medium [$mg.kg^{-1}$, $mg.m^{-3}$, $mg.l^{-1}$]
IR	rate of contact with the contaminated medium [$kg.day^{-1}$, $l.day^{-1}$, $m^3.day^{-1}$] (inhalation of air per day)
FI	ratio of intake of the monitored medium from the contaminated source [0 – 1, dimensionless]
EF	frequency of exposure [$day.year^{-1}$]
ED	duration of the exposure [year]
BW	average body weight of the exposed individual [kg]
AT	time at which the exposure dose is averaged [day]

For substances with non-cancerous effects, the parameter AT corresponds to the time of the duration of the exposure, whereas with the cancer effect, there is the accumulation of exposure

doses during the whole length of the life of the individual. The average daily intake of substances is related to the supposed length of human life LT (as a rule 70 years) and the exposure in this case is expressed as the life-long average daily intake of LCDI so that in the equation the parameter AT is replaced by LT.
The purpose **of the characterization of the risk** is to summarize all data and information and to quantitatively express the rate of the actual health risk from chronic exposure of the contaminant under the stated situation, which may serve as the source information for the decision about measures, i.e. risk management. The recommended index of the risky character of substances with a non-cancerous effect is the risk index "Hazard Quotient" (HQ), expressed as the ratio of daily intake and the respective reference dose (RfD).

When evaluating the risk character of the affection of substances with non-cancerous effects, it is valid that if the average daily intake (CDI) is lower than the reference dose ($HI < 1$), then the supposed exposure is so low that with the highest probability it does not bear any health risks. If $HI > 1$, it is necessary to obtain detailed data about the monitored substance and the manner of exposure or to start suitable corrective measures.

For the measurement of the risk of the cancerous effect for the exposed population, the lifetime increase of the probability of the origination of cancer disease ILCR is used ("Incremental Lifetime Cancer Risk"), i.e. the theoretical number of statistically supposed cases of the tumour disease and the number of people exposed. ELCR can be obtained as the multiple of the lifetime of the average daily dose of LADD and the value of the slope factor SF according to the equation valid for relatively low risks to the value 1×10^{-2}:

$ILCR = LADD \cdot SF$

ILCR	Incremental Lifetime Cancer Risk (theoretical number of statistically expected cases of the tumor per number of exposed people)
LADD	Lifetime Average Daily Dose [$mg.kg^{-1}.day^{-1}$]
SF	Slope Factor [$mg.kg^{-1}.day^{-1}$]$^{-1}$

The following values of ILCR (MŽP 2011) are considered to be acceptable rate of risk for carcinogens

- 1×10^{-6}(probability of the origination of cancer for 1 person in a million) when evaluating regional influences – usually above 100 people at risk
- 1×10^{-5}(probability of the origination of cancer for 1 person in 100,000) when evaluating regional influences – usually between 10 and 100 people at risk
- 1×10^{-4}(probability of the origination of cancer for 1 person in 10,000) when evaluating individuals up to 10 people

In the case of exposure by further contaminants, their individual contributions to non-carcinogenic risk are summed up (synergistic effect) and then it is necessary to consider the summary quotient of risk or ILCR:

- HItotal = HI1 + HI2 + HI3 + ... + HIn
- $ILCR_{total} = ILCR_1 + ILCR_2 + ILCR_3 + ... + ILCR_n$

The following equation states the manner of quantification of exposure by inhalation of indoor air:
where:

$$CADD = \frac{C_{max} \times InhR \times ET \times EF}{BW \times 365 \frac{d}{yr}}$$

$$LADD = \frac{C_{ave} \times InhR \times ET \times EF \times ED}{LT \times BW \times 365 \frac{d}{yr}}$$

CADD	Chronic Average Daily Dose [$mg.kg^{-1}.day^{-1}$]
LADD	lifetime average daily dose [mg/kg-day]
C_{max}	maximum 7-year concentration of chemical in indoor air [mg/m^3]
C_{ave}	Time-averaged concentration of chemical in outdoor air over the exposure duration [mg/m^3]
InhR	inhalation rate indoors [m3/hr]
EF	Frequency of exposure in the indoor environment [$hour.year^{-1}$]
ET	exposure time indoors [hr/day]
LT	lifetime = 70 years
ED	duration of exposure [year]
BW	average body weight [kg]

4.6.1. Evaluation of exposure

The evaluation of exposure was conducted for the priority contaminants – chloroform and naphthalene – based on the estimated indoor concentration level modelled with the Johnson-Ettinger model and exposure parameters defined in chapter 4.4.

Values of calculated indexes of hazardous substances or carcinogenic effect, HI and ILCR are mentioned in the following tables.

Table No. 4-9: Results of evaluation of **non-carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**children**).

Substance	**C_{ind-g}**	**$CADD_{inhalation}$**	**$HI_{inhalation}$**	**HI_{total}**
	[mg/m^3]	**[$mg.kg^{-1}.d^{-1}$]**		
Chloroform	3,5E-09	6,1E-11	1,4E-09	6,2E-08
Naphthalene	4,6E-09	8,0E-11	6,1E-08	

where C_{ind-g} is for the modelled indoor gas contamination.

Table No. 4-10: Results of evaluation of **non-carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**adults**).

Substance	**C_{ind-g}**	**$CADD_{inhalation}$**	**$HI_{inhalation}$**	**HI_{total}**
	[mg/m^3]	**[$mg.kg^{-1}.d^{-1}$]**		
Chloroform	3,5E-09	2,9E-11	1,4E-09	6,2E-08
Naphthalene	4,6E-09	3,8E-11	6,1E-08	

Note: The HI values between adults and children differ in the order of one trillionth, that's why in this rounding the values look the same.

Table No. 4-11: Results of evaluation of **carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**children**).

Substance	**C_{ind-g}**	**$LADD_{inhalation}$**	**$ILCR_{inhalation}$**	**$ILCR_{total}$**
	[mg/m^3]	**[mg.kg^{-1}.d^{-1}]**		
Chloroform	3,5E-09	5,3E-12	2,7E-13	2,7E-13

Table No. 4-12: Results of evaluation of **carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**adults**).

Substance	**C_{ind-g}**	**$LADD_{inhalation}$**	**$ILCR_{inhalation}$**	**$ILCR_{total}$**
	[mg/m^3]	**[mg.kg^{-1}.d^{-1}]**		
Chloroform	3,5E-09	1,1E-11	1,2E-12	1,2E-12

4.6.2. Estimation of health risks

In this chapter is the interpretation of the health risk related to the evaluation of the exposure scenario and individual methods of exposure.

The submitted results represent the estimated health risks that can be approximately expected in conditions specific for the stated site in presumed conditions but, what is important, while integrating many uncertain inputs (due to the lack of data about the construction design etc.). All model calculations of exposure doses and health risks are therefore loaded by certain restrictions and uncertainty. They are in detail specified in the separate chapter 4.7. Restrictions and uncertainty.

Scenario: Residents (adults and children)

Non-carcinogenic risks

The results of the calculation presented in the tables above show that when taking into consideration the maximum ascertained levels of contamination of the soil gas as monitored (and afterwards modelled for indoor conditions) the exposure method of inhalation **represent no health risks for children, as well as adults** attending the basement levels of the buildings (HI_{total} for both age groups 6,2E-08).

Carcinogenic risks:

The values of the lifelong increase of the probability of the origination of ILCR tumor diseases for residents (children and adults) attending the base floors of the buildings do not exceed the acceptable level of risk of 1.10-6 for the evaluation of individuals up to 100 persons. Therefore **the probability of origination of tumor diseases caused by the exposition to contaminated intruded soil gas is very low**.

4.7. Restrictions and uncertainty

The evaluation of possible health risks always relates to a series of uncertainties that are derived, e.g. generally defined exposure parameters or the application of specific preconditions. Uncertainties to bring into the evaluation of risks are the method of quantitative evaluation of exposure, which includes certain simplifying preconditions, constants and empirical relations, which need not correspond to the relations of the site of interest and the actual behaviour of the risk recipients. The results of the evaluation of health risks are restricted by the existing level of knowledge of the methodology for the evaluation of the possible affection of monitored factors on human health.

Health risks are evaluated within the submitted RE and are related to the following restrictions and uncertainties:

- To ensure safety and protection and for more sensitive risk recipients then during the evaluation of risks from the viewpoint of safety, conservative preconditions are introduced. Exposure parameters are defined on the side of caution due to which some results may be overvalued in relation to the actual status. During the evaluation of the exposition it is supposed that the individual faces maximum concentrations during the whole period of this exposure and that this contamination is divided proportionally. The exposure may also differ depending on the type, age, sensitivity of the individual, etc.
- During selection of exposure parameters, in the case of uncertainty, higher values of parameters are taken into consideration that the risk analysis on the side of security (e.g. duration of exposure, volume of breathed air) is as objective as possible and, at the same time, prevents any devaluation of risks resulting from exposure by radio nuclides.
- The evaluated exposure scenario and transport routes are models and cannot be fully applied for each individual. The submitted analysis cannot involve individual transport routes in the rate source of contamination → individual recipient.
- The soil gas survey on which is this RE based might not capture the real maximum concentrations of soil gas occuring in the placement of future building construction.
- The Johnson-Ettinger model results are loaded with high uncertainty because of subjective estimation of many parameters which are not known at this moment (foundation structures composition, thickness, soil physical properties etc.)

The loading of the results of the risk evaluation by the above-mentioned types of uncertainties may not principally influence the ascertained conclusions.

5. Conclusions and recommendations

Health risk evaluation based on soil gas survey results for the Pardes BeHisahon site was performed in this study.

In case of active soil gas sampling the exceeding values, when compared to Tier 1 RBTL, were detected only in single cases of naphthalene and chloroform.

Based on Johnson-Ettinger model the rate of soil gas intrusion through the foundation constructions was simulated and indoor soil gas concentration was modelled. Obtained values were then used for the health risk evaluation resulting from indoor exposition of residents (children and adults) by inhalation of intruded contaminated soil gas. **For this scenario both the non-carcinogenic and carcinogenic risks resulting from discovered concentration level of chloroform and naphtalene in the soil gas were not confirmed.** From this reason no further corrective measures are suggested.

According to the evaluation of all available data about the site, especially regarding to the level of the soil and soil gas residual contamination it can be stated that no human health risks were identified/calculated for the studied exposure scenario (penetration of the soil gas into the underground constructions - basements of new buildings at the site).

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