



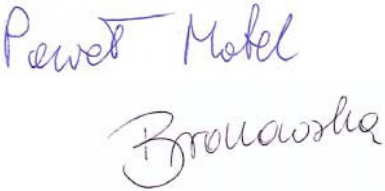
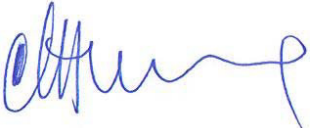
Phase II Environmental Site
Assessment
of the Cinkarna Metalurško-kemična industrija
Sites in Celje and Mozirje

Prepared for:
**Cinkarna Metalurško-kemična industrija
Celje d.d, Slovenia**

Prepared by:
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Executive Summary

In August 2014, Cinkarna Metalurško-kemična industrija Celje d.d. (the Company) commissioned execution of a Phase II Environmental Site Assessment and preparation of a Phase II Environmental Report in order to verify the status of soil and groundwater contamination at the land which is operated by Cinkarna Metalurško- kemična industrija Celje d.d. Phase II Environmental Site Assessment was performed by ENVIRON Poland Sp.z o.o. This is an executive summary which presents the key findings and recommendations from the performed assessment. For further details, please contact the management board of Cinkarna Metalurško-kemična industrija d.d.

I. Field works of the Phase II Environmental Site Assessment took place between August 19 and September 3, 2014. The following scope of works was performed:

- Drilling of 70 boreholes for the purpose of soil sampling (52 boreholes at Cinkarna Celje production facility, 3 boreholes at the gypsum pipeline, 3 boreholes at the Cinkarna Mozirje facility, 3 boreholes at Za Travnikom red gypsum landfill, 3 boreholes at Bukovžlak red gypsum landfill, 3 boreholes at Bukovžlak non-hazardous solid wastes landfill and 3 boreholes at the farming land located adjacent to the landfills);
- Installation of 28 temporary monitoring wells, collection and analysis of 28 groundwater samples (22 temporary monitoring wells at Cinkarna Celje production facility, 3 temporary monitoring wells at the gypsum pipeline, 3 temporary monitoring wells at the Cinkarna Mozirje facility);
- Collection of groundwater samples from 14 permanent monitoring wells installed at the landfills (4 permanent monitoring wells at Za Travnikom red gypsum landfill, 4 permanent monitoring wells at Bukovžlak red gypsum landfill, 6 permanent monitoring wells at Bukovžlak non-hazardous solid wastes landfill);
- Analysis of 142 soil samples (109 soil samples collected at Cinkarna Celje production facility, 6 soil samples collected at the gypsum pipeline, 6 soil samples collected at the Cinkarna Mozirje facility, 6 soil samples collected at Za Travnikom red gypsum landfill, 6 soil samples collected at Bukovžlak red gypsum landfill, 6 soil samples collected at Bukovžlak non-hazardous solid wastes landfill and 3 soil samples collected at the farming land located adjacent to the landfills) and one sample of currently produced gypsum (sample GYP-1);
- As a QA/QC measure, two Trip Blank soil samples and one Trip Blank groundwater samples were transported to the investigated sites and were analysed following delivery of the samples to the laboratory.

II. Laboratory analysis of collected soil and groundwater samples has revealed the following:

1. At the **Cinkarna Celje** production site, sixteen areas (zones of suspected pollutant concentrations) were designed and in each area at least one borehole was drilled and soil and groundwater samples were collected and analysed. Laboratory analysis of collected samples revealed high concentrations of heavy metals in collected soil samples, for such metals as Zinc, Antimony, Arsenic, Barium, Cadmium, Copper, Cobalt, Lead and Nickel. In numerous samples, both the Slovenian Critical Values and Dutch List Intervention Values were exceeded.

The highest concentrations were observed for:

- Zinc (concentrations up to 180,000 mg/kg, which is 250 times higher than Dutch List Intervention Value of 720 mg/kg),
- Antimony (concentrations up to 530 mg/kg, which is 24 times higher than Dutch List Intervention Value of 22 mg/kg),
- Arsenic (concentrations up to 10,000 mg/kg, which is 131 times higher than Dutch List Intervention Value of 76 mg/kg),
- Barium (concentrations up to 3,200 mg/kg, which is 3.5 times higher than Dutch List Intervention Value of 920 mg/kg),
- Cadmium (concentrations up to 660 mg/kg, which is 50 times higher than Dutch List Intervention Value of 13 mg/kg),
- Copper (concentrations up to 160,000 mg/kg, which is 842 times higher than Dutch List Intervention Value of 190 mg/kg),
- Cobalt (concentrations up to 770 mg/kg, which is 4 times higher than Dutch List Intervention Value of 190 mg/kg),
- Lead (concentrations up to 45,000 mg/kg, which is 84 times higher than Dutch List Intervention Value of 530 mg/kg) and
- Nickel (concentrations up to 670 mg/kg, which is 6.7 times higher than Dutch List Intervention Value of 100 mg/kg).

The highest concentrations of heavy metals were associated with presence of man-made fills, mainly in the layers of gravel-size metallurgical waste. Man-made fills were observed in all executed boreholes. The layer of man-made fills reaches a thickness of 1.4-3.6 m-bgl in Area 1, 1.2-4.7 m-bgl in Area 2, 2.1-3.7 m-bgl in Area 3, 3.5 m-bgl in Area 4, 2.2 m-bgl in Area 5, 0.5-1.4 m-bgl in Area 6, 1.2-1.6 m-bgl in Area 7, 0.6-3.8 in Area 8, 1.1-2.0 m-bgl in Area 9, 0.9-1.4 m-bgl in Area 10, 1.7 m-bgl in Area 11, 0.5-4.4 m-bgl in Area 12, 0.5-3.5 m-bgl in Area 13, 0.9 m-bgl in Area 14, 3.0-4.5 m-bgl in Area 15 and 1.2 m-bgl in Area 16. The results of analysis of groundwater samples collected from 25 temporary monitoring wells installed at Cinkarna Celje site indicated that groundwater is impacted with heavy metals, in particular Zinc, which was observed in all collected groundwater samples. In some groundwater samples, concentrations of Zinc were significantly high and exceeded Dutch List Intervention Values for groundwater (800 µg/l) i.e. in groundwater samples collected from temporary monitoring wells No. 2-1 (25,000 µg/l), 2-5 (34,000 µg/l), 3-1 (120,000 µg/l), 4-1 (1,700 µg/l), 5-1 (7,700 µg/l), 7-1 (1,600 µg/l), 8-5 (18,000 µg/l), 8-6 (2,000 µg/l), 8-7 (1,700 µg/l), 11-1 (1,000 µg/l), 12-3 (8,400 µg/l), 12-11 (1,600 µg/l) and 12-13 (2,400 µg/l). Elevated concentrations of Arsenic, Cadmium, Cobalt, Copper, Lead, Mercury and Nickel were also observed.

2. At the **Cinkarna Mozirje** production site, three areas (zones of suspected pollutant concentrations) were designed and in each area one borehole was drilled and soil and groundwater samples were collected and analysed. Laboratory analysis of collected soil samples revealed natural, background concentrations of heavy metals, except for concentration of Zinc in one soil sample (concentration of Zinc of 850 mg/kg in the soil sample MO-1 at 2.2 m-bgl, which exceeded a Dutch List

Intervention Value of 720 mg/kg). Presence of organic compounds was detected in two soil samples collected from a layer of man-made fills (MO-1 at 2.2 m-bgl and MO-2 at 0.5 m-bgl). In both samples compounds from the group of Polycyclic Aromatic Hydrocarbons (the sum of PAHs in the first sample was 4.46 mg/kg and was 18.8 mg/kg in the second one), as well as mineral oil (TPHs fraction C12-C35 in the first sample was 19 mg/kg and 100 mg/kg in the second one) were detected (both the Slovenian Critical Values and Dutch List Intervention Values were not exceeded). Analysis of groundwater samples collected from three temporary monitoring wells installed at Cinkarna Mozirje site did not reveal significant impacts both of heavy metals and organic compounds. In particular, no presence of Polycyclic Aromatic Hydrocarbons or Volatile Organic Compounds was observed.

3. At the **Bukovžlak landfill for red gypsum**, three boreholes were drilled for the purpose of collection of soil samples and four groundwater samples were collected from existing, permanent monitoring wells.

Laboratory analysis of collected soil samples revealed natural, background concentrations of heavy metals in all soil samples, except for one soil sample, collected from the borehole BG-2 at a depth of 4.2 m-bgl (sample collected from a layer of silty, red-colored fine industrial waste material ("pyrite waste")). Laboratory analysis of this sample revealed high concentrations (exceeding Dutch List Intervention Values) of Arsenic (2,000 mg/kg), Copper (1,800 mg/kg), Lead (910 mg/kg) and Zinc (2,400 mg/kg).

Analysis of groundwater samples collected from four permanent monitoring wells installed in the vicinity of the Bukovžlak landfill for red gypsum, indicated low concentrations of heavy metals, typical for natural, not impacted groundwater, in the groundwater sample BUK-1, collected from a monitoring well located up-gradient of the landfill and in the groundwater sample BUK-2, collected from a monitoring well located down-gradient of the landfill.

Elevated concentrations of heavy metals were detected in two groundwater samples collected from monitoring wells located down-gradient of the landfill: in the groundwater sample K-10 (Arsenic concentration of 1,550 µg/l and Zinc concentration of 990 µg/l) and in the groundwater sample K-11 (Cadmium concentration of 43 µg/l, Cobalt concentration of 210 µg/l, Nickel concentration of 140 µg/l and Zinc concentration of 8,400 µg/l). Presence of elevated concentrations of heavy metals in K-10 and K-11 groundwater samples is not an influence of red gypsum. Both permanent wells (K-10 and K-11) are located in the area built of "pyrite waste" (silty, red-colored fine industrial waste material), which was incorporated in the air side of the dam Bukovžlak. Increased concentrations of heavy metals in groundwater sample collected from a monitoring wells K-10 and K-11 result from leaching of heavy metals from the "pyrite waste". The "pyrite waste" is known to contain elevated concentrations of leachable heavy metals such as Arsenic, Cadmium, Cobalt, Copper, Lead, Nickel and Zinc.

4. At the **Bukovžlak landfill for non-hazardous solid wastes**, three boreholes were drilled for the purpose of collection of soil samples and six groundwater samples were collected from existing, permanent monitoring wells.

Laboratory analysis of collected soil samples revealed natural, background concentrations of heavy metals in all soil samples, except for one soil sample, collected from the borehole BS-2 at a depth of 1.0 m-bgl (sample collected from a layer of silty, red-colored fine industrial waste material ("pyrite waste")). Laboratory analysis of this sample revealed high concentrations (exceeding Dutch List Intervention Values) of Antimony (48 mg/kg), Arsenic (1,200 mg/kg), Cadmium (15 mg/kg), Copper (3,200 mg/kg) and Zinc (4,100 mg/kg).

Analysis of groundwater samples collected from six permanent monitoring wells installed in the vicinity of the Bukovžlak landfill for solid wastes, indicated low concentrations of heavy metals, typical for natural, not impacted groundwater, in groundwater samples BUK-3 and N-3, collected from a monitoring wells located up-gradient of the landfill and in the groundwater samples A-1 and A-2, collected from monitoring wells located down-gradient of the landfill. Elevated concentrations of heavy metals were observed in one groundwater sample collected from a monitoring well located down-gradient of the Bukovžlak landfill for solid wastes: in groundwater sample A-3 (Cobalt concentration of 220 µg/l, Nickel concentration of 140 µg/l and Zinc concentration of 9,200 µg/l), all of them exceeding Dutch List Intervention Values.

Elevated concentrations of heavy metals were observed in one groundwater sample located up-gradient of the the Bukovžlak landfill for solid wastes: in groundwater sample P-4 (Cadmium concentration of 9.9 µg/l, Copper concentration of 110 µg/l, and Zinc concentration of 4,700 µg/l - all of them exceeding Dutch List Intervention Values). This monitoring well (P-4) is located up-gradient of Bukovžlak landfill for solid wastes but down-gradient of the Bukovžlak landfill for red gypsum (10 meters north of the landfill's embankment). P-4 monitoring well is located in the area built of "pyrite waste" (silty, red-colored fine industrial waste material), which was incorporated in the air side of the Bukovžlak landfill dam and disposed of in the location of solid waste landfill Bukovžlak. Increased concentrations of heavy metals in groundwater sample collected from a monitoring well P-4 result from leaching of heavy metals from the "pyrite waste". The "pyrite waste" is known to contain elevated concentrations of leachable heavy metals such as Arsenic, Cadmium, Cobalt, Copper, Lead, Nickel and Zinc.

5. At the **Za Travnikom landfill for red gypsum landfill**, three boreholes were drilled for the purpose of collection of soil samples and four groundwater samples were collected from existing, permanent monitoring wells.

No elevated concentrations of heavy metals and organic compounds were observed in any of the collected soil samples. The observed concentrations of heavy metals and organic compounds indicated natural, background concentrations.

Analysis of groundwater samples collected from four permanent monitoring wells installed in the vicinity of the Za Travnikom landfill for red gypsum, indicated low concentrations of heavy metals, typical for natural, not impacted groundwater, in a groundwater sample Z-1A, collected from a monitoring well located up-gradient of the landfill and in two samples collected down-gradient of the landfill (ZT-1A and ZT-2A). In groundwater sample TV-1A collected from a monitoring well located down-gradient of the landfill, elevated concentrations of heavy metals were observed

for Cobalt (concentration of 1,700 µg/l), Nickel (concentration of 430 µg/l) and Zinc (concentration of 9,000 µg/l). Presence of elevated concentrations of heavy metals in TV-1A groundwater sample is not an influence of red gypsum. According to the information of Cinkarna's representatives, on this location "pyrite waste" was incorporated in the air side of the dam Za Travnikom. Increased concentrations of heavy metals in groundwater sample collected from a monitoring well TV-1A result from leaching of heavy metals from the "pyrite waste". The "pyrite waste" is known to contain elevated concentrations of leachable heavy metals such as Arsenic, Cadmium, Cobalt, Copper, Lead, Nickel and Zinc.

6. At the **farming land located north of Bukovžlak landfill**, no significant soil contamination with respect to both heavy metals and organic compounds was observed in any of collected three soil samples. The observed concentrations of heavy metals and organic compounds indicated natural, background concentrations.
 7. Other parameters, including inorganic parameters (Cyanides, Sulphates, Chlorides and Ammonium,) and metals such as Beryllium, Boron, Iron, Manganese, Phosphorus, Selenium, Thallium, Tin, Titanium and Vanadium were tested both in soil and groundwater samples. However, these parameters were not evaluated against Dutch List Intervention Values (DLIV) and Slovenian Critical Values (SCV) for soil and against Dutch List Intervention Values (DLIV) and Slovenian Threshold Values for groundwater because these reference documents do not contain screening values for given parameters.
- III. Based on the conducted investigations, the most significant contamination which needs improvement actions was identified at Cinkarna Celje site.

Despite observed environmental impacts (i.e. elevated concentrations of heavy metals in some of soil and groundwater samples collected at Bukovžlak and Za Travnikom landfills, which are clearly the result of impact of pyrite waste and not of deferred red gypsum), it is understood that the already implemented mitigation measures and control at the landfills, including a yearly monitoring of groundwater, collection of leachates from Bukovžlak landfill for solid wastes, capping of the landfills' surface with waters (landfills for red gypsum) and vegetation (Bukovžlak landfill for solid wastes) are oriented on minimization of environmental impacts. Additionally the company has prepared a project of installation of a capping system equipped with a system of drainage and collection of rain water in the frame of closing Bukovžlak solid waste landfill. At the landfill Za Travnikom a project of dewatering of the landfill's surface is already under completion and the same solution could be carried out on the landfill of red gypsum Bukovžlak.

- IV. Concentrations of heavy metals in soil and groundwater samples collected at Cinkarna Mozirje site, do not indicate a need to undertake improvement (remediation type) measures.
- V. It is recommended to perform improvement activities at the Cinkarna Celje site. The Recommended Improvement Action Plan is based on the following assumptions:
 1. Contamination is spread under the ground surface in irregular way at the majority of the Cinkarna Celje area and it is of historical origin. According to available

information, industrial operations in the current location of Cinkarna Celje were initiated in 1949. In the initial period, the location of the current Cinkarna Celje site was used for different types of chemical and metallurgical production including mechanical workshop. The most eastern part was used as a landfill of metallurgical and other waste from the previous location of Cinkarna. It was also reported that in the eastern part of the site, open storage for pyrite and residues originating from roasting of pyrite was historically present. The man-made fills observed across the site area are considered to comprise remains of historically deposited industrial wastes.

2. The Cinkarna Celje site occupies an area of approximately 45.81 hectares (ha), whereof app. 11.55 ha is built up area and app. 13.56 ha represent paved outdoor areas around the buildings used as traffic and parking areas. The remaining parts (i.e. 20.7 hectares) of the site are covered with vegetation (i.e. trees, lawns).
3. The improvement activities are to be conducted with limited influence on the local environment and the production processes performed at the site. While performing any type of remediation actions at Cinkarna Celje site, it is necessary to ensure appropriate Health and Safety measures at the same time with continuous, undisturbed and safe operation of the production plant.

VI. The most reasonable scenario:

- In order to ensure that heavy metals are not migrating out of the areas of their current presence, the areas which are not hardened or covered by buildings should be covered by permanent vegetal cover.
- Quality of groundwater at Cinkarna Celje should be monitored on permanent basis; it is recommended to install a network of permanent monitoring wells. According to land surveying measurements performed in August 2014 (within investigations conducted by ENVIRON), the groundwater flow direction is towards the north-west. It is recommended to install permanent groundwater monitoring wells downgradient and upgradient of the potential groundwater flow. The potential cost of permanent monitoring system installation at the site is approximately 50,000-80,000€. The hydrogeological monitoring should be based on measurements of groundwater table depth at least one time per month. Groundwater sampling and testing should be conducted every three months; in the future, based on obtained monitoring results, the frequency of sampling and testing can be modified accordingly.
- In order to observe the quality of groundwater, it is recommended to install a network of permanent monitoring wells. According to land surveying measurements performed in August 2014 (within investigations conducted by ENVIRON), the groundwater flow direction is towards the north-west. It is recommended to install permanent groundwater monitoring wells in the following areas:
 - inflow of groundwater (south-eastern part of the site): in location of temporary monitoring wells 10-3, 16-1 and on a lawn in the vicinity of the fire-station),

- Area 12 (with observed groundwater contamination with Arsenic, Chromium, Nickel, Cadmium and Zinc): in location of temporary monitoring wells 12-3, 12-11 and 12-13,
 - central part of the site: in location of temporary monitoring wells 3-1, 5-1, 7-1, 8-5, 8-6, 8-7,
 - outflow of groundwater: in location of temporary monitoring wells 2-1, 2-5, 6-3 and one additional monitoring well on a lawn in the vicinity of Hudinja river (north-western border of the site).
- The on-site groundwater monitoring system via on-site monitoring wells, should be supplemented by monitoring of quality of surface water in both rivers located in the site's vicinity. According to the site management, monitoring of water, sediment and biotope of Hudinja river has been performed by the company since 2005, but the scope of monitoring is limited to parameters which are associated with actual production of TiO₂.
 - With the aim to determine the possible impact on the environment and human health (ZVO-1) it is recommended to prepare a comprehensive monitoring program on rivers Hudinja and Vzhodna Ložnica. The scope of the monitoring program should cover at least all the pollutants that exceed Dutch List Intervention Values and/or Slovenian Critical Values. The frequency and duration of monitoring should be determined by the competent authority.
- VII.** If future groundwater monitoring results indicate a significant impact of the contaminated fill material present at the site, in order to avoid further propagation (migration) of contaminants through groundwater into adjacent water bodies (Hudinja and Vzhodna Ložnica rivers), it is proposed to consider implementation of further mitigation measures.
- In cases where due to construction needs it will be necessary to excavate soil at Cinkarna Celje site, the excavated soil should be remediated and all dusting preventive measures during the work should be undertaken. It is also recommended to implement appropriate Health and Safety measures for workers that may come into contact with impacted soils.
- VIII.** All improvement works should be discussed, with participation of a legal advisor, with a competent environmental authority. Prior to initiation of improvement works, it is recommended to obtain a confirmation (a formal document/decision/certificate) from a competent environmental authority that the proposed scope of works will result in: (1) acceptable limitation of impacts on humans and environment, and (2) that the current/future owners/occupants of the site will not be held liable for a historical contamination. After completion of the works, it is recommended to obtain a formal confirmation from competent authorities that agreed activities have been completed in line with agreed scope and conditions.

1 Introduction

In June 2014, ENVIRON Poland Sp. z o.o. was requested by Cinkarna Celje d.d ("the Company" or the "Subject Group") to perform a Phase II Environmental Site Assessment and to prepare a Phase II Environmental Report in order to verify the status of soil and groundwater contamination at the land which is operated by Cinkarna Celje d.d.

The land which was subject to this Phase II Environmental Site Assessment included:

- Cinkarna Celje production facility in Celje,
- Cinkarna Celje production facility in Mozirje,
- Za Travnikom red gypsum landfill,
- Bukovžlak red gypsum landfill,
- Bukovžlak non-hazardous solid wastes landfill.

Additionally, during the performed works, one additional area (further referred to as Area No. 15) was investigated. Area 15 is located adjacent to the territory of Cinkarna Celje, on a land owned by private owners, and a pipeline used for transportation of waste gypsum from the Cinkarna Celje production facility to Za Travnikom landfill is crossing this area. It was reported by the Company representatives that a pipeline used for transportation of gypsum has historically been leaking and spillages of gypsum into the ground may have occurred in this area.

The Company's intention was to perform the Phase II Soil and Groundwater Investigation in compliance with requirement resulting from the implementation of the Directive 2010/75/EU dated January 7, 2011 on the "Integrated pollution prevention and control of industrial emissions, IED".

ENVIRON proposed to follow the specific guidelines given in the draft European Commission Guidance concerning baseline reports under Article 22(2) of Directive 2010/75/EU on industrial emissions. The Guidance puts an emphasis on both soil and groundwater, and both of these environmental components were analysed in this investigation.

However, at the stage of performance of field works and preparation of this Phase II Environmental Assessment Report, no country-specific guidelines for performance of Phase II Environmental Assessment Reports under the Article 22(2) of Directive 2010/75/EU on industrial emissions were known to have been published in Slovenia.

The aim of the Phase II Soil and Groundwater Investigation report was to document the state of soil and groundwater at the moment of performance of Investigation, i.e. in August 2014.

This report may act as a point of reference for the entity benefiting from the environment in order to restore the location to its initial state (at the time of the definitive cessation of activities), i.e. to the state when the IED directive has been implemented.

The European Commission Guidance concerning baseline reports under Article 22(2) of Directive 2010/75/EU on industrial emissions recommends that preparation of a baseline report includes the following stages:

- Stage 1: Identifying the hazardous substances that are currently used, produced or released at the installation
- Stage 2: Identifying the relevant hazardous substances
- Stage 3: Assessment of the site-specific pollution possibility
- Stage 4: Analysis of Site history
- Stage 5: Analysis of Environmental setting
- Stage 6: Site Characterisation
- Stage 7: Site Investigation
- Stage 8: Production of the baseline report

This Phase II Environmental Site Assessment Report presents the results of Site Investigation works and laboratory analyses performed in August-September 2014.

During the field works that took place between August 19 and September 3, 2014, the following scope of works was performed:

- Drilling of 70 boreholes for the purpose of soil sampling (52 boreholes at Cinkarna Celje production facility, 3 boreholes at the leaking gypsum pipeline, 3 boreholes at the Cinkarna Mozirje facility, 3 boreholes at Za Travnikom red gypsum landfill, 3 boreholes at Bukovžlak red gypsum landfill, 3 boreholes at Bukovžlak non-hazardous solid wastes landfill and 3 boreholes at the farming land located adjacent to the landfills);
- Installation of 28 temporary monitoring wells, collection and analysis of 28 groundwater samples (22 temporary monitoring wells at Cinkarna Celje production facility, 3 temporary monitoring wells at the leaking gypsum pipeline, 3 temporary monitoring wells at the Cinkarna Mozirje facility);
- Collection of groundwater samples from 14 permanent monitoring wells installed at the landfills (4 permanent monitoring wells at Za Travnikom red gypsum landfill, 4 permanent monitoring wells at Bukovžlak red gypsum landfill, 6 permanent monitoring wells at Bukovžlak non-hazardous solid wastes landfill);
- Analysis of 142 soil samples (109 soil samples collected at Cinkarna Celje production facility, 6 soil samples collected at the leaking gypsum pipeline, 6 soil samples collected at the Cinkarna Mozirje facility, 6 soil samples collected at Za Travnikom red gypsum landfill, 6 soil samples collected at Bukovžlak red gypsum landfill, 6 soil samples collected at Bukovžlak non-hazardous solid wastes landfill and 3 soil samples collected at the farming land located adjacent to the landfills) and one sample of currently produced gypsum (sample GYP-1);

- As a QA/QC measure, two Trip Blank soil samples and one Trip Blank groundwater samples were transported to the investigated sites and were analysed following delivery of the samples to the laboratory.

2 Background Information

CINKARNA Metalurško-kemnična industrija Celje, d.d. (further referred as 'Cinkarna' or the Client) performs its activities in Slovenia, nearby two cities, which are Celje (further referred as Celje site) located approximately 80 km northeast of the Slovenian capital city of Ljubljana and Mozirje (further referred as Mozirje site) located app. 75 km northeast of the Slovenian capital city of Ljubljana and around 30 km northwest of Celje. Additionally, Cinkarna operates two landfills, which are Bukovžlak landfill (divided into two sections: one used for storage of solid wastes and another one used for storage of red gypsum) located app. 1.2 km east of the Celje site and Za Travnikom landfill located app. 2.1 km east of the Celje site.

The sites' addresses:

- Cinkarna Celje - Kidričeva 26, SI-3001 Celje, Slovenia.
- Cinkarna Celje - Ljubija 11, 3330 Mozirje, Slovenia.

Information provided in this section is mainly based on Phase I Environmental Due Diligence Assessment (EDDA)¹, which was prepared for both site locations by URS Deutschland GmbH in March/April 2013.

2.1 Sites Description

Cinkarna Celje:

Celje site is located within an industrial zone of the city Celje app. 1.3 km away from the town centre and app. 80 km northeast of the Slovenian capital city of Ljubljana. The property covers an area of approximately 45.81 hectares (ha), whereof app. 11.55 ha is built up area and app. 13.56 ha represent paved outdoor areas around the buildings used as traffic and parking areas. The remaining parts of the site are covered with vegetation (i.e. trees, lawns).

Majority of the property is owned by Cinkarna, a small portion belongs to the Municipality of Celje. Access to the site is given from the Kidričeva Street, which passes southwest of the site, but also can be accessed by railway from the east. Site details are shown in Figure 1.

Cinkarna Mozirje:

The Mozirje site is located within an industrial area of the city Mozirje app. 75 km northeast of the Slovenian capital city of Ljubljana and app. 30 km northwest of Celje. The property covers an area of app. 2.2 ha.

Almost the entire property is occupied by a complex of eighteen partly interconnected buildings (administration building, two main production buildings, several storages used for hazardous materials, raw material, final products, hazardous waste, metal waste, biomass boiler house, laboratories and the canteen) and a parking lot. Buildings are mainly constructed with a metal-frame, concrete bricks with metal sheet or tile roofing. Warehouse for raw materials, used for storing of solid raw materials and packaging (Building 394) had a wooden structure with ACMs panel roofing. As reported by the site representatives, after

¹ Report title: Phase I Vendor Environmental Due Diligence Assessment of the CINKARNA Metalurško-kemnična industrija Celje, d.d. in Slovenia prepared by URS Deutschland GmbH in March/April 2013.

completion of the Environmental Due Diligence Audit site visit in 2013 the company removed the ACMs panel roofing. The outdoor areas around the building complex mainly include residential homes, green areas and farmlands.

The entire property is owned by Cinkarna. Access to the site is provided from the main road Ljubija Street, which passes north of Mozirje site. Site details are shown in Figure 2.

Bukovžlak Landfill:

The Bukovžlak landfill is located app. 1.2 km east of the Celje site and it occupies a total area of app. 36 ha. Majority of the landfill is owned by the Municipality of Celje and it is operated by Cinkarna. The landfill is divided into two areas: an area for solid waste disposal (northern part) and an area used as a tailing pond for red gypsum (southern part). There is a building used for the collection and pumping of liquid wastewater leached from the landfill for solid waste. Site details are shown in Figure 3.

Za Travnikom Landfill:

The Za Travnikom landfill is located app. 2.1 km east of Celje site and it occupies a total area of app. 50.6 ha. This landfill is owned and operated by Cinkarna and it is partly organized as a tailing pond for gypsum and partly as a dry landfill. There is one building at the landfill used for filtration of "red gypsum", originating from the production site in Celje. The building covers a total area of 1,431 m², with accompanying 7,961 m² of paved areas used for traffic and parking. Site details are shown in Figure 4.

2.2 Current Sites Operation

Cinkarna Celje:

The Celje site is organized as a multipurpose production site. The main operation is the production of Titanium-dioxide, supported with the production of sulphuric acid. Since its establishment in 1949, the site was involved in Zinc processing and production of Zinc and Titan-zinc products, including: sheets, wire, anodes and alloys. Cinkarna is also a manufacturer of graphic materials, including offset printing plates, offset and flexo printing inks and various chemicals used in graphic industry. One part of the site is designed for the preparation and re-packing of agro-chemical products. Additionally, the site has developed a production of building materials, including mortars, plasters, screeds and others. Cinkarna has also developed the processing of fluorinated polymers (PTFE, FEP, PFA, PVDF, ECTFE) and elastomers, as well as coating of metal parts with vulcanized rubber linings.

On-site activities include:

- ***Titanium-dioxide (TiO₂) production***, which is the main production process at the site. Titanium-dioxide is produced as pigment and as an ultra-fine solution as a result of the following processes:
 - ore milling of ilmenite and Titanium slag,
 - preparation of "black liquor" by mixing milled ore and sulphuric acid through digestion, settling and reduction of the ore and acid mixture,
 - purification and filtration of prepared "black liquor" with addition of flocculate solution and through filter-bags,

- hydrolysis of the filtrated “black liquor”,
 - two-phase washing of the hydrolyzed “black liquor” and reduction treatment with introduction of Titanium(III)sulphate and concentrated sulphuric acid,
 - pigmentation (doping) of hydrolysate with introduction of white suspension flocculate and pigmentation salts,
 - filtration of doped hydrolysate with compressed air, water and filter elements, followed with drying of the hydrolysate cake,
 - calcination of the dry hydrolysate cake,
 - grinding of the prepared calcinate into raw pigment,
 - wetting and sand milling of raw pigment followed by surface treatment with Alsulphate, Na-silicate, sulphuric acid, sodium aluminate, Zr-sulphate and other chemical solutions,
 - washing and drying of the pigment solution,
 - micronization of dried pigment into final product,
 - packing, storage and dispatch of final product.
- ***Sulphuric acid (H₂SO₄) production***, which is an auxiliary process in the production of TiO₂, which comprises following processes:
 - incineration of elemental sulphur, in liquid or in melted solid form in a furnace, resulting in the generation of SO₂,
 - conversion of SO₂ into SO₃ by catalytic oxidation,
 - absorption of SO₃ and conversion thereof into H₂SO₄.
- ***Metallurgy***, which is a production unit used for Zinc processing and includes the following production processes and final products:
 - Titanium-Zinc and Zinc sheets production – melting of raw material in the induction furnace, casting of ingots, hot rolling of ingots into 18 mm plates, duoreversible cold rolling of plates into sheets, cleaning and polymer coating, flattening, cutting and coiling of final products,
 - Zinc wire production - melting of raw materials in the gas furnace, continuous rod casting, wire rolling, wire drawing, cleaning and packing,
 - Zinc alloys production “Zamak” - melting of raw materials in the induction furnace, continuous casting of ingots, automated stacking of ingots and packing,
 - Zinc anodes production - melting of raw materials in the induction furnace, casting of ingots, preheating and hot rolling of ingots plates, plates cutting and packing.
- ***Graphic materials production***, which comprises the following products and associated production processes:
 - offset printing plates – production of lithographic plates include surface treatment of aluminium strips through the following steps: acid bath, electrochemical graining, acid pilling, cathode and anode processing, post-treatment and drying with hot air. Further, prepared aluminium strips may be finished at the coating line with application of coating solution within the reverse coater,

- offset printing and flexographic inks – production includes mainly mixing of different raw materials,
- graphic agents/chemicals – production steps include mixing of acids, salts and hydroxides with solvents and additives followed with correction mixing.
- **Building materials production unit**, which is involved in preparation of building and construction materials, including mortars, plasters, facade products, tile adhesives, etc. Production processes includes drying, grinding and mixing of raw materials into final products.
- **Agro-chemical products unit**, which produces Copper fungicides and sells sulphur fungicides (as commercial goods) for plant protection, fertilizers and soil substrates. The production of copper fungicides includes: dissolving of raw materials with acid, wet filtration of generated suspension, drying of filter cake, dry filtration and packing. The production of soil substrates is based on mixing of raw materials with appropriate nutrients and packing.
- **PTFE processing (Polimeri) production unit**, which was developed by Cinkarna for processing of fluorinated polymers (PTFE, FEP, PFA, PVDF, ECTFE) and elastomers, as well as coating of metal parts with vulcanized rubber linings. Following production processes are conducted within this unit:
 - transfer moulding - injection mouldings of granulated raw materials,
 - coating of thermoplastic and powder coating, includes sand blasting, oven heating, application of coating agents, drying and cooling,
 - coating with elastomer foils, includes sand blasting, primer coating, intermediate coating and glue application, coating with rubber foil and autoclave vulcanization,
 - polymer processing, comprising processing of PTFE in presses and by extrusion,
 - processing of metal parts, valves production and assembly process.
 - Utilities include natural gas, electricity, steam, water supply systems and sewer systems for storm water, sanitary and process wastewater.

Cinkarna Mozirje:

The Mozirje site is a mineral pigments plant operated since 1896, which currently includes development, manufacture and sale of powder coatings, masterbatches, paints and thinners for commercial and industrial use. On-site activities include:

- production of powder coating (weighing, mixing, extrusion, cooling, crushing, grinding, sieving and packing),
- production of masterbatches (weighing, mixing or gravimetric dosing, extrusion, cooling, palletizing, centrifuging, sieving, de-dusting and packing),
- production of anticorrosion paints and thinners (weighing, mixing, grinding and packing),
- laboratory testing of products,
- heating via two on-site biomass boilers,
- operation of three cooling systems,
- operation of compressor station,

- warehousing of raw materials, semi-finished and final products, hazardous and non-hazardous waste, hazardous and flammable materials,
- dispatch and shipment of final products via internal (parent company's) and external trucks,
- internal transportation of goods with forklifts,
- operation of workshop,
- administrative work,
- operation of a canteen (no kitchen).

Utilities include electricity, internal sewage and public water systems. In addition, Mozirje site owns and operates two biomass boilers for heating, three stationary air compressors, two transformers, a sprinkler system, three cooling systems and seven air conditioning units.

Bukovžlak Landfill:

The Bukovžlak landfill consists of two parts separated by a big barrier (dam). The northern part is a landfill for solid waste disposal ONOB, including pyrite waste, barite mud, barrels with waste printing inks and their raw materials, waste powder coatings, mud from production of Zinc sulphate, filter cake from water treatment, solid waste (linings) from neutralization tanks from Titanium dioxide production and construction waste materials. The second, southern part of the landfill is a tipping area used for disposal of red gypsum, which was suspended in water.

ONOB was operated by Cinkarna since 1966 (building permit since 1979) and it is currently in a process of closing down. Waste was received until 2010.

Deposited solid waste before 1990s mainly included pyrite wastes and therefore it has impact on the quality of groundwater. Pyrite waste, part of which was built-in also as an alternative building material in both landfill's barriers, is constantly leaching out and it forms acidic wastewater containing metals, and requires collection and pumping out to the wastewater treatment plant located in Cinkarna (a part of Titanium dioxide production plant).

A tipping area was designated for disposal of red gypsum, which was suspended in water (had sat on the bottom and has been covered with a layer of water). This part of the landfill was abandoned about 1991. Current activity includes occasionally (few days a month) discharging of neutralized liquid waste from Titanium dioxide production (normally discarded into surface water).

The landfill is subject to annual groundwater monitoring using a network of permanent groundwater monitoring wells.

Za Travnikom Landfill:

The Za Travnikom landfill is operated by Cinkarna since 1991 and it includes tipping area for disposal of red gypsum, which was suspended in water (had sat on the bottom and has been covered with a layer of water). After 2008 dry red gypsum is disposed of on tipping area. Pyrite waste was also built-in as an alternative building material in the air side of the dam. The landfill is subject to annual groundwater monitoring using a network of permanent groundwater monitoring wells.

2.3 Surrounding Land Characterization

Cinkarna Celje:

The surroundings of the Celje site include facilities used for commercial, residential and industrial purposes.

Current use of neighbouring properties includes the following:

North: Creek Vzhodna Ložnica, (adjacent), local railway track (100 m, adjacent from northeast), a public road (140 m) and further commercial-industrial zone of Celje town including metal processing facility “EMO”, wood processing facility “Merkscha”, municipal thermal-power plant and incineration plant, grain silo and bakery “Klasje” and plastic extrusion facility “Termoplast”. Military premises are located 80 m to the north-east from the site boundary.

South: Public road (adjacent), followed by commercial zone including retail markets (Harvey Norman, Tuš, Baumax, etc.), transportation-logistic site “Intereuropa” (road and rail transport) and then residential houses (340 m from the site).

East: Local railway track (adjacent), followed by residential houses and farmlands and then landfill Bukovžlak (1.2 km from Celje site), and then the landfill Za Travnikom (2.1 km from Celje site).

West: River Hudinja (adjacent), followed by commercial-industry zone including galvanization facility “Pocinkovalnica”, metal processing facility “Sevs” and retail markets (Lidl, Jysk, Penca, etc.). Former Cinkarna site (donated 1995), including newly constructed commercial-residential centre “Tehnopolis”, which is located 230 m to the south-west from the present site location.

The nearest residential houses are situated app. 30 m from the eastern site boundaries.

The following current industrial premises present neighbouring sites with potentially significant environmental impacts: Store Steel - steel production, EMO – metal processing, Energetika Celje – power plant and incineration, Merkscha - wood processing and Pocinkovalnica – galvanization. Potential impact from these industries rest with air emissions, wastewater discharge and waste disposal.

Cinkarna Mozirje:

The surroundings of the Mozirje site include residential housing and farmland/meadows, watercourses (Savinja River, Ljubija and Struga creeks) and woods.

Current use of neighbouring properties includes the following:

North: Main road ‘Letus-Loagarska valley’ and a single farm house (adjacent), farmland/meadows (across the road), several detached farm houses and residential homes (app. 10 to 100 m away from the site), Ljubija settlement (app. 300 m away from the site) and Ljubija creek, flowing through the site from the north towards Savinja river (to the south).

South: Wood, along the Savinja river (app. 10 m), Struga creek flowing through the south-west part of the site, farmland/meadows (on the other side of Savinja river) and residential houses of Loke pri Mozirju settlement (app. 60 m south-west and app. 120 m south-east of the site, on the other side of Savinja river).

East: Farmland/ meadows (adjacent), two farm houses (app. 200 m away from the site).

West: Church (adjacent), residential houses (app. 25 m), farmland/meadows, creek Struga (south-west and west of the site) and Mozirje town centre (app. 1 km north-west of the site).

The nearest residential houses are located app. 10 to 25 m from the western and northern site boundaries.

The Savinja River (approximately 10 m of the site to the south) is under protection as a natural monument.

Bukovžlak and Za Travnikom Landfills:

The surroundings of the two landfills are mainly represented by farmlands and open land plots/meadows but also include residential houses. A municipal landfill, operated by the Public Utility Company "Simbio", is located between Bukovžlak and Za Travnikom. An old, inactive municipal landfill is located adjacent to the Bukovžlak landfill to the east and north-east. The memorial park "Teharje" is located adjacent north-east of the Bukovžlak landfill, along the northern area of Bukovžlak, which is used for solid waste disposal. The landfill of slag from steel production, operated by private company Storkom, is located south to the red gypsum landfill Bukovžlak.

2.4 Topography and Hydrology

Cinkarna Celje:

Topography of Celje site is flat, with an elevation of about 240 above sea level (m asl). There are two surface water bodies bordering the site of Cinkarna, as follows: River Hudinja flows adjacent to the site to the east and Creek Vzhodna Ložnica is adjacent to the north. Creek Vzhodna Ložnica joins River Hudinja at the north-west corner of the site.

According to the provided data on conducted flood risk assessment, the whole area of Cinkarna, i.e. region between the watercourses Vzhodna Ložnica and Hudinja and Kidričeva Street on south, is endangered by floods. The flood risk assessment revealed that Cinkarna is located within the zone with rare flooding potential, characterized with 10 to 20 years return period. Risk assessment identifies Creek Vzhodna Ložnica as the main flooding source. The site was impacted by flooding in September 2007 due to overflow from the adjacent surface water streams, mainly from the Creek Vzhodna Ložnica. The western and central parts of the site were totally flooded, standing 20-50 cm under water. Only the eastern area of the site, including the sulphuric acid plant with storages for elemental sulphur, wastewater neutralization plant, the main warehouse for final products and vehicle service, was not affected by the flood.

Cinkarna Mozirje:

The site topography is flat with the site elevation of approximately 331.5 m asl.. The nearest surface waters are Ljubija creek, flowing through the site from the north towards Savinja river, creek Struga, flowing through the south-east part of the site and Savinja River, which is located approximately 10 m to the south of the site.

The site provided information that flood occurred on November 5, 2012. The area of the south-west part of the site (three warehouses, buildings No. 393, 394 and 402), the closest to the Savinja river, were flooded. The water level in this area was 40–50 cm above the ground surface. Reportedly, water was pumped out from warehouses and the flood caused damages to machines and equipment.

Bukovžlak and Za Travnikom Landfills:

The topography of the landfills is hilly. The creek Vzhodna Ložnica is passing approximately 600 m north of the landfills Bukovžlak and Za Travnikom.

According to the provided data on conducted flood risk assessment, the whole area of Cinkarna, i.e. region between the watercourses Vzhodna Ložnica and Hudinja and Kidričeva Street on south, is endangered by floods. The flood risk assessment revealed that Cinkarna is located within the zone with rare flooding potential, characterized with 10 to 20 years return period. Risk assessment identifies Creek Vzhodna Ložnica as the main flooding source.

2.5 Geology and Hydrogeology

Cinkarna Celje:

Based on the data available², Celje site area spreads over Quaternary alluvial sediments deposited over Oligocene and Miocene strata. First aquifer is formed within upper alluvial Quaternary sediments. As Miocene and Oligocene strata appear less permeable than Quaternary alluvium, in general they represent hydro-geological barrier. Cinkarna's production area lies on alluvial debris, mainly consisting of clayey silt. Alluvial water bearing layers are recharged by infiltration from precipitation and partially from River Voglajne. Bedrock is represented by low permeable clastic Oligocene and Miocene layers, Oligocene's andesite tuffs and Miocene's conglomerates, sandstones and marls.

In the area of Celje site, aquifers are supplied mainly from precipitation and partly from the infiltration of surface water. Depth to groundwater could not be ascertained. Based on the available data of the wider area, it is estimated that the aquifer layers are located at an elevation between 230 and 234 m asl, hence groundwater should be found at a depth of 1 to 3 m below ground surface (m bgs). General direction of groundwater flow in this area is expected toward the south-west.

Slovenia is characterized as a region with medium seismic intensity. Although a relatively low magnitude of earthquakes, the impact can be very severe because of a relatively shallow hypocentre. According to Macroseismic Intensity map of Slovenia, the area of Celje site has 7° intensity according to MSK scale with a 500 year return period.

² Geological Survey of Slovenia, publicly available data (<http://www.geozssi/podrocje.aspx?langid=1033>).

Cinkarna Mozirje:

Based on the data available³, the subsoil at Mozirje site comprises mainly Oligocene marls (at the depth of 2.1 m in the northern part of the site to 2.7 m in the southern part) overlain by 1.0 to 1.6 m thick layer of poor to well granulated alluvial gravels. Brown sandy clay (silt to sandy silt with gravels) overlain by gravels at the depths of 0.2 to 1.1 m and the top soil formed of humus layer to the depth of 0.2 m.

Based on information provided by site contacts, groundwater levels are around 1.5 m bgl. The groundwater flow direction is towards Savinja River (towards south) and Ljubija creek.

Slovenia is a region with medium seismic intensity. According to site representatives, the site is not located within an earthquake zone. Mozirje site is located in an area that is exposed to earthquake of 70 EMS (European Macro seismic Scale) that could lead to a damage of the buildings (e.g. small cracks in the walls and stacks, falling of tiles and large pieces of roofing panels, etc.).

Bukovžlak and Za Travnikom Landfills:

Landfills Bukovžlak and Za Travnikom spreads over area placed over Quaternary slope sediments, which are similar to alluvial sediments, consisting mainly of silt and intersected with clayey layers. Besides relatively impermeable silty and clayey sediments, appearance of permeable layers is also recorded.

In the immediate area of the landfills, general direction of groundwater flow is toward the north, in line with the terrain morphology and toward the major watercourses. In the hilly area, the direction of groundwater flow is conditioned with direction of lower layer slopes. At the River Ložnica's valley, direction of groundwater is influenced by direction of river flow, from east to west.

2.6 Sites History

Cinkarna Celje:

The Cinkarna Company was established in 1873 and in early years provided only Zinc smelter activity. In 1949 Cinkarna moved to its current location in Celje and established an organic dyestuffs production. In 1953 Pražarna&Kemična and Cinkarna were merged. In the 1960s of the 20th century affiliation of organic dyestuffs plant (in 1961) and Mozirje mineral pigments plant (in 1962) took place. Since then, sulphuric acid production was launched based on the contract. In 1966 aluminium offset-plate production was commissioned. In 1970 Cinkarna was transformed from a primarily metallurgy-oriented company into chemical company. In 1973 Titanium dioxide production was commissioned and Bukovžlak landfill started its operation as a red gypsum disposal site. Solid waste landfill Bukovžlak was operated by Cinkarna since 1966 (building permit was issued in 1979). In 1981 new Zinc rolling-mill was commissioned and related production of Titanium Zinc-sheets was launched. In the 80s of the 20th century, sulphuric acid production and Titanium dioxide production installations were modernized which caused decreasing of SO₂ emissions (in case of the sulphuric acid production). In 1991 Za Travnikom landfill started its operation.

³ Report on geological and geotechnical investigation for the construction of the new warehouse prepared by Geosvet on February 7, 2006.

In 1993 Cinkarna was transformed into "limited liability" company. In the same year, powder coatings production was initiated in Mozirje. Between 1994 and 1995 the Titanium oxide production was improved and pollution control equipment was installed. In 1997 Cinkarna Celje was transformed into a joint-stock company. The year 2000 commenced intensive investments into Titanium dioxide pigment production and upgrade of sulphuric acid production and dry gypsum landfill (Za Travnikom), which was completed in 2006. Since 2008, red gypsum disposal (dry) was commissioned. In 2009, new masterbatch line was launched and Zinc sulphate production was closed. Since 2010, Cinkarna obtained IPPC permit in compliance with IPPC Directive. In the same year, Bukovžlak solid waste landfill was designated to close.

For the purpose of conducting the site investigation for the Phase II ESA, the area of the Cinkarna Celje site was divided into 16 different locations taking into account historical and current operations. These areas comprise:

- (1) **Area of the administration building:** former activity included landfill of tar and other waste from the previous location of Cinkarna (since 1953) such as: slag from Zinc smelting production, waste from production of lithopone, fungicide (blue Copper), super Phosphate, Barium sulphide (BaS) and Zinc bleach. Potential contamination might have originated from waste, which included heavy metals, petroleum compounds and volatile organic compounds (VOCs).
- (2) **Hazardous waste storage area and chemicals storage PE Grafika:** former activity included landfill for disposal of waste from Barium sulphide (BaS) production. Following hazardous substances were used: Barium sulphide, Zinc sulphate ($ZnSO_4$), Barium sulphate ($BaSO_4$) and Zinc sulphide (ZnS).
- (3) **Production area of Titanium dioxide TiO_2 -PD2:** since 1964 former activity included production of lithopone ($ZnS \times BaSO_4$) and Zinc sulphate ($ZnSO_4$). This production line was shutdown in 1993. At this area, warehouse for Zinc ashes and sulphuric acid (H_2SO_4) as well as landfill of barite mud were also present. Potential contamination might have come from heavy metals, Titanium (Ti), Barium (Ba), petroleum compounds and chloric acid (HCl) spilling and result from the presence of chemicals such as: Barium sulphide (BaS), Zinc sulphate ($ZnSO_4$), Barium sulphate ($BaSO_4$), Zinc sulphide (ZnS), sulphuric acid (H_2SO_4), chloric acid (HCl), potassium permanganate ($KMnO_4$), Zinc (Zn) and Zinc ash, calcium oxide (CaO), calcium hydroxide ($CaOH_2$), hydrogen peroxide (H_2O_2), sodium hypochlorite (NaClO) and NaClOCl.
- (4) **Production area of fungicide (blue Copper):** former activity included production of lithopone and zinc sulphate ($ZnSO_4$) – until 1993. Potential contamination might have originated from heavy metals and accidental oil spilling in the past.
- (5) **Building Razvoj (north):** former activity (since 1961 until 1982) included production area of synthetic organic sulphur dyes and azo dyes. Potential contamination might have been related with the presence of chemicals such as: benzene, aniline, toluene, nitrobenzene, aromatic amines, phenol, sulphur, sulphuric acid, synthetic organic dyes that contain nitrogen as the azo group, organic compounds sulphur dyes, nitric acid (HNO_3), sodium hydroxide (NaOH) and chloric acid (HCl).
- (6) **Area at the Grafika 4 and Grafika 5 in direction to S-channel:** former activity (since about 1948 until 1976) included UST of benzene and warehouse for organic

sulphure dyes and their raw materials. Between 1976 and 2012 used for production of offset printing inks and varnish. Potential contamination might have come from the presence of chemical such as: benzene, aniline, toluene, nitrobenzene, aromatic amines, phenol, sulphur, sulphuric acid, synthetic organic dyes that contain nitrogen as the azo group, organic compounds sulphur dyes, nitric acid (HNO_3), sodium hydroxide (NaOH) and chloric acid (HCl). In 1992 fire in warehouse of printing ink's raw materials appeared. The building was completely destroyed and the one was built at the same place. Fire residues were put into metal drums and disposed of at the solid waste landfill in Bukovžlak.

- (7) **Area of temporary storage for construction waste:** former activity included (between 1948 and 1994) organic sulphur dyes and azo dyes (synthetic organic dyes that contain nitrogen as the azo group) production and between 1982 and 1988 graphic chemicals production. Potential contamination might have come from organic dyestuffs chemicals, azo compounds, organic compounds containing sulphur, VOCs and nitrogen spilling and been related with the presence of chemical such as: benzene, aniline, toluene, nitrobenzene, aromatic amines, phenol, sulphur, sulphuric acid, synthetic organic dyes that contain nitrogen as the azo group, organic compounds sulphur dyes, nitric acid (HNO_3), sodium hydroxide (NaOH) and chloric acid (HCl).
- (8) **Production of Titanium dioxide (TiO_2):** before 1970s the area was undeveloped and comprised a swampy field. Starting from 1973 (beginning of production of Titanium dioxide), potential contamination in the area might have originated from the presence of: potassium carbonate (K_2CO_3), sodium silicate (Na_2SiO_3), phosphoric acid (H_3PO_4), zirconium oxychloride, Copper dihydroxide ($\text{Ca}(\text{OH})_2$), hydrochloric acid (HCl), sodium hydroxide (NaOH), aluminium powder, sulphuric acid (H_2SO_4) and wetting agents. Potential chemicals, which remained in the ground might be: pyrite ore, iron oxides and sulphuric acid due to accidental small amounts of spilling - some minor sulphuric acid spilling incidents were recorded.
- (9) **Boiler house (Kotlarna):** former activity included storage area of heavy fuel oil and heating oil (daily tank). Potential contamination might have originated from oils spilling, however no such incidents were recorded.
- (10) **Production area of Zinc alloys:** former activity included Zinc dust production using process of Zinc smelting (New Jersey method). Potential contamination might have originated from heavy metals due to Zinc ore use and presence of chemicals such as: Zinc sulphide (ZnS), Zinc oxide (ZnO) and Zinc dust.
- (11) **Production area of Titanium Zinc sheet:** no former activity was provided at this area.
- (12) **Production area of sulphuric acid (H_2SO_4):** former activity included sulphuric acid (H_2SO_4) production from pyrite ore and open storage for pyrite and residues after roasting of pyrite as well as a catalyst warehouse. Potential contamination might have originated from pyrite ore, iron oxides, sulphuric acid (H_2SO_4) and Sulphur (S), which remained in the ground. Currently area is used for H_2SO_4 production from elemental Sulphur with USTs for liquid or solid Sulphur, temporary storage of inorganic Sulphur containing waste. Potential contamination may originate from: H_2SO_4 , S , V_2O_5 , levoxin, fuel oil, $\text{Ca}(\text{OH})_2$ and NH_4OH . Some H_2SO_4 spilling incidents were recorded.
- (13) **Area PE Vzdrževanje in Energetika (maintenance and power supply):** no former activity was provided at this area.

- (14) **Area of the pumping station of chemicals and temporary storage of waste from production of offset printing plates in PE Grafika:** no former activity was provided at this area.
- (15) **Pipeline for gypsum:** materials such as construction waste, pyrites, etc. were used during construction of the pipeline as backfilling. Occasional pipeline leaks have occurred causing contamination with gypsum ($\text{CaSO}_4 \times 2\text{H}_2\text{O}$).
- (16) **Gas station:** current location of UST for Diesel oil. Potential contamination may originate from oil spilling, however, no contamination from the current or historical activity was reported.

Cinkarna Mozirje:

Mozirje site was developed on greenfield land in 1896 as Santaler Farb und Schirgel Werke for the paint production. In 1920, the company has expanded its activity and in the years 1922 – 1933 the company built another facility in Letuš for production of wood packaging for paints. After 1948, the company was nationalized and chemical and wood manufacturing plant Mozirje started to expand its production. In 1957, the Municipal Assembly of Mozirje decided to give the part of the wood production to the wood industry (GLIN Nazarje Company).

In 1962, the company joined Cinkarna Celje and started to refurbish the site. Between 1962 and 1963 the company built a new production facility for the production of earth paints and in 1964 the construction of another building for production of printing inks was finished. In 1965, the production line expanded with the range of anti-corrosion coatings. In 1977–1978, the production program expanded to one-component polyurethane foam for the construction business. Due to concerns that the old plant did not meet technological requirements for the production of dry dispersion paints, the production was moved to a newly built facility in 1982. Production of coating was moved to the new facility in 1985, where it started with the production of dispersion and façade paints. In 1990, the program has expanded to production of powder coatings, being still the most promising product business unit. At the end of 1998, the company started with the production of masterbatches (paint concentrate for plastics) at the location of the dry dispersion paints production. The company has terminated the production of dry dispersion paints at this location and transferred it to the PE Chemistry Celje (equipment was sold). In 2002, the company transferred the entire fabrication process of PU-foam into the renovated premises of the existing building. In January 2006, the equipment was sold for not meeting the profitability targets.

For the purpose of conducting of Phase II ESA, the area of the Mozirje site was divided into 3 different locations with increased risk of soil and groundwater contamination, which include:

- (1) **Warehouse of hazardous substances:** current activity includes storage of flammable chemicals such as xylene, Dowanol and white spirit. Potential contamination may come from accidental small amounts of raw materials spilling; however no such incidents were recorded.
- (2) **Warehouse of masterbatches:** current activity includes storage of raw materials (concentrates, which improve the characteristics of polymeric materials) and final products, which are masterbatches. Possible contamination at that area may come

from accidental small amounts of raw materials spilling; however no such incidents were recorded.

- (3) **Location behind the sc. Miklavž Church (historical underground tank of organic solvents):** no current activity is provided at this location. Historically, USTs for xylene, heating oil and solvents were present in this location. Most likely, the USTs are still present in the ground but were reportedly emptied and backfilled.

Bukovžlak Landfill:

Bukovžlak landfill started its operation as a tipping area designated for disposal of red gypsum in 1973 together with commissioning of Titanium dioxide production. In 1966 landfill for solid waste disposal ONOB (northern part), including pyrite waste, barite mud, barrels with waste printing inks and their raw materials, waste powder coatings, mud from production of sulphuric Zinc, filter cake from water treatment, solid waste (linings) from neutralization tanks from Titanium dioxide production and construction waste materials was initiated. A tipping area for disposal of red gypsum was abandoned about 1991, when Za Travnikom landfill started its operation. Waste at ONOB was received until 2010, when Cinkarna decided to close Bukovžlak landfill for soil waste.

Reportedly, there is a possibility of human remains from World War II in the immediate vicinity of the Bukovžlak landfill (at the area of Memorial Park Teharje). Moreover, it was reported by Cinkarna Celje representatives that an uncontrolled release of gypsum sludge and pyrites through the dam drain occurred in the 1970's. As a result, the wastes disposed of at the Bukovžlak landfill migrated in the northern direction to the farming land, in line with the terrain morphology and toward a major watercourse (river Vzhodna Ložnica, located approx. 1 km north of the landfill).

Za Travnikom Landfill:

The Za Travnikom landfill is operated by Cinkarna since 1991 and included tipping area for disposal of red gypsum. After 2008 dry red gypsum is disposed of on a tipping area.

2.7 Environmental Assessment

2.7.1 EHS Management

Cinkarna has implemented a certified quality system ISO 9001:2008 and a certified environmental management system according to DIN ISO 14001:2004, at both site locations - Celje and Mozirje. The certificate was issued by IQNet and SIQ and is valid until August 2015. Cinkarna has also implemented a certified health and safety management system according to BS OHSAS 18001:2007, at both site locations. The OHSAS 18001 certificate was issued by IQNet and SIQ and it is valid until August 2015. The Mozirje site is also registered in EMAS system by Ministry of Agriculture and Environment, Environmental Agency, on 30 November 2012, until 31 October 2015.

In general, environmental issues are managed for both sites together within the Department for environmental protection located in Cinkarna Celje by Mrs. Bernarda Podgoršek-Kovač, Head of the Environmental Protection Department and her team. Internal and external audits are conducted every year for both site locations.

2.7.2 Environmental Permits

Cinkarna Celje and Landfills:

Cinkarna holds a valid environmental permit dated 28 October 2010 covering Cinkarna's operations in Celje and both landfills. The environmental permit was issued by the Ministry of the Environment and Spatial Planning and Environmental Agency (ARSO), in accordance with Slovenian Law on Environmental Protection (ZVO-1) and IPPC Directive (Directive 2008/1/EC).

According to the provided list of obtained Operational permits for the facilities operated by Cinkarna, there are only a few facilities/units without Operational permits, all within Titanium-dioxide Production Unit, as follows: settling tank for black liquor, 2 washing pigment decanters, one Sulfacid reactor. Officially the main production building (TiO₂ plant) is missing an operational permit. However, according to the building inspector officer, there are actually two separate operational permits that could be interpreted as sufficient.

In addition, Cinkarna holds the following permits:

- Water permit for abstraction of groundwater from the water catchments at Za Travnikom landfill, issued by ARSO on December 2004 and amended on June 2011;
- Water permit for use of fresh water from the public mains, issued by ARSO on March 2011;
- Water permit for use of surface water from the River Hudinja, issued by ARSO on May 2005;
- Environmental permit for greenhouse gas emission (CO₂), issued by ARSO on January 2011;
- Permit for using warehouse for radioactive waste, issued by Administration of Republic of Slovenia for Nuclear Safety on December 2006.

Cinkarna Mozirje:

Mozirje site is not a subject to an IPPC permit.

Mozirje site holds a valid Water permit for the use of drinking water from the public mains for process purposes, dated 22 December 2010 with the validity until 30 November 2040. The site also holds a valid environmental permit for wastewater discharge. The environmental permit for wastewater discharge was initially issued in July 2005, extended on July 26, 2010 and is valid until July 27, 2015. The permit includes discharge of process, sanitary and cooling wastewater into the Ljubija and Struga creeks.

2.7.3 Air emissions

Cinkarna Celje:

There are 45 air emission sources at Celje site, which are collected and released into the atmosphere via stacks, are placed in following areas/facilities:

- **Sulphuric acid production:** two sources of emissions: from H₂SO₄ production and preheating of S-acid. Types of emission include: SO_x, heat, smoke, CO and NO_x.

- **Titanium dioxide production:** emission sources include: four emitters from ore milling (ball mills A, B, C and D), one from slag and ilmenite premixing, two from digestion and dissolution processes, two from pre-drying, three from calcination (including two from calcinate milling), three from dryer (including two from belt dryer and one from multi-stage dryer), five from micronization process (micronization 1 and 2), three from packaging, one from auxiliary raw materials preparation and one from boilers PK401 and PK400. Types of emission include: particular matters, H₂S, SO_x, heat, CO and NO_x.
- **Agro-chemical substances production:** two sources of emissions: one from dryer Hoskova, one from blue Copper packing and mixing plant. Types of emission include: particular matters, CO, NO_x, SO_x and heat.
- **Building materials:** two sources of emissions: from the mill for building materials and from dryer for building materials. Types of emission include: particular matters, CO, NO_x, SO_x and heat.
- **Zinc sheets production:** emission sources include: four emitters from smelting (ABB 1, ABB2, Russ 1, as well as Russ 2, Russ 3 and Russ 4, the latter three collected in one chimney), one from the block furnaces Junker, one from the furnace Kupperbusch and two from Thede-napa furnace. Types of emission include mainly particular matters, CO, NO_x, SO_x and heat, but also in case of emissions from Thede-napa, smelting Russ 2 and smelting Russ 3 – also sum of inorganic particles such as Pb, Co, Ni, Se, Te, Sb, Cr, CN, F, Cu, Mn, V and Sn.
- **Zinc wire production:** one source of emissions from smelting (wire). Types of emission include particular matters, CO, NO_x and heat.
- **Secondary Zinc production:** one source of emissions from the rotary kiln Thede. Types of emission include NO_x and SO_x.
- **Graphic materials production:** two sources of emissions: one from aluminium sheet coating, and one from flexographic inks. Types of emission include: mist of acid (in case of emissions from aluminium sheet coating), particular matters, total organic carbon (TOC), CO, NO_x and SO_x.
- **PTFE (Polimeri) processing:** three sources of emissions: one from small blast room, one from autoclave and one from big blast room. Types of emission include: particular matters and TOC.

Besides, Cinkarna operates the following diffuse emission sources:

- Particulate matters (dust) at warehouses - warehouses for ore, sulphur, sand and gypsum and temporary construction waste disposal;
- Particulate matters (dust) at production plants - Titanium-dioxide, metallurgy, building materials and agro-chemicals;
- H₂ at ore digestion at TiO₂ production;
- CO₂ at the waste acid neutralisation process at TiO₂ production;
- Particulate matters (dust) at disposal of dry material at Za Travnikom landfill.

The Celje site regularly conducts annual air emission monitoring at the above mentioned emission sources by engaging external accredited companies/laboratories. Additionally, the site conducts internal air emission measurements on the main sources, by Cinkarna's

laboratory once every three months, minimum. Celje site also performs continual flue gas monitoring at 2 air emission sources. The environmental inspectorate has conducted 2 unannounced control monitoring campaigns with an external laboratory in 2012. The results of these unannounced monitoring's were in accordance with prescribed limit values.

The Celje site is registered under the VOC Directive, Slovenian Decree on limit values for emissions of volatile organic compounds in the air, which are using organic solvents (Official Gazette of RS No. 112/05, 37/07, 88/09, 92/2010 and 51/2011), due to the usage of organic solvents in the printing inks production. Due to the low VOC emissions levels, the site is not required to develop a VOC reduction plan.

Celje site received neighbourhood complaints regarding air and odour emissions in the past. Complaints were reported by individuals or by environmental inspection officers and were mainly related to sulphuric odour (from TiO₂ and sulphuric acid production). Complaints were recorded and addressed on short notice and with engagement of appellants. Complaints were followed with internal air monitoring and results were presented to the appellants. In order to reduce air emission and odour from the H₂SO₄ production, Cinkarna equipped the pits used for elemental sulphur melting with a filter system. Costs related to the installation of this system amounted to 230000 EUR, the project is now completed.

The Celje site is subject to the Emission Trading Act and participates in emission trading. Until 2012, free annual allocated amount was 31,994 tons. The new amount set for the period 2013-2020 on 58,501 tons is more than sufficient for the site. Due to the fact that the site is using sulphur instead of fossil fuels for the steam production, there is no CO₂ generation and Cinkarna will be awarded with bonus coupons. Cinkarna obtained a Permit for emission of greenhouse gasses in January 2011, issued by Ministry of the Environment and Spatial Planning and Environmental Agency (ARSO). Latest greenhouse gas emission report was prepared in February 2013, stating that total emission of CO₂ in 2012 was 23,073 tons. Slovenian Institute of Quality and Metrology – SIQ from Ljubljana is responsible for validation of the report.

Cinkarna Mozirje:

Based on the provided data⁴, there are a total of 12 stationary air emission sources at Mozirje site, which are collected and released into the atmosphere via stacks, which are placed in following areas/facilities:

- **Powder coating production (Building 379):** three emission sources from the milling units, central exhaust system from the powder coating production and the local exhaust from the powder coatings production are regulated under the Ordinance on stationary air emission sources.
- **Masterbatch production (Building 378):** three local exhausts from coatings, matserbatch production (bag filters) and drying unit of the matserbatch production as well as central ventilation of the coatings are regulated under the Ordinance on stationary air emission sources. The production of substances containing volatile organic compounds (VOCs) is reportedly too small to be relevant for the VOC Ordinance.

⁴ The site provided an inventory and a site layout map of air emission sources.

- **Coatings production and laboratory (Building 377):** two exhausts from the masterbatch production and the laboratories for the masterbatch production are regulated under the Ordinance on stationary air emission sources.
- **Production of hot water for heating in biomass-fired boilers (Building 597):** stack from the boiler house (two pellet-fired boilers) was installed in 2012. The emissions are regulated under the Ordinance on small combustion plants. The heating unit is subject to regular (annual) air emission monitoring, which is being performed every 5 years.

Mozirje site has reportedly never received neighbourhood complaints regarding air and/or odour emissions.

2.7.4 Water supply and Usage

Cinkarna Celje:

The Celje site is supplied with drinking and fire-fighting water by public mains and abstraction of surface water from the river Hudinja in the following quantities (per year 2011 data): Sanitary wastewater from public mains in the amount of 16,000 m³, boiler feed water from the River Hudinja in the amount of 24,000 m³, cooling water from public mains and from River Hudinja in the amount of 1,500 m³, Process water from river Hudinja and groundwater wells in the amount of 1,622,000 m³. Fire-fighting water is supplied through public mains. Consumption thereof is not recorded. The total supply of water from the public mains is 60,000 m³, whereas the supply of surface and groundwater is 2,700,000 m³.

Cinkarna Mozirje:

The Mozirje site is supplied with drinking water by public mains. Drinking water is used for drinking, sanitary, fire-fighting and process (cooling) purposes. Based on the available data, the annual water consumption decreased from 4,158 m³ in 2010 to 3,418 m³ in 2011, despite the higher production in 2011. Decreasing of water consumption is due to the installation of the new line for masterbatch production, whereby the use of water in cooling process was decreased. The lower consumption of water was due to introduction of closed system for cooling water in the powder coating mixing unit. Reportedly, the site has installed a sprinkler system but without a sprinkler tank.

2.7.5 Wastewater

Cinkarna Celje:

The following wastewater streams are generated at Celje site:

- Sanitary wastewater (16,000 m³/year), which is discharged into municipal sewer and 3 on-site septic pits.
- Stormwater from roofed and covered areas (not measured), which is discharged into Vzhodna Ložnica and Hudinja rivers without treatment.
- Process wastewater (V-1), non-process wastewater and stormwater – overflow from red gypsum tailing pond Za Travnikom (1,700,000 m³/year), which is discharged into Dobje creek after neutralization, sedimentation and filtration treatment processes.

- Process wastewater (V2-1) from offset plate production (10,000 m³/year), which is discharged into Hudinja river after neutralization, sedimentation and filtration treatment processes.
- Process wastewater (V2-2) from technological water preparation facility (170,000 m³/year), which is discharged into Hudinja river after neutralization treatment process.
- Discharge (V2-3) of neutralized liquor from TiO₂ production (260,000 m³/year), which is discharged into Hudinja river after neutralization and sedimentation treatment processes.
- Process wastewater (V3), non-process wastewater and stormwater (170,000 m³/year) – from red gypsum landfill Bukovžlak, which is discharged into Vzhodna Ložnica river without treatment.
- Process wastewater (V4-1) from boiler (1000 m³/year), which is discharged into Vzhodna Ložnica river without treatment.
- Process wastewater (V4-2) from boiler and cooling water from sulphuric acid production (34000 m³/year), which is discharged into Vzhodna Ložnica river without treatment.
- Wastewater (V5-1) from maintenance workshop (250 m³/year), which is discharged into municipal sewer after treatment on water/oil separator.
- Process wastewater (V5-2) from graphic chemicals production (700 m³/year), which is discharged into municipal sewer after neutralization and sedimentation processes.
- Process wastewater (V5-5) from Copper fungicides production (1,200 m³/year), which is discharged into municipal sewer after chemical cleaning and sedimentation processes.
- Discharge (V6-1) of leachate from Bukovžlak tailing pond and landfill (30,000 m³/year), which is transferred via pipeline to Cinkarna wastewater treatment plant (WWTP).

The sanitary wastewater streams are collected on-site in a sewer system and discharged into the public sewer where they are routed to the public wastewater treatment plant (WWTP). The sewer system was integrity tested during the process of obtaining the operation permits for individual buildings/facilities. No major deficiencies at the sewer system were reported by the site contacts.

Cinkarna Mozirje:

The following wastewater streams are generated at the Mozirje site:

- Stormwater (paved areas, parking lots, roofs);
- Sanitary wastewater from lavatories, washroom, canteen (no cooking, no grease separator required) and three biological treatment units;
- Process (cooling) wastewater (masterbatch production and paints & thinners production).

Stormwater run-off is collected from the roofs and sealed outdoor areas and discharged into the Ljubija and Struga creeks after treatment in oil/water separation units. The sanitary wastewater streams are collected on-site in a sewer system, treated via three on-site biological treatment units and discharged into Ljubija creek (discharge points VOD3 and VOD5) and Struga creek (discharge point VOD4). Process (cooling) wastewater from the

masterbatch production is mechanically treated (three-chambers treatment unit and sieves) and discharged into the Ljubija creek (discharging point VOD1), while cooling wastewater from the paints & thinners production is discharged into the Struga creek (VOD2).

Wastewater quantity and quality monitoring is being regularly performed and measured parameters are compliant with the conditions prescribed by the environmental permit for their wastewater discharge.

2.7.6 Waste Management

Cinkarna Celje:

Most relevant hazardous waste, which is generated at the Celje site (in 2011, total amount of generated hazardous waste was approximately 61 tons):

- 15 02 02* – absorbers and cleaning rags,
- 13 02 05* – mineral-based non-chlorinated engine, gear and lubricating oils,
- 13 05 03* - interceptor sludge,
- 13 05 07* - oily water from oil/water separators,
- 08 01 11* - waste paint and varnish containing organic solvents or other hazardous substances,
- 12 01 09* - machining halogen-free emulsions and solutions,
- 17 06 05* - construction materials containing asbestos,
- 12 01 12* - waste waxes and grease,
- 16 08 07* - spent catalysts contaminated with hazardous substances.

Most relevant non-hazardous waste, which is generated at Celje site (in 2011, total amount of generated non-hazardous waste was: 265,232 tones:

- 20 03 01 - mixed municipal waste,
- 15 01 06 - mixed packaging,
- 15 01 01 - paper and cardboard packaging,
- 15 01 02 - plastic packaging,
- 15 01 03 - wooden packaging,
- 15 01 07 - glass packaging,
- 15 01 05 - composite packaging,
- 20 01 01 - paper and cardboard,
- 20 01 39 - plastics,
- 15 02 03 - absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02,
- 16 02 14 - discarded equipment other than those mentioned in 16 02 09 to 16 02 13,
- 07 02 99 - waste not otherwise specified,

- 11 01 10 - sludge and filter cakes other than those mentioned in 11 01 09,
- 16 03 04 - inorganic wastes other than those mentioned in 16 03 03,
- 16 01 17 - ferrous metal,
- 20 03 07 - bulky waste,
- 20 03 04 - sludge from septic pits,
- 06 11 01 - calcium-based reaction wastes from Titanium dioxide production,
- 06 11 99 - waste not otherwise specified,
- 05 07 02 - waste containing sulphur,
- 20 01 08 - biodegradable waste from kitchen and canteen,
- 19 08 09 - grease and oil mixture from oil/water separation containing only edible oil and fats.

Waste is collected at the place of origin in the production areas. All waste streams are collected separately depending on the waste type. After collection, waste is sent to warehouses and storages. Hazardous waste is stored at the Central warehouse (CSKL) while non-hazardous waste is stored at numerous plateaus (DSKL), organized within each production unit.

Central warehouse (internal code CSKL) represents one storage building, located at the northern part of the site, used for storage of hazardous waste and substances. Hazardous waste and substances are stored within the same building and are divided with wire-mesh. The warehouse is equipped with 1m³ concrete pits – secondary containment for collection of potential spills. Waste is separated according to the waste type and is properly labelled. Hazardous liquid waste and sludge are stored in 200 l metal barrels and placed on wooden pallets. Waste packaging, mainly in metal barrels, is stored separately from other hazardous waste and placed on a steel-structure. Waste oil is collected at the place of origin in the 200 l metal barrels, placed within closed containers equipped with secondary containments. Full barrels are transported from the protective containers to the Central warehouse.

Non-hazardous waste is stored at separate storages (DSKL), organized within each of onsite production units. It is kept in metal containers, big bags and 200 l metal barrels. Waste is properly labelled. Waste is taken over and disposed of by certified companies. The Cinkarna Celje site keeps copies of relevant waste disposal documents. Each waste takeover is accompanied with a movement document.

Cinkarna Mozirje:

Most relevant hazardous waste, which is generated at the Mozirje site included:

- Sludge from oil/water separation units – 188 kg;
- Waste paints and thinners – 839 kg;
- Waste fluorescent tubes – 62 kg;
- Used waxes and greases – 2,582 kg;
- Waste mineral oils – 458 kg;
- Absorbents and oil filters – 47 kg;

- Waste batteries and accumulators – 3 kg; and
- Waste electric and electronic equipment (WEEE) – 38 kg.

Most relevant non-hazardous waste, which is generated at the Mozirje site included:

- Domestic/commercial waste – 1,954 kg;
- Paper and cardboard – 4,110 kg;
- Plastics – 375 kg;
- Plastic packaging – 14,960 kg;
- Metal packaging – 2,150 kg;
- WEEE, different from hazardous WEEE – 81 kg;
- Sludge from other treatment units – 2,000 kg;
- Sludge from sanitary wastewater treatment units – 5,000 kg;
- Waste powder coatings – 11,700 kg; and
- Waste printing toners – 6 kg.

Hazardous and non-hazardous wastes are separately stored within a warehouse (Building 393). Beside hazardous and non-hazardous waste, mentioned warehouse is also used for storage of hazardous materials, flammable substances, raw materials and final products. Waste is stored within metal and plastic drums and cans, big bags placed on wooden pallets and within metal containers. The warehouse is equipped with shafts (concrete pits) for collection of hazardous substances in case of spillage or leakage. Pits are reportedly, not connected with the sewage system.

Metal waste is stored within the semi-open, roofed storage (Building 353). Paper and cardboard are collected within designated container located next to the powder coating production facility (Building 379), while plastic is collected next to the warehouse for final goods (Building 599). All waste types, hazardous and non-hazardous wastes, are collected separately before disposal or recycling by certified waste disposal firms.

Mozirje site prepared a Waste Management Plan in April 2012, for the years 2012-2015. The site keeps copies of relevant waste disposal documents.

2.7.7 Storage, usage and handling of hazardous waste

Cinkarna Celje:

As required by Decree on storage of hazardous liquids in stationary storage tanks (Official gazette of RS, No.104/09), Celje site performs regular integrity testing and inspection of the onsite tanks over 40m³, which are:

- Eight tanks for H₂SO₄ (each capacity of 1,080 m³),
- One tank for liquid sulphur (capacity of 600 m³),
- Two tanks for HCl (capacity of 45 m³),
- One tank for Na₂O × 2SiO₂ (capacity of 50 m³),
- Two tanks for NaOH (capacity of 125 m³ each),

- One tank for diesel (capacity of 22 m³),
- One tank for CuCl₂ (capacity of 55 m³).

As prescribed by the Decree, integrity testing and inspection of operating tanks should be carried out at least once in every 5 years, and testing of empty tanks should be conducted every 15 years in minimum. Cinkarna engages certified companies to conduct independent regular testing of the tanks. In 2009 the Company performed rehabilitation of ASTs used for storage of sulphuric-acid.

There is one central warehouse (internal code CSKL) for hazardous materials. The central warehouse represents one storage building, located at the northern part of the site, used for storage of hazardous waste and hazardous materials. Hazardous waste and substances are stored within the same building, but are divided with wire-mesh. The warehouse is equipped with 1m³ concrete pits - secondary containment for collection of potential spills. Hazardous materials are kept in the original packaging, mainly 200 l plastic and metal barrels, intermediate bulk containers (IBCs) and card-board boxes, placed on wooden pallets. From the central storage, substances are transported to the smaller warehouses organized at numerous locations for each of the production units. The production unit Maintenance and Energetics operates a central storage for maintenance materials located at the northeast part of the site location. It comprises two covered warehouses for oils, lubricants and technical gasses and an open area for non-hazardous substances. Flammable substances are stored all over the site location within secured, properly labelled and ventilated metal containers.

Cinkarna Mozirje:

Based on the hazardous materials inventory, the most relevant hazardous substances stored/ handled at Mozirje site:

- White spirit;
- Xylene;
- Glycol Ether (Dowanol);
- Alkyd resin (binders);
- Polyurethane resin (binders);
- Fuel oil;
- Paints;
- Pigments;
- Powder coatings;
- Additives and
- Zinc powder.

These substances are stored within above ground storage tanks (ASTs), or in designated storages within drums, canisters and plastic bags.

Mozirje site operates ASTs, which are:

- One horizontal AST (steel, double walled) divided into three parts for: white spirit in a 15 m³ tank, Xylene in a 20 m³ tank and Glycol Ether (known under commercial name 'Dowanol') in a 5 m³ tank. The AST are located within the storage for flammable substances (Building 402). The storage is equipped with a concrete pit for collection of hazardous materials in case of spills or leakages. The pit is reportedly, not connected with the sewer system. The ASTs were installed in 1997 and the last integrity test was performed in 2007.
- Two vertical ASTs (steel, single-walled) used for storage of Alkyd resin (known under the commercial name 'Domalkyd 1673 60 D-60') and Polyurethane resin (known under the commercial name 'Domalkyd 7625 60 D-60') each in 12.5 m³ tanks. The ASTs are located within the masterbatch production facility (Building 378). The storage is equipped with a concrete pit for collection of hazardous materials in case of spills or leakages. The pit is reportedly, not connected with the sewage system. The ASTs were installed in 1985 and the last integrity test was performed in 2011.
- One 3 m³ natural gas AST for heating, (steel, single-walled), was used until 2012. The AST is located in an open area, next to the canteen (Building 358). The AST was installed in 1992 and the last integrity test was performed in 2007.
- One 3 m³ natural gas AST for heating, (steel, single-walled), was used until 2012. The AST is located in an open area, next to the storage/laboratories facility (Building 377). The AST was installed in 1992 and the last integrity test was performed in 2011.
- One 20 m³ fuel oil AST (steel, single-walled). Fuel oil was used until 2012 for heating (small combustion units). The AST is located in the fuel oil storage (Building 382). The AST was installed in 1988 and the last integrity test was performed in 2008.

There are also decommissioned ASTs at the site, emptied and planned to be dismantled, which are:

- One steel, single walled 5 m³ AST is used for storage of Alkyd resin. The AST is located within the masterbatch production facility (Building 378). The AST was installed in 1985 and was decommissioned 1995.
- Three steel ASTs, 1.5 m³ each, are used for storage of fuel oil. The ASTs are located within the storage of the administration building (Building 366) and they were used for heating of the administration building. The ASTs were installed in 1989 and were decommissioned in 2012, when the new heating system fuelled with biomass was installed.

Hazardous materials, such as pigments, powder coating resins, paints, thinners, etc. are also stored in designated storages (Buildings 393, 402, 377 and 599) in original packaging (drums, canisters and plastic bags), placed on pallets or shelves. In addition, fillers and pigments for the production of masterbatches are stored within two silos, located next to the masterbatch production facility. The fillers for the production of powder coatings are stored within three silos, next to the facility for the powder coating production. Small amounts of hazardous materials, such as paints, thinners, adhesives, resins, etc. are also handled and stored throughout the production facilities.

Underground storage tank (UST) divided into three separated tanks for storage of Xylene (40 m³ tank), White Spirit (20 m³ tank) and Methyl Isobutyl Ketone (20 m³ tank) was used

in the past. The USTs are located in the western part of the site. Reportedly, USTs have not been used for about 30 years now. Based on a statement regarding the decommissioned USTs, issued by the authorized company Eko-Teh on August 25, 1997, the USTs were emptied, cleaned, sealed and put out of operation in a way to prevent further use of the tanks and equipment.

2.7.8 REACH and GHS Status

Cinkarna Celje:

Celje site provided submission reports for the following substances: Titanium dioxide, sulphuric acid, Titanium oxide sulphate, sodium titanate as intermediates, residues associated to Zinc smelting and calcium sulphate. The site only uses/ processes chemicals that are produced in the EU, which have been registered by the suppliers.

Cinkarna Mozirje:

Mozirje site manufactures chemicals and also uses processes chemicals that are produced in the EU. The site annually informs relevant authority on chemical production, placing on the market and registration of chemicals.

2.7.9 PCBs

Cinkarna Celje:

At Celje site, following transformer stations are owned and operated by Cinkarna:

- RTP TiO₂ (power of 20 MVA and transformer rate 20(10)/6.3 KV),
- TP 1-2 (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP 3-4 (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP 5-6 (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP 7-10 (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP 8 Kotlarna (power of 1 MVA and transformer rate 6.3/0.4 KV),
- TP 9 Črno mletje (power of 1 MVA and transformer rate 6.3/0.4 KV),
- TP "S" kislina (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP Litopon (power of 3×1 MVA and transformer rate 6.3/0.4 KV),
- TP Vzdrževanje (power of 2×0.63 MVA and transformer rate 6.3/0.4 KV),
- TP OOB (power of 2×0.4 MVA and transformer rate 6.3/0.4 KV),
- TP Zn Zlitine (power of 1 MVA and transformer rate 6.3/0.4 KV),
- TP Žica (power of 0.63 MVA and transformer rate 6.3/0.4 KV),
- TP Grafika 2 (power of 1 MVA and transformer rate 6.3/0.4 KV),
- TP Grafika 3 (power of 3×1 MVA and transformer rate 6.3/0.4 KV),
- TP KKČ (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP Valjarna (power of 2×1 MVA and transformer rate 6.3/0.4 KV),
- TP NKP (power of 2×1 MVA and transformer rate 6.3/0.4 KV),

- TP Marketing (power of 0.25 MVA and transformer rate 10/0.4 KV),
- TP Sadra (power of 2×1 MVA and transformer rate 20/0.4 KV).

Last disposal of PCB-containing equipment was conducted in July 2009. The shipment comprised disposal of electrical capacitors used at the Metallurgy production unit (total quantity of 1,240 kg). Capacitors were taken over by the certified company Kemis from Vrhnika, in accordance with Regulation on the disposal of polychlorinated biphenyls and terphenyls (Official Gazette of RS No. 34/08 and 09/09). Equipment replacing PCB-containing equipment, as well as the dielectric fluids present at the site, is now PCB free.

No other potentially PCB-containing equipment or building material is reportedly present at Celje site.

Cinkarna Mozirje:

Two transformers located at two transformer stations are owned and operated by Mozrije site. The transformers were installed in 2004 and 2007 and are PCB-free. Transformers are maintained internally by the maintenance department and regular inspections are conducted externally by the Company Electro Celje. No other potentially PCB-containing equipment or building material is reportedly present at Mozrije site.

2.7.10 ACMs

Cinkarna Celje:

ACMs are reportedly present at Celje site as corrugated roof panels and façade elements. In March 2003 the site prepared a report regarding onsite facilities and buildings containing ACMs and delivered it to the Ministry of the Environment and Spatial Planning, as legally required by the Regulation on the conditions under which the reconstruction or demolition of buildings and maintenance on buildings, installations or equipment removed materials containing asbestos (Official Gazette of RS No. 72/01). The report identified approximately 30,000 m² or 600 tons of ACMs roofing and facade elements. Nowadays, there is still 192 tons of identified ACMs at the following onsite facilities:

- Titanium-dioxide Production Unit – production hall facade, a part of the roof, the ore storage and process of ore milling building facade and the facade of the neutralization process;
- Maintenance and Energy Production Unit – a part of the roof and a part of the façade;
- Metallurgy Production Unit – roof of the Zinc wire production building.

Although there is no legal requirement in Slovenia (or EU) to remove intact non-friable ACMs, it should be noted that the disposal of friable ACMs in Slovenia can only be carried out as hazardous waste and therefore elevated costs may occur. Non-friable ACMs can be disposed at landfills designated for such non-hazardous waste. Beside the mentioned 30,000 m² of ACMs, the site has removed ACMs in the past, reportedly always with certified contractors.

Cinkarna Mozirje:

Considering the age of the site, the presence of asbestos containing materials (ACMs) in building insulation, installations, etc. cannot be excluded. However, no asbestos survey has been conducted at the site and none is legally required.

The Cinkarna Mozirje site has already substituted 1,300 m² ACMs roof panels with non-asbestos roof panels. Although there is no legislative requirement in Slovenia (or EU) to remove non-friable ACMs, it should be noted that disposal of friable ACMs in Slovenia can only be carried out as hazardous waste and therefore elevated costs would occur. Non-friable ACMs could be disposed at designated landfills for disposal of non-hazardous waste.

2.8 Known Soil and Groundwater Contamination

Cinkarna Celje and Landfills:

Areas with known soil impacts are mainly related to former onsite production activities. Following areas within the Cinkarna Celje site location are registered with known soil impacts:

- Area at the north-west part of Cinkarna Celje site, between the Management building and River Hudinja – historically, landfill of tar and other waste from the previous location of Cinkarna (since 1953) such as: slag from Zinc smelting production, waste from production of lithopone, fungicide (blue Copper), super phosphate, BaS and Zinc bleach. Potential contamination may originate from presence of man-made fills containing wastes, which include heavy metals, petroleum compounds and VOCs;
- Area at the central-west part of Cinkarna Celje site, currently used as open storage for non-hazardous waste, next to the TiO₂ production unit – this area was used as open storage for Zinc ashes;
- Area at the central-east part of the Cinkarna Celje site, next to the open storage boxes currently used for white gypsum - this area was used as open storage for pyrite ore and later on partly also for waste vanadium-pentoxide (V₂O₅) (formerly used as catalyst in production of sulphuric-acid) and sulphur filtration cake;
- Area at the eastern part of the Cinkarna Celje site, next to the sulphuric-acid production plant and between onsite railway tracks – this area was used as large open waste storage for pyrite residuals generated after production of sulphuric-acid when pyrite was used as raw material. Large quantity of pyrite residuals was removed in the past from the production site and disposed at the Bukovžlak landfill, within the area for solid waste. Yet, certain quantity of pyrite residuals remained onsite. Accurate quantities of pyrite burns are unknown;
- Area adjacent to the Bukovžlak landfill to the north – in periods of high groundwater level, this area transforms into a swampy terrain and results in a red colored wetland appearance.

Investigation of soil contamination:

In 2006, the Cinkarna Celje engaged the external company Envita to prepare an environmental report focusing on soil contamination. A total of 6 topsoil samples were

taken, 30 cm in depth, for chemical analyses and determining possible contamination with heavy metals.

Based on the Slovenian Regulation on Limit, Warning and Critical Concentration of hazardous substances in the soil (Official Gazette of RS No. 68/96 and 41/04) soil was classified as "inadequate for cultivation of plants intended for human and animal nutrition or for collection and filtration of water". Concentrations of heavy metals such as: Copper (Cu), Zinc (Zn), Cadmium (Cd) and Lead (Pb) exceeded not only limit values but also critical values established by the above mentioned Regulation.

As presented within the independent Study "Distribution of Zinc and Cadmium pollution in Celje basin" prepared by Geological Survey of Slovenia in 2005, Cinkarna Celje production site is identified as a main source of contamination in the city of Celje. The study is based on chemical analyses of topsoil samples (0-5 cm) taken at several points at a distance of up to 12 km from the Cinkarna site. Sampling was focused on surrounding river valleys, as follows: Savinja (west and south), Voglajna (east) and Hudinja (north). Depending on the orientation of the valley, soil impacted by Cinkarna's operations may be found at a distance of 7 to 20 km from the site. River Voglajna's valley to the east is identified as the most influenced area while the northern valley of River Hudinja is least impacted. This, probably historical, contamination resulted from air emissions associated with former process operations.

Cinkarna's management initiated a long-term monitoring campaign focused on topsoil contamination with heavy metals. The campaign was initiated in 2012 with two sampling cycles conducted in April and October and it is planned to continue until 2015. Sampling points were located within the Cinkarna production site, at the Za Travnikom landfill, in the area next to the public road and the steel production facility "Store Steel" (1 km south-east of the site) and at a distant countryside area. According to the analyses results from testing conducted in 2012, the concentrations of Zn, Pb and Cu were over the critical values in almost all samples taken within the premises of the Cinkarna production site. Concentrations of these parameters detected in samples taken outside of Cinkarna's premises were mainly below the critical values, while samples taken in the distant areas showed concentrations mainly below prescribed limit values.

Monitoring of groundwater quality:

No groundwater quality investigation has been conducted at Cinkarna Celje and Cinkarna Mozirje production sites and there are no existing monitoring wells at the site.

The Company is obliged by conditions set within the Environmental Permit (IPPC Permit) to conduct regular monitoring of the groundwater quality for the locations of the Bukovžlak and the Za Travnikom landfills. In order to fulfil the required obligation, the site has installed monitoring wells at these two locations and developed and initiated the following monitoring programs:

- Groundwater monitoring program for the solid waste landfill Bukovžlak: the program is developed to cover the area used for solid waste disposal. The monitoring program was approved by the Ministry of Environment and Spatial Planning and Environmental Agency in December 2005;

- Environmental pollution monitoring program – the Bukovžlak landfill for waste generated during the production of Titanium dioxide: program is developed to cover the area used for liquid waste disposal, in accordance with the Regulation on monitoring of environmental pollution caused by waste from the production of Titanium dioxide (Official Gazette of RS No. 57/00 and 43/04);
- Environmental pollution monitoring program – the Za Travnikom landfill for waste generated during the production of Titanium dioxide, developed in October 2005: The program is developed for the area used for liquid waste disposal at the Za Travnikom landfill, in accordance with the Regulation on monitoring of environmental pollution caused by waste from the production of Titanium-dioxide (Official Gazette of RS No. 57/00 and 43/04).

The last monitoring campaign, in accordance with abovementioned monitoring programs, was conducted in June and October of 2013 and results were presented in related Reports prepared in March 2014 by the accredited laboratory of Institute for Public Health from Maribor.

The data for 2011 are:

In the area of the Bukovžlak landfill used for solid waste, a total of 3 groundwater samples were taken at following monitoring wells: BUK-2 (south-east area, next to the dam), A-2 (northern area, after the landfill) and PB-4 (central-south area, below the dam). Results of the analyses were compared with limit values set by Regulation on operational monitoring of groundwater contamination (Official Gazette of RS No. 49/06, 70/08 and 114/09).

Samples from A-2 and PB-4 contained Ammonium, Iron, Boron, Nitrites and Titanium over the limit values. In A-2 other heavy metals were also detected above the limit values as follows: Zinc, Cadmium, Cobalt, Molybdenum and Nickel. No above limit values were detected in sample taken from BUK-2 monitoring well.

In the area of the Bukovžlak landfill used for previously treated liquid waste, a total of 3 groundwater samples were taken at the following monitoring wells: BUK-1 (area before the landfill to the south), BUK-2 (south-east area, next to the dam) and P-4 (central-south area, below the dam). When results of the analyses are compared with limit values set by Regulation on operational monitoring of groundwater contamination, only samples taken from P-4 was found with concentrations above limit values for sulphates, Zinc and Iron, while an elevated concentration of sulphates was also detected in monitoring well BUK-2. In monitoring well BUK-1, no parameters above the limit value were noted.

Groundwater monitoring at the Za Travnikom landfill included sampling of three monitoring wells: Z1 (water catchment south-west of the landfill), ZT-1A (below the dam) and ZT-2A (north of the landfill). Results of the analyses are compared with limit values set by the Regulation on operational monitoring of groundwater contamination and no violation of the limit values was detected.

Regardless of the above stated contamination of soil and detected violation of limit values for groundwater, no outstanding authority requirements regarding the implementation of any further measures which are to include additional investigation or remediation activities, currently exist.

Cinkarna Mozirje:

No known soil and/or groundwater impacts were reported. No outstanding authority requirements currently exist. The Mozirje site contact was not aware of any soil and groundwater investigations and/or remediation been conducted at the site.

2.9 Identification of hazardous substances that are currently used, produced or released at the installation

The following table presents a list of hazardous substances present at the premises of Cinkarna Celje d.d. in a quantity larger than 1 tone. Hazardous substances are those substances or mixtures of substances, which are defined under the Article 3 of Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures, called "CLP". The table presents the location where each hazardous substance is stored or used, and information whether a substance is stored in retail containers or storage tanks.

PE Production of TiO₂

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
sulphuric acid (96-98%)	žveplova(VI)kislina (96-98%)	15,700	Aboveground
potassium carbonate	kalijev karbonat	70	Container
sodium silicate	natrijv silikat (30-40%)	73	Aboveground
phosphorus (V) acid (approx. 75%)	fosforjeva (V)kislina (cca.75%)	40	Aboveground
zirconium oxychloride	cirkonijev oksiklorid	40	Container
calcium hydroxide - hydrated lime	hidrirano apno	500	Container
hydrochloric acid (min 31 wt.%)	klorovodikova kislina (min 31ut%)	110	Aboveground
sodium hydroxide (30 - 50 wt.%)	natrijev hidroksid (30-50 ut%)	350	Aboveground
aluminium powder	aluminijev prah	10	Container
sulphur (granulated)	Žveplo granulirano	8,465	Container
sulphur (fluid)	žveplo tekoče	1,080	Aboveground
fuel oil	kurilno olje	21	Aboveground
calcium hydroxide - hydrated lime	apno hidrirano	7	Container
sulphuric acid (30-40%)	Žveplova(VI) kislina (30-40%)	27	Container

Building products

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
calcium hydroxide - hydrated lime	Apno hidrirano CL90S -p	30	Container
portland cement (CAS 65997-15-1)	Cement beli BPC ITAL BIA	80	Container
	Cement II/B-M(L_P)42,5	80	Container
	Cement II-A-M(LL-S)42,5	80	Container
	Cement I 42,5N sulfatno	10	Container
	Nivedur S	350	Container
	Nivedur S-beli	100	Container
	Nivedur E	300	Container
	Nivedur E-beli	20	Container
	Nivedur E MIDI	25	Container
	Nivedur E MIX	20	Container
	Nivedur E RAPID	20	Container
	Nivedur I	20	Container
	Nivedur P	150	Container
	Nivedur G	100	Container
	Nivedur Flex - MIX	15	Container
	Nivedur G MIX	10	Container
	Nivedur M MIX	5	Container
	Hidrozan	80	Container
	Hidrozan MIX	8	Container
	Gramadur	40	Container
	Gramadur FLEX	60	Container
	betonsanir 01 vezna malta	5	Container
	betonsanir 02 izravnalna malta	5	Container
	betonsanir 04 reparaturna malta	5	Container
	Nivedur S - RAPID	20	Container
	Nivefas	30	Container
	Nivefil	7	Container
	Nivelan B	25	Container
	Nivelan V	15	Container
	Nivelan Z 2mm	30	Container
	Nivelan Z 1,5mm	30	Container
	OMALT CSO	10	Container
	OMALT FM	75	Container
OMALT KMF	5	Container	
OMALT MzZ M5 Z	200	Container	
OMALT MzZ M10 Z	70	Container	
OMALT CASO C	70	Container	
OMALT CASO	300	Container	
OMALT CE	40	Container	

	OMALT GM	150	Container
	OMALT MzZ M5	270	Container
	OMALT SOF fini sušilni omet	10	Container
	OMALT SOG grobi sušilni omet	20	Container
	OMALT MP	50	Container
	OMALT MzZ M10	70	Container
	OMALT -TM	30	Container
	Vezur	30	Container
	Viadur	30	Container
	Vilacem SQ	10	Container
	OMALT -MCSO	70	Container
	OMALT MCE	50	Container
	Hidrozan elastik komp.A	3	Container
white cement	Alborg white cem 1 52,5R	80	Container
calcium formiat	kalcijev formiat	15	Container
Glue	YTONG tankoo slojna malta	300	Container
adhesive agent	Lepilo moj dom Flex 25kg	50	Container

Blue Copper

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
calcium oxide	Apno žgano metal. kosovno	10	Container
Copper oxychloride (CAS 1332-65-6)	Cuprablau Z ultra-polprod	15	Container
	MB-polprodukt s klor.kisl	53	Container
	Cuprablau Z WG 35%	6.53	Container
	Cuprablau Z 35 WP	30	Container
	Cuprablau Z Ultra WP	28	Container
	COC 25 WG	24	Container
	COC 30 WG	24	Container
	COC 35 WG	24	Container
natruim carbonate	Natrijev karbonat	2.4	Container
Solution of Copper chloride	Raztopina bakrovega klorida	100	Aboveground
sulphur (80%)	Žveplo 80%	50	Container
Copper oxychloride	Bakrov oksiklorid 57 %	60	Container
Copper hydroxide	Bakrov hidroksid 60% Cu	150	Container
	Bakrov hidroksid 20 WG	24	Container
hydrochloric acid	Klorovodikova kislina teh.	30	Aboveground
Copper sulphate monohydrate	Bakrov sulfat monohidrat	3.71	Container
Copper oksiklorid	Bakrov oksiklorid 50 WP	24	Container
Tribasic Copper sulfate 53%	Tribazičen bakrov sulfat 53 %	24	Container
	TBCS 30 WG	24	Container

Growing media

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
Ferrous sulphate heptahydrate	zelena galica 25kg	50	Container
Pesticide	basmol	1.2	Container

PE GRAFIKA

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
METHYLENCHLORID	METHYLENCHLORID 4704	3	Container
naphta A III	NAFTA A III	23	Container
		40	Container
citric acid	CITRONSKA KISLINA TEH.	1.5	Container
Propylene glycol methyl ether; 1-Methoxy-2-propanol.	DOWANOL PM	25	Underground
ethyl acetate	ETILACETAT TEH.	32	Underground
isopropyl alcohol	ISOPROPILALKOHOL	48	Underground
potassium hydroxide	KALIJEV HIDROKSID	5	Container
light aromatic naphtha	LAHKA AROMATSKA NAFTA	40	Underground
lithium carbonate	LITIJEV KARBONAT	25	Container
naphta A II	NAFTA A II	40	Underground
ethyl alcohol (99%)	ETILNI ALKOHOL 99,9 % - SOD	2.4	Underground
ethanol (30%)	HACOCELL H 35 SPEC. ETHANOL 30%	5	Container
nitrocellulose pigment preparation	NC AH 27	6.5	Container
	PREDISOL PBC 1060	2	Container
	PREDISOL PRC 1056	2	Container
printing chemical	TYZOR IAM	2.5	Container
ethyl alcohol (99%)	DENATURIRAN 99,9% ETILNI ALKOHOL	32	Container
(Dipropylene Glycol Monomethyl Ether	DPM (ARCOSOLV DPM)	8	Underground
nitrocellulose preparations	NC-C 65	6	Underground
calcium hydroxide - hydrated lime	APNO HIDRIRANO - RINFUZA (Grafika)	15	Container
phosphoric acid	FOSFORNA KISLINA 85 PROC. CISTERNA	15	Container
sodium hydroxide	NATRIJEVA LUG-TEHNIČNI 100%	4.5	Container
acetic acid (98%)	OCETNA KISLINA P.A.98%	2	Container
hydrochloric acid	KLOROVODIKOVA KISLINA TEHNIČNA	6	Container
methylethyl ketone	METILETILKETON	3.5	Container
printing chemical	P-15 JEDKA ZA PLOSCE	1,955	Container
	P-17 ČISTILO ZA	12	Container

	PRESUŠENO TISK.BARVO		
	P-204 GUMI-REG ZA REGENERACIJO GUM	1,057	Container
Naphtha (petroleum), hydrodesulphurised heavy	P-21 ČISTILO ZA VALJE IN ODTIS. GUMO	12	Container
	P-211 AKTIVATOR ZA IZMIVANJE PLOŠČ	3	Container
	P-23 ČISTILO A II	4	Container
	P-24 ČISTILO A III	2,935	Container
alcohol buffer, propanol	P-41 SUPER PUFER KLASIČEN	14,755	Container
alcohol buffer, prepared isopropyl alcohol 99,9%	P-43 ISO SREDSTVO ZA VLAŽENJE KONT.	56	Container
alcohol buffer (chloro-2- methyl-4-isothiazolin-3- one [EC no. 247-500-7] and 2-methyl-2H - isothiazol-3-one [EC no. 220-239-6] (3:1))	P-56 ALKO PUFER ZA ALK.VLAŽENJE	2.13	Container
printing ckemical - developer (sodium meta silicate)	P-71 CTP RAZVIJALEC	3.54	Container
	P-71+ PLUS RAZVIJALEC ZA CTP TERM.PLOŠČE	5.64	Container
	P-75 RAZVIJALEC-PCP	5.54	Container
	P-75C RAZVIJALEC-PCP KONCENTRAT 1+4	1.88	Container
	P-76 RAZVIJALEC-R ROČNI ZA POZIT.PL.	1.64	Container
	P-76C RAZVIJALEC-RC KONCENTRAT 1+9	1,827	Container
methoxy propanol, dipropylene methyl ether	PLASTOFLEX, LAMINATFLEX, ELASTOFLEX, KONCENTRAT: vse razen 45, 70, 80, 85, SLOW in SET	25	Container
	9410 OB-A LAMINATFLEX – BELA / WHITE	2	Container
	PLASTOFLEX in LAMINATFLEX: SET	4	Container
Ethanol	ETA RAZREDČILO/THINNER	3	Container
ethanol, propanol	P RAZREDČILO/THINNER	2	Container

PE METALURGIJA

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
Zinc residues	Ostanki plavljenja cinka (OPC)	35	Container

PE VZDRŽEVANJE IN ENERGETIKA (maintenance and energy)

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
gas propane butane	PLIN PROPAN - BUTAN	1.64	Container
epoxy-polyamide coating	EPOKTIT B,C,RAL- komponenta A	1.2	Container
KOROPLAST (T,B,C,RAL)	KOROPLAST (T,B,C,RAL)	1.2	Container
DIESEL	Olje plinsko D1 - Dizelsko gorivo	42	Aboveground in the embankment

OE MARKETING

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
epoxy-polyamide coating	EPOKTIT B,C, komp. A	2.3	Container
Coating	OSNOVNA ANT. BARVA	3	Container
DUPLOSAN KV	DUPLOSAN KV	2.5	Container
U46M	U46M	1.92	Container
KYLEO	KYLEO	2,016	Container
BOOMEFEKT	BOOMEFEKT	2.88	Container
portland cement	NIVEDUR	7	Container
	Nivedur E-beli, MIDI,	6	Container
	Nivedur E RAPID, I, P, S, E	15	Container
	Nivedur S - RAPID	3.6	Container
	Nivedur G	6	Container
	Nivedur S-beli	2.4	Container
	Hidrozan	3.6	Container
	Gramadur	2.4	Container
	Gramadur FLEX	12	Container
	betonsanir	6	Container
	Nivefas	3.6	Container
	OMALT CSO, CASO, GM, MzZ M5, SOF, SOG, MP, TM, MP, MCSO	24	Container
	OMALT FM, KMF	3.6	Container
	OMALT MzZ M10, CE, VEZUR, VIADUR	3.6	Container
Vilacem SQ 25kg	1.2	Container	
Ferrous sulphate	zelena galica	4.8	Container
Copper oxychloride	Cuprablau Z	2	Container
	Cuprablau Z ultra	2	Container

Za Travnikom Landfill

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
Diesel Oil	Olje plinsko D1 - Dizelsko gorivo	10	Aboveground

Cinkarna Mozirje

Hazardous substance	Commercial Names	Maximum Amount of Stock (tons)	Storage
ARADUR 115X70 BD	ARADUR 115X70 BD	5	Container
CINKOKSID HARZSIEGEL STANDARD	CINKOKSID HARZSIEGEL STANDARD	5	Container
CINKOLI 820 SUPERFEIN	CINKOLI 820 SUPERFEIN	5.2	Container
DOMALKYD 7625 60 D-40	DOMALKYD 7625 60 D-40	10	Aboveground
DOWANOL PM	DOWANOL PM	10	Aboveground
KSYLEN	KSILEN	12	Aboveground
METILETILKETON	METILETILKETON	3	Container
MATTIERUNGSMITTEL DT 3360	MATTIERUNGSMITTEL DT 3360	2	Container
SHELLSOL A	SHELLSOL A	2	Container
SOLVENT SPECIAL	TOPILO SPECIALNO	8	Aboveground
VERSAMID 115X70	VERSAMID 115X70	5	Container
EPOKTIT B,C,RAL-komponenta A	EPOKTIT B,C,RAL-komponenta A	15	Container
EPOKTIT - komponenta B	EPOKTIT - komponenta B	3	Container
EPOKTIT PRIMER - komponenta A	EPOKTIT PRIMER - komponenta A	3	Container
EPOKTIT PRIMER - komponenta B	EPOKTIT PRIMER - komponenta B	1.4	Container
KOROCINK E - komponenta A	KOROCINK E - komponenta A	2	Container
KOROCINK S - komponenta A	KOROCINK S - komponenta A	2	Container
KOROCINK T	KOROCINK T	1.5	Container
KOROPLAST (T,B,C,RAL)	KOROPLAST (T,B,C,RAL)	6	Container
Coating	OSNOVNA ANTIKOROZIJSKA BARVA	10	Container
Coating	OSNOVNA ANTIKOROZIJSKA BARVA HITROSUŠEČA	3	Container
thinner 149 L	RAZREDČILO 149 L	4	Container
thinner 224	RAZREDČILO 224	1.5	Container

3 Site Investigation Methodology

3.1 Rationale for site investigation

In this Phase II Environmental Site Assessment, a targeted sampling strategy was applied. A targeted sampling strategy is understood as a strategy of soil and groundwater sampling which is focused on sampling in zones of suspected pollutant concentrations. For this purpose, the following zones were selected:

- **Sixteen** areas (named Nos. 1 to 16) were located at the area of Cinkarna Celje, which were selected based on knowledge of either historical or current presence or use of hazardous substances. In each zone, at least one borehole was drilled for the purpose of collection of soil samples and at least one groundwater monitoring well was installed for the purpose of collection of groundwater samples. A summary of selected sampling locations is historical and current operations at each of the zones and details of chemical use given in a table below.

Sampling Location ID	Sampling location description	Sampling location rationale	Analyzed samples
Area 1 - area of the administration building	An empty area covered with grass. Beneath a layer of soil, man-made fills comprising industrial wastes were encountered. Fills were present to a depth of 1.4 m-bgl (borehole 1-4 and 1-5) to 3.6 m-bgl (borehole 1-1)	Historically, landfill of tar and other waste from the previous location of Cinkarna (since 1953) such as: slag from Zinc smelting production, waste from production of lithopone, fungicide (blue Copper), super phosphate, BaS and Zinc bleach. Potential contamination may originate from presence of man-made fills containing wastes, which include heavy metals, petroleum compounds and VOCs. Currently, used for an administration building and as a lawn. Boreholes 1-1, 1-2, 1-3, 1-4 and 1-5 were located evenly across the green area. Borehole 1-5 was converted into a temporary groundwater monitoring well.	1-1 – soil samples (1.4 and 3.5 m-bgl); 1-2 – soil samples (1.0 and 3.5 m-bgl); 1-3 – soil samples (1.0 and 4.4 m-bgl); 1-4 – soil samples (1.0 and 3.5 m-bgl); 1-5 – soil samples (1.0 and 3.5 m-bgl) and a groundwater sample.
Area 2 - hazardous waste storage area and chemicals storage PE Grafika	Boreholes were drilled in vicinity of buildings. Beneath asphalt/crushed stone, man-made fills	Historically used as landfill for disposal of waste form BaS production. Hazardous substances: BaS, ZnSO ₄ , BaSO ₄ and ZnS. Currently, since about	2-1 – soil samples (1.0, 2.5 and 3.5 m-bgl) and a groundwater sample;

	<p>comprising industrial wastes were encountered. Fills were present to a depth of 1.2 m-bgl (borehole 2-6) to 4.7 m-bgl (borehole 2-1)</p> <p>Boreholes 2-5 and 2-4 were drilled in areas covered with crushed stone and the remaining boreholes were drilled through asphalt cover.</p>	<p>1988, place for hazardous waste storage and raw materials storage for flexo and offset printing inks and graphic chemicals production. Chemicals: nitrocellulose preparations, methyl ethyl ketone, methylene chloride, acrylic surfactants, mineral oils, offset printing inks and acrylic surfactants are used. Potential contamination from both former and current activity may originate from heavy metals, petroleum compounds and other organic compound, organic pigments and VOCs.</p> <p>Boreholes 2-1, 2-2, 2-3, 2-4, 2-5, 2-6 and 2-7 were located in a vicinity of buildings of Growth Medium Storage, Growth Substrate Production Facility, Printing Chemicals Facility, Grafika Storage 2.</p> <p>Boreholes 2-1 and 2-5 were converted into temporary groundwater monitoring wells.</p>	<p>2-2 – soil samples (1.0, 2.5 and 3.5 m-bgl);</p> <p>2-3 – soil samples (1.0, 2.0 and 3.0 m-bgl);</p> <p>2-4 – soil samples (1.0, 3.8 m-bgl);</p> <p>2-5 – soil samples (0.8 and 3.0 m-bgl) and a groundwater sample;</p> <p>2-6 – soil samples (1.0 and 3.4 m-bgl);</p> <p>2-7 – soil samples (0.7 and 3.7 m-bgl).</p>
<p>Area 3 - production area of TiO₂-PD2 (in the past production of lithopone (ZNSxBaSO₄) and Zinc sulphate (ZnSO₄))</p>	<p>Boreholes were drilled through asphalt cover.</p> <p>Beneath asphalt, man-made fills comprising clayey material were encountered. Fills were present to a depth of 3.7 m-bgl (borehole 3-1) and 2.1 m-bgl (borehole 3-2).</p>	<p>Historically used for production of lithopone (ZnS × BaSO₄) and ZnSO₄ (started in 1964 and shutdown in 1993), warehouse for Zn ashes and H₂SO₄ and landfill of barite mud. Potential contamination may originate from heavy metals, Ti, Ba, petroleum compounds and HCl spilling due to historically presence of chemicals: BaS, ZnSO₄, BaSO₄, ZnS, H₂SO₄, HCl, KMnO₄, Zn and Zn ash, CaO, CaOH₂, H₂O₂, NaClO and NaClOCl. No contamination from the current activity was observed.</p> <p>Boreholes 3-1 and 3-2 were located on a yard surrounded</p>	<p>3-1 – soil samples (1.0 and 3.0 m-bgl) and a groundwater sample;</p> <p>3-2 – soil samples (1.0 and 3.5 m-bgl).</p>

		<p>by TiO₂ production building, on a hardened surface</p> <p>Borehole 3-1 was converted into temporary groundwater monitoring well.</p>	
<p>Area 4 - Area 4 - production area of fungicide (blue Copper),</p>	<p>Borehole 4-1 was drilled through asphalt cover.</p> <p>Beneath asphalt, man-made fill comprising black colored gravel and industrial wastes was present to a depth of 3.5 m-bgl.</p>	<p>Historically (until 1993) used for production of lithopone and ZnSO₄. Currently area of production of fungicide (blue Copper) with UST for blue Copper. Potential contamination may originate from heavy metals and accidental oil spilling in the past. Currently, chemicals such as: Cu, HCl, Ca(OH)₂, CuOCl₂, CuCl₂, CuSO₄, Cu(OH)₂ and S are used. No information on potential contamination from the current activity, no such incidents were recorded.</p> <p>Borehole 4-1 was located in a passage between Blue Copper Production Building and Wooden Storage building, on a hardened surface</p> <p>Borehole 4-1 was converted into temporary groundwater monitoring well.</p>	<p>4-1 – soil samples (1.5 and 3.8 m-bgl) and a groundwater sample;</p>
<p>Area 5 - building Razvoj (north),</p>	<p>Borehole 5-1 was drilled in the area covered with grass.</p> <p>Beneath the soil, man-made fill comprising black industrial waste mixed with gravel was present to a depth of 2.2 m-bgl.</p>	<p>Historically (between 1961 and 1976) used for production of synthetic organic sulphur dyes and azo dyes. Potential contamination may originate from presence of chemicals: benzene, aniline, toluene, nitrobenzene, aromatic amines, phenol, sulphur, sulphuric acid, synthetic organic dyes that contain nitrogen as the azo group, organic compounds sulphur dyes, HNO₃, NaOH and HCl. Currently used as research and development department with</p>	<p>5-1 – soil samples (1.0 and 3.4 m-bgl) and a groundwater sample;</p>

		<p>offices and laboratories (building Razvoj). No occurrence of chemical pollution was observed.</p> <p>Borehole 5-1 was located adjacent north to the Development and Investment Building, on the grass.</p> <p>Borehole 5-1 was converted into temporary groundwater monitoring well.</p>	
<p>Area 6 - area at the Grafika 4 and Grafika 5 in direction to S-channel,</p>	<p>Boreholes were drilled in the areas covered with grass.</p> <p>Beneath the soil, man-made fills (black, with coal grains) were present to a depth of 0.5-1.4 m-bgl.</p>	<p>Historically (between 1948 and 1976) location of UST of benzene and warehouse for organic sulphure dyes and their raw materials. Between 1976 and 2012 used for production of offset printing inks and varnish. Potential contamination may originate from the presence of chemicals such as: benzene, aniline, toluene, nitrobenzene, aromatic amines, phenol, sulphur, sulphuric acid, synthetic organic dyes that contain nitrogen as the azo group, organic compounds sulphur dyes, nitric acid (HNO₃), sodium hydroxide (NaOH) and chloric acid (HCl).</p> <p>In 1992, fire in warehouse of printing ink's raw materials appeared. The building was completely destroyed and a new one was built at the same place. Fire residues were disposed of at the solid waste landfill in Bukovžlak. Since about 1988, until now, the building has been used for flexo printing ink production, graphic chemicals production and a raw materials warehouse with USTs for organic solvents and mineral oils. Potential contamination: oils and solvents spilling as well as minor contamination of organic</p>	<p>6-1 – soil samples (1.0 and 3.0 m-bgl) and a groundwater sample;</p> <p>6-2 – soil samples (1.0 and 2.5 m-bgl);</p> <p>6-3 – soil samples (1.2 and 3.2 m-bgl) and a groundwater sample.</p>

		<p>materials, pigments and resins.</p> <p>Borehole 6-1 was located south of the solvent storage area (in Underground Storage Tanks).</p> <p>Borehole 6-2 was located north of the solvent storage area (in Underground Storage Tanks).</p> <p>Borehole 6-3 was located north of the Printing Inks Production facility.</p> <p>Boreholes 6-1 and 6-3 were converted into temporary groundwater monitoring wells.</p>	
<p>Area 7 - area of temporary storage for construction waste,</p>	<p>Boreholes 7-1 was drilled in the area covered with grass.</p> <p>Borehole 7-2 was drilled through asphalt cover.</p> <p>Beneath the soil/asphalt, man-made fills (brown to black, with industrial wastes) were present to a depth of 1.6 m-bgl in 7-1 and 1.2 m-bgl in 7-2.</p>	<p>Historically (between 1948 and 1994) area of organic sulphur dyes and azo dyes production and between 1982 and 1988 graphic chemicals production. Potential contamination may originate from organic dyestuffs chemicals, azo compounds, organic compounds containing sulphur, and VOCs: benzene, aniline, toluene, nitrobenzene, aromatic amines, phenol, as well as sulphur, sulphuric acid, synthetic organic dyes that contain nitrogen as the azo group, organic compounds sulphur dyes, nitric acid (HNO₃), sodium hydroxide (NaOH) and chloric acid (HCl).</p> <p>Currently location of temporary storage of construction waste. Potential contamination from current activity is less likely due because of lack of chemical storage in this area.</p> <p>Borehole 7-1 was located adjacent east and borehole 7-2 adjacent south of the building Storage, which historically (1948-</p>	<p>7-1 – soil samples (1.0 and 3.0 m-bgl) and a groundwater sample;</p> <p>7-2 – soil samples (0.6, 2.5, 3.0 and 3.6 m-bgl) and a groundwater sample.</p>

		<p>1994) was used for production of dyes. In 1982-1988, graphic chemicals production was performed with use of organic solvents.</p> <p>Both boreholes 7-1 and 7-2 were converted into temporary groundwater monitoring wells.</p>	
<p>Area 8 - production of Titanium dioxide TiO₂</p>	<p>Boreholes 8-2, 8-4 and 8-5 were drilled in areas covered with grass and the remaining boreholes were drilled through asphalt cover.</p> <p>Beneath asphalt/soil layer, man-made fills comprising industrial wastes were encountered. Fills were present to a depth of 0.7 m-bgl (borehole 8-2) to 3.8 m-bgl (borehole 8-5).</p>	<p>Since 1973, TiO₂ production area, including installed decanters, acid pipelines and storage tanks for liquid chemicals, acid pools, sewage treatment (neutralization) plant as well as ore and chemicals warehouses. Potential contaminants in this area include: K₂CO₃, Na₂SiO₃, H₃PO₄, zirconium oxychloride, Ca(OH)₂, HCl, NaOH, aluminium powder, H₂SO₄ and wetting agents. Potential presence of substances in the ground (in a man-made fill): pyrite ore and iron oxides. Historical spillages of sulphuric acid spilling incidents were also recorded.</p> <p>Boreholes were drilled in vicinity of the following buildings/installations: Acid Neutralization Facility (8-1 and 8-2), TiO₂ Production Facility (8-3, 8-4, 8-5), Acidic Effluent Pools (8-6), Liquid Chemicals (acids and bases) Unloading Ramp (8-7) and Ore Storage (8-8).</p> <p>Both boreholes 8-5, 8-6 and 8-7 were converted into temporary groundwater monitoring wells.</p>	<p>8-1 – soil samples (1.0 and 3.0 m-bgl);</p> <p>8-2 – soil samples (0.7 and 3.0 m-bgl);</p> <p>8-3 – soil samples (0.7 and 3.5 m-bgl);</p> <p>8-4 – soil samples (1.0 and 2.8 m-bgl);</p> <p>8-5 – soil samples (1.0 and 2.0 m-bgl) and a groundwater sample;</p> <p>8-6 – soil samples (1.0 and 2.7 m-bgl) and a groundwater sample;</p> <p>8-7 – soil samples (1.0 and 3.0 m-bgl) and a groundwater sample;</p> <p>8-8 – soil samples (1.0 and 3.0 m-bgl).</p>
<p>Area 9 - boiler house (Kotlarna)</p>	<p>Boreholes 9-1 and 9-2 were drilled in areas covered with grass.</p>	<p>Currently, water steam production plant (boiler) is placed. Historically, location of storage area of heavy fuel oil</p>	<p>9-1 – soil samples (1.0 and 2.3 m-bgl);</p> <p>9-2 – soil samples</p>

	<p>Beneath asphalt/soil layer, man-made fills comprising industrial wastes were encountered. Fills were present to a depth of 2.0 m-bgl (borehole 9-1) and 1.1 m-bgl (borehole 9-2).</p>	<p>and heating oil. Potential contamination may originate from oil spillages.</p> <p>Borehole 9-1 was located adjacent north of a former heavy fuel storage tank (west of a boiler house building).</p> <p>Borehole 9-2 was located adjacent north of a former heavy fuel storage tank and unloading ramp.</p> <p>Borehole 9-2 was converted into temporary groundwater monitoring well.</p>	<p>(1.0 and 2.5 m-bgl) and a groundwater sample;</p>
<p>Area 10 - production area of Zinc alloys</p>	<p>Boreholes 10-3 and 10-4 were drilled in area covered with grass and boreholes 10-1 and 10-2 were drilled through asphalt cover.</p> <p>Man-made fills (silty clay with construction waste, reddish industrial waste material) were observed in boreholes 10-3 and 10-4.</p>	<p>Historically, used for Zinc dust production in process of Zinc smelting. Currently, used for Zinc alloys production. Potential contamination with heavy metals may originate from Zinc ore use and accidental spillages of oils.</p> <p>Boreholes 10-1 and 10-2 were located adjacent north of a Zinc Alloy Production Facility, on asphalt-covered road.</p> <p>Boreholes 10-3 and 10-4 were located adjacent south of a Zinc Alloy Production Facility, on a green area.</p> <p>Borehole 10-4 was converted into temporary groundwater monitoring well.</p>	<p>10-1 – soil samples (1.0 and 3.0 m-bgl);</p> <p>10-2 – soil samples (0.5 and 1.7 m-bgl);</p> <p>10-3 – soil samples (1.0 and 1.8 m-bgl);</p> <p>10-4 – soil samples (1.0 and 2.1 m-bgl) and a groundwater sample.</p>
<p>Area 11 - production area of Titanium Zinc sheet</p>	<p>Borehole 11-1 was drilled in the area covered with grass.</p> <p>Beneath the soil, man-made fill comprising grey</p>	<p>Currently used for Zinc Titanium sheets production (rolling track). Potential contamination may originate from accidental spillages of oil.</p>	<p>11-1 – soil samples (1.0 and 2.5 m-bgl) and a groundwater sample.</p>

	compact clay was present to a depth of 1.7 m-bgl.	Borehole 11-1 was located adjacent south of the Titanium Zinc Sheet Production Facility building and was converted into a temporary groundwater monitoring well.	
Area 12 - production area of sulphuric acid H ₂ SO ₄ and open storage for white gypsum	<p>Borehole 12-7 was drilled through the concrete bottom of the White Gypsum Storage. The remaining boreholes were drilled in areas covered with grass.</p> <p>In all drilling locations, man-made fills were encountered. In three boreholes (12-9, 12-10 and 12-13), a layer of red, silty industrial waste ("pyrite") was encountered.</p>	<p>Historically used for H₂SO₄ production from pyrite ore (FeS₂) stored in open storage (Rudni dvor), open storage for residues after roasting of pyrite and a catalyst warehouse. Potential contamination may come from pyrite ore, iron oxides, H₂SO₄ and S, which remained in the ground. Currently, used for H₂SO₄ production from elemental S with USTs for liquid or solid S temporary storage of inorganic S containing waste and open storage for white gypsum. Potential contamination may originate from: H₂SO₄, S, V₂O₅, levoxin, fuel oil, Ca(OH)₂ and NH₄OH. Some H₂SO₄ spilling incidents were recorded.</p> <p>Boreholes 12-1, 12-3 and 12-4 were located on a yard between sulphuric acid tanks and Sulphuric Acid Production Facility.</p> <p>Boreholes 12-5 and 12-6 were located on a yard, adjacent north of the White Gypsum Storage.</p> <p>Borehole 12-7 was drilled through the concrete bottom of the White Gypsum Storage.</p> <p>Borehole 12-8 was located adjacent west to the Melted Sulfur Storage.</p> <p>Boreholes 12-9, 12-10, 12-11,</p>	<p>12-1 – soil samples (1.0 and 3.0 m-bgl);</p> <p>12-3 – soil samples (0.8 and 3.0 m-bgl) and a groundwater sample;</p> <p>12-4 – soil samples (0.8 and 2.7 m-bgl);</p> <p>12-5 – soil samples (1.0 and 3.0 m-bgl);</p> <p>12-6 – soil samples (1.0 and 2.8 m-bgl);</p> <p>12-7 – soil samples (0.5 and 2.5 m-bgl);</p> <p>12-8 – soil samples (1.0 and 2.5 m-bgl);</p> <p>12-9 – soil samples (0.5 and 2.7 m-bgl);</p> <p>12-10 – soil samples (0.5 and 3.0 m-bgl);</p> <p>12-11 – soil samples (1.0 and 3.0 m-bgl) and a groundwater sample;</p> <p>12-12 – soil samples (1.0 and 3.5 m-bgl);</p> <p>12-13 – soil samples</p>

		12-12 and 12-13 were located on a green area north of the Melted Sulfur Storage and east of the Sulfuric Acid Production Facility.	(1.0 and 3.5 m-bgl) and a groundwater sample.
Area 13 - area PE Vzdrževanje in Energetika (maintenance and power supply)	<p>Borehole 13-1 was drilled through asphalt and Borehole 13-2 was drilled on a road pavement (gravel).</p> <p>In borehole 13-2, beneath the gravel layer, man-made fill comprising industrial waste and red, silty industrial waste ("pyrite") was observed, present to a depth of 3.5 m-bgl</p>	<p>Currently, location of a maintenance building with workshops and offices, open storage of hazardous substances (such as gases, oils, coatings and solvents), storage of waste equipment and a collection point of separately collected waste (such as metals, plastic and wood). Potential contamination may originate from accidental oil spilling and contamination with heavy metals and result from the presence of: acetylene, oxygen, propane-butane, paints and thinners, various sprays and mineral oils.</p> <p>Borehole 13-1 was drilled through asphalt between Maintenance Storage "C" and "D".</p> <p>Borehole 13-2 was drilled through gravel, east of Maintenance Storage "D".</p>	<p>13-1 – soil samples (1.0 and 3.0 m-bgl) and a groundwater sample;</p> <p>13-2 – soil samples (1.0 and 3.0 m-bgl).</p>
Area 14 - area of the pumping station of chemicals and temporary storage of waste from production of offset printing plates in PE Grafika.	<p>Borehole 14-1 was drilled in the area covered with grass.</p> <p>Beneath the soil, man-made fill comprising brown gravel with industrial waste was present to a depth of 0.9 m-bgl.</p>	<p>Currently, location of USTs and pumping station for chemicals as well as open waste storage. Potential contamination may originate from: oils, light aromatic oils, ethyl alcohol, Dowanol, ethyl acetate, isopropyl alcohol and CaSO₄.</p> <p>Borehole 14-1 was located adjacent south of the Grafika 2 Building and was converted into a temporary groundwater monitoring well.</p>	14-1 – soil samples (1.0 and 2.5 m-bgl) and a groundwater sample.
Area 15 - Pipeline for gypsum	Boreholes 15-1, 15-2 and 15-3 were drilled in the	Currently used for transportation of gypsum with a pipeline.	15-1 – soil samples (0.5 and 2.3 m-bgl) and

	<p>area located adjacent to a pipeline connecting Cinkarna Celje with Za Travnikom Landfill. The area does not belong to the company but was selected for sampling due to potential impacts from historical spills of gypsum from the pipeline.</p> <p>It was observed, that the subsoil in all three drilling locations was comprised of man-made fills: gravel and clayey material mixed with red-colored industrial waste (present to a depth of 3.0-4.5 m-bgl).</p>	<p>Materials such as construction waste, pyrites, etc. were used during construction of the pipeline as backfilling. Occasional pipeline leaks have occurred, potentially causing contamination with gypsum.</p> <p>Boreholes 15-1, 15-2 and 15-3 were located south of the excavation in which the pipeline for gypsum is located.</p> <p>A sample of currently produced gypsum (named GYP-1) was also analyzed in order to determine the chemical composition of the gypsum.</p>	<p>a groundwater sample.</p> <p>15-2 – soil samples (0.5 and 1.5 m-bgl) and a groundwater sample.</p> <p>15-3 – soil samples (0.5 and 3.0 m-bgl) and a groundwater sample.</p> <p>GYP-1 – gypsum sample (from current production)</p>
Area 16 - Gas station	<p>Borehole 16-1 was drilled in the area covered with grass.</p> <p>Beneath the soil, man-made fill comprising brown gravel with industrial waste was present to a depth of 0.9 m-bgl.</p>	<p>Former and current activity in this area has been a fuel station with one semi-buried storage tanks for fuels. Currently location of UST for Diesel oil. Potential contamination may originate from oil spillages.</p> <p>Borehole 16-1 was located adjacent west to the Underground Storage Tank for Diesel Fuel, associated with an on-site fuel station.</p> <p>Borehole 16-1 was converted into a temporary groundwater monitoring well.</p>	<p>16-1 – soil samples (1.0 and 3.5 m-bgl) and a groundwater sample.</p>

- **Three zones (named MO-1, MO-2 and MO-3)** were located at the production site of Cinkarna Mozirje. The zones were selected based on knowledge of historical or current use of hazardous substances. In each zone, one representative borehole was drilled, which was later transformed into a groundwater monitoring well. The zones (and associated soil and groundwater samples) were located in the following locations: MO-1 (warehouse of hazardous and flammable substances, with currently stored substances including xylene, Dowanol, white spirit), MO-2 (warehouse of Masterbatch, historically used for production of Lead-based paints and polyurethane foam. Historically present chemicals in this location included Zinc dust, toluene, xylene, white spirit, Lead oxide, turpentine oil. Currently it is used for

storage of final products) and MO-3 (historical location of underground storage tanks for xylene, other solvents and heating oil; the tanks were emptied and sealed, reportedly over 20 years ago).

Sampling Location ID	Sampling location description	Sampling location rationale	Analyzed material
MO-1	Borehole for soil sampling, located south of warehouse of hazardous and flammable substances. Following soil sampling, a temporary monitoring well was installed.	Warehouse of hazardous and flammable substances, with currently stored substances including xylene, Dowanol, white spirit.	Soil samples (0.7 and 2.2 m-bgl), groundwater sample
MO-2	Borehole for soil sampling, located south of warehouse of Masterbatch. Following soil sampling, a temporary monitoring well was installed.	Warehouse of Masterbatch, historically used for production of Lead-based paints and polyurethane foam. Historically present chemicals in this location included Zinc dust, toluene, xylene, white spirit, Lead oxide, turpentine oil. Currently it is used for storage of raw materials and final products.	Soil samples (0.5 and 3.0 m-bgl), groundwater sample
MO-3	Borehole for soil sampling, located in a green area comprising a historical location of underground storage tanks for solvents and petroleum products. Following soil sampling, a temporary monitoring well was installed.	Historical location of underground storage tanks for xylene, other solvents and heating oil; the tanks were emptied and sealed, reportedly over 20 years ago.	Soil samples (1.0 and 3.0 m-bgl), groundwater sample

- Farming land** located north of Bukovžlak landfill. It was reported by Cinkarna Celje representatives that an uncontrolled release of gypsum sludge and pyrites through the dam drain occurred in the 1970's. As a result, the wastes disposed of at the Bukovžlak landfill migrated in the northern direction, in line with the terrain morphology and toward a major watercourse (river Vzhodna Ložnica, located approx. 1 km north of the landfill). Two soil samples (named FIE-2 and FIE-3) from the potentially impacted farming land were collected (at a depth of 1 meter bgl) in order to observe whether the soils in farming use have been impacted with the uncontrolled release from Bukovžlak landfill. An additional soil sample (named FIE-1) was collected in a mixed farming-woodland area located 1 km, expected to be not impacted with operation of any of the company's landfills. Sample FIE-1 was analyzed as a reference sample in order to observe natural concentrations of chemicals in soil in the analyzed region.

Sampling Location ID	Sampling location description	Sampling location rationale	Analyzed material
FIE-1	Borehole for soil sampling, located on a farming land	Farming land located 150 meters down-gradient of Bukovžlak landfill, in the location expected to have been impacted by historical uncontrolled release of gypsum sludge and pyrites	Soil sample 1.0 m-bgl
FIE-2	Borehole for soil sampling, located on a farming land	Farming land located 500 meters down-gradient of Bukovžlak landfill, in the location expected to have been impacted by historical uncontrolled release of gypsum sludge and pyrites	Soil sample 1.0 m-bgl
FIE-3	Borehole for soil sampling, located on a mixed farming land/woodland area	Reference soil sampling location collected in an area expected to be not impacted by operation of the landfills (located 1 km east of Bukovžlak landfill)	Soil sample 1.0 m-bgl

- Za Travnikom red gypsum landfill:** in order to analyze potential impacts to soil associated with operation of Za Travnikom landfill, three boreholes were drilled and soil samples were collected: one borehole located up-gradient of the landfill (ZG-3) and two boreholes on a meadow down-gradient of the landfill (ZG-1 and ZG-2). Groundwater samples from four of existing monitoring wells were also collected and analyzed: from monitoring well Z-1A (located up-stream of the landfill) and monitoring wells TV-1A, ZT-1A and ZT-2A (all located down-gradient of the landfill).

Sampling Location ID	Sampling location description	Sampling location rationale	Analyzed material
ZG-1	Borehole for soil sampling, located on green area (meadow)	Down-gradient of Za Travnikom landfill for red gypsum	Soil samples (0.7 and 3.0 m-bgl)
ZG-2	Borehole for soil sampling, located on green area (meadow)	Down-gradient of Za Travnikom landfill for red gypsum	Soil samples (0.7 and 2.0 m-bgl)
ZG-3	Borehole for soil sampling, located on green area (meadow)	Up-gradient of Za Travnikom landfill for red gypsum	Soil samples (0.7 and 2.3 m-bgl)
Z-1A	Permanent monitoring well	Up-gradient of Za Travnikom landfill for red gypsum	Groundwater
ZT-1A	Permanent monitoring well	Down-gradient of Za Travnikom landfill for red gypsum	Groundwater
ZT-2A	Permanent monitoring well	Down-gradient of Za Travnikom landfill for red gypsum	Groundwater
TV-1A	Permanent monitoring well	Down-gradient of Za Travnikom landfill for red gypsum	Groundwater

- Bukovžlak red gypsum landfill:** in order to analyze potential impacts to soil associated with operation of Bukovžlak landfill for red gypsum, three boreholes were drilled: one borehole located up-gradient of the landfill (BG-3) and two down-gradient of the landfill (BG-1 and BG-2). Groundwater samples from four of existing monitoring wells were also collected and analyzed: from monitoring well BUK-1 (located up-gradient of the landfill) and monitoring wells BUK-2, K-10 and K-11 (all located down-gradient of the landfill).

Sampling Location ID	Sampling location description	Sampling location rationale	Analyzed material
BG-1	Borehole for soil sampling, located on green area (meadow)	Down-gradient of Bukovžlak landfill for red gypsum	Soil samples (1.0 and 3.0 m-bgl)
BG-2	Borehole for soil sampling, located on green area (meadow)	Down-gradient of Bukovžlak landfill for red gypsum	Soil samples (1.0 and 4.2 m-bgl)
BG-3	Borehole for soil sampling, located in a forest	Up-gradient of Bukovžlak landfill for red gypsum	Soil samples (0.7 and 3.3 m-bgl)
BUK-1	Permanent monitoring well	Up-gradient of Bukovžlak landfill for red gypsum	Groundwater
BUK-2	Permanent monitoring well	Down-gradient of Bukovžlak landfill for red gypsum	Groundwater
K-10	Permanent monitoring well	Down-gradient of Bukovžlak landfill for red gypsum	Groundwater
K-11	Permanent monitoring well	Down-gradient of Bukovžlak landfill for red gypsum	Groundwater

- Bukovžlak non-hazardous solid wastes landfill:** in order to analyze potential impacts to soil associated with operation of Bukovžlak landfill for solid wastes, three boreholes were drilled: one borehole located up-gradient of the landfill (BS-3) and two on a meadow down-gradient of the landfill (BS-1 and BS-2). Groundwater samples from six of existing monitoring wells were also collected and analyzed: from monitoring wells BUK-3, N-3 and P-4 (located up-stream of the landfill) and monitoring wells A-1, A-2 and A-3 (all located down-gradient of the landfill).

Sampling Location ID	Sampling location description	Sampling location rationale	Analyzed material
BS-1	Borehole for soil sampling, located on green area (meadow)	Down-gradient of Bukovžlak landfill for solid wastes	Soil samples (1.0 and 2.8 m-bgl)
BS-2	Borehole for soil sampling, located on green area (meadow)	Down-gradient of Bukovžlak landfill for solid wastes	Soil samples (1.0 and 2.7 m-bgl)
BS-3	Borehole for soil sampling, located on	Up-gradient of Bukovžlak landfill for solid wastes	Soil samples (1.0 and

	green area (meadow)		4.0 m-bgl)
BUK-3	Permanent monitoring well	Up-gradient of Bukovžlak landfill for solid wastes	Groundwater
N-3	Permanent monitoring well	Up-gradient of Bukovžlak landfill for solid wastes	Groundwater
P-4	Permanent monitoring well	Up-gradient of Bukovžlak landfill for solid wastes	Groundwater
A-1	Permanent monitoring well	Down-gradient of Bukovžlak landfill for solid wastes	Groundwater
A-2	Permanent monitoring well	Down-gradient of Bukovžlak landfill for solid wastes	Groundwater
A-3	Permanent monitoring well	Down-gradient of Bukovžlak landfill for solid wastes	Groundwater

3.2 Methods used for forming boreholes

Drillings were made by team of AACM Central Europe Llc, supervised jointly by geologist, Mr. Laszlo Szasz and by Paweł Motel, Senior Consultant of ENVIRON Poland Sp. z o.o. Soil drillings were performed between August 19 and August 28, 2014 (10 working days of drilling of boreholes and sampling of soil). Boreholes were drilled with a percussion drilling window sampling rig of a portable type (Cobra) of a diameter of 60mm. The sampling rig enabled collection of undisturbed soil profiles in 1-meter sections. During the drilling, soil samples were collected from discreet depths at every 50-100 cm. Following collection, soil samples were subject to visual and olfactory observations and Photo-Ionisation Detector (PID) readings, in locations where based on visual or olfactory observations, potential presence of organic compounds was observed.

During the investigation, the field personnel maintained a log of Site activities and field observations. Observations of soil samples including a description of the color and texture of the soil core samples; the depth to ground water and the top of the saturated zone, if encountered; and odours, if any were recorded in the logbook.

Soil samples were collected following strict procedures to avoid cross-contamination. The equipment (augers and sampling tools) were decontaminated with the use of a phosphate-free detergent (SOVOGLANZ ACTIV), brush and distilled water rinse. The decontamination procedure will be performed after each change of lithology, after each unusual change of sample color or the presence of foreign bodies, and following the drilling of each borehole.

From each of the boreholes, at least two soil samples were selected for laboratory analysis. Additional soil samples were collected and placed in laboratory-supplied jars for the purpose of potential expansion of scope of analysis.

Soil samples were placed into 60 ml glass jars provided by the laboratory, with a plastic screw-cap capable equipped with a sealing preventing from volatilization of organic compounds.

Following completion of sampling works on each working day, collected soil samples were placed in refrigerators located in Cinkarna Celje's laboratory, in order to provide appropriate storage conditions (temperature of 4°C or less).

3.3 Methods used for forming of temporary groundwater monitoring wells and groundwater sampling

Following collection of soil samples, in selected locations, temporary groundwater monitoring wells were installed. Because a diameter of executed boreholes was 60 mm, monitoring wells with a filter of diameter of 50 mm were selected for installation as groundwater monitoring wells. Installed filters were produced by Stuewa Brunnenfilter Bohrbedarf and were equipped with 0.3-mm screening. Following installation, groundwater monitoring wells' top pipe elevation was measured by a certified land surveying company Vizura Matko d.o.o. from Celje. Groundwater table depth elevation measurements in all groundwater monitoring wells were performed on the same day, in order to determine groundwater flow direction.

Those measurements were made on one day – August 29, 2014. Details of the installed groundwater monitoring wells are given in a table below:

Monitoring Well ID	Monitoring Well Depth (pipe length; not equal to the borehole depth)	MW Top Pipe Elevation (meters above sea level)	Ground Level Elevation (meters above sea level)	Groundwater Depth Measured on August 29, 2014 (meters below ground level)
1 5	5 meters	239.47	238.59	3.81
2 1	5 meters	239.44	238.66	4.01
2 5	5 meters	239.34	238.74	4.32
3 1	4 meters	239.04	238.76	3.44
4 1	5 meters	239.82	238.65	3.43
5 1	4 meters	239.19	238.76	3.5
6 1	5 meters	239.41	238.89	3.19
6 3	4 meters	239.45	238.99	3.61
7 1	4 meters	238.71	238.37	2.21
7 2	4 meters	239.48	238.38	2.24
8 5	3 meters	238.95	238.81	1.94
8 6	3 meters	238.89	238.76	1.75
8 7	3 meters	238.63	238.63	2.06
9 2	4 meters	240.11	239.07	2.2
10 3	4 meters	239.4	239.15	1.73
11 1	4 meters	239.02	238.84	1.51
12 3	4 meters	239.4	239.1	1.24
12 11	5 meters	239.52	238.95	0.98

12 13	3 meters	239.11	238.91	1.16
13 1	4 meters	239.59	238.92	(insufficient volume on a day of measurement)
14 1	4 meters	238.83	238.71	1.53
15 1	3 meters	240 (approximate)	240	2.50
15 2	4 meters	240 (approximate)	240	2.50
15 3	4 meters	240 (approximate)	240	2.35
16 1	4 meters	239.85	239.17	0.98
MO-1	3 meters	330.19	330.19	2.25
MO-2	4 meters	329.26	329.26	3.12
MO-3	4 meters	333.92	333.92	3.66

Following installation, groundwater monitoring wells were subject to sampling, which took place on the following dates:

- August 20, 2014: groundwater samples 15-1, 15-2, 15-3;
- August 23, 2014: groundwater samples 3-1 and 8-7;
- September 1 and 2: remaining groundwater samples.

Groundwater samples were collected using a battery-operated peristaltic pump manufactured by Eijlkenkamp, using disposable sampling pipes. Prior to sampling, each groundwater monitoring well was purged by pumping at least three volumes of water and allowing at least 30 minutes to stabilize. Each groundwater sample contained two glass bottles of a volume of 300 ml and one glass vial of a volume of 40 ml.

Following sampling from each monitoring well, basic parameters of groundwater were determined in-situ, using a portable, combined pH/EC-meter manufactured by Hanna Instruments. Measured parameters included temperature, pH and EC. The observed values were recorded.

3.4 Methods used for groundwater sampling from existing, permanent monitoring wells

A total of 14 permanent monitoring wells located at the landfills were sampled: A-1, A-2, A-3, BUK-3, N-3, P-4, BUK-2, K-10, K-11, BUK-1, ZT-1A, ZT-2A and Z-1A.

Groundwater sampling from existing, permanent monitoring wells installed at the landfills' area, was performed on September 2 and 3, 2014. Due to significant depth of groundwater table in several locations, and taking into account a larger diameter of the monitoring wells (80mm), purging of the monitoring wells and groundwater sampling was performed using disposable bailer samplers of a diameter of 40 mm. Prior to sampling, each groundwater monitoring well was purged by pumping at least three volumes of water and allowing at least

30 minutes to stabilize. Each groundwater sample contained two glass bottles of a volume of 300 ml and one glass vial of a volume of 40 ml.

Following sampling from each monitoring well, basic parameters of groundwater were determined in-situ, using a portable, combined pH/EC-meter manufactured by Hanna Instruments. Measured parameters included temperature, pH and EC. The observed values were recorded.

3.5 Constraints applicable to the placement of site investigation locations

In Cinkarna Celje, the property covers an area of 45.81 hectares, whereof approximately 11.55 ha is built up area and 13.56 ha represent paved outdoor areas around the buildings used as traffic and parking areas. Built-up areas were not available for execution of boreholes. For the purpose of drilling of boreholes, safety precaution measures had to be implemented in order to limit the risk of damage to underground utilities. Therefore, numerous drilling locations were selected on hardened areas (concrete, asphalt) in order to provide a safe distance from underground utilities. Seventeen borehole locations were placed on hardened surfaces and core-drilling of the surface was performed prior to actual drilling in soil. These drilling locations included boreholes: 2-1, 2-2, 2-3, 2-5, 2-6, 2-7, 3-1, 3-2, 4-1, 7-2, 8-3, 8-6, 8-7, 10-1, 10-2, 12-7 and 13-1.

In Cinkarna Mozirje, all three drilling locations were selected on unpaved surface.

At the landfills area, all drilling locations were selected on unpaved, green areas.

3.6 Methods used for collecting, preserving and transporting samples to the analytical laboratory

For the purpose of delivery of soil samples to “i2 Analytical” laboratory in Ruda Śląska, Poland, two batches of samples were created and delivered to the laboratory using road transport. Each batch of samples was placed in coolboxes provided by the laboratory, each one equipped with three pieces of frozen ice-packs. The first batch of samples was sent from Celje on August 23, 2014 (soil samples from boreholes 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 3-1, 3-2, 6-1, 6-2, 6-3, and 8-7; groundwater samples 15-1, 15-2, 15-3, 8-7 and 3-1). The second batch of samples was sent from Celje on September 5, 2014.

Both batches of samples were sent with accompanying Chain of Custody documentation describing the list of delivered samples, dates of sampling and scope of analysis to be applied. Copies of Chain of Custody documentation are attached as Annex H to this report.

3.7 Analytical suite used on samples

All the soil and groundwater samples collected during field works were analysed in an accredited environmental analytical laboratory of “i2 Analytical” located in Ruda Śląska, Poland.

Majority of the samples (both soil and groundwater) were analysed within a scope of an analytical package referred to as Comprehensive Quantitative Risk Assessment (QRA), encompassing the following analytical parameter groups:

- Heavy Metals (HMs) – 20 metals, including Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Selenium, Tin, Vanadium and Zinc;

- Volatile Organic Compounds (VOCs) and Semi Volatile Organic Compounds (SVOCs);
- Chlorinated Benzenes and Chlorinated Phenols;
- Phthalates;
- Phenol Index;
- Inorganic Parameters (ammonium, chlorides, iron, calcium, potassium, sodium, magnesium, phosphorus), pH and electrical conductivity (EC);
- Polycyclic Aromatic Hydrocarbons (EPA-16 PAHs);
- Total Petroleum Hydrocarbons (C6-C12 and C12-C35 TPH);
- Total Organic Carbon (TOC);
- Sulphates, Cyanides;
- Asbestos fibres (for soil samples).

Additionally, both soil and groundwater samples were analysed for presence of Titanium, Fluorides and Thallium which are not included in the scope of Comprehensive QRA.

In total, the following number of samples were analysed within a scope of Comprehensive QRA analysis:

- **128 soil samples:** 100 soil samples collected at Cinkarna Celje, 6 soil samples collected at Cinkarna Mozirje, 18 soil samples collected at landfills (Za Travnikom and Bukovžlak), 3 soil samples collected at farming land north of the landfills and one sample of Gypsum (typical waste disposed of at Za Travnikom landfill).
- **42 groundwater samples:** 25 groundwater samples collected at Cinkarna Celje, 3 groundwater samples collected at Cinkarna Mozirje and 14 groundwater samples collected at landfills (Za Travnikom and Bukovžlak).

Additionally, in order to verify the contents of man-made fills encountered in various locations, 15 soil samples collected at Cinkarna Celje production facility were analysed for presence of selected groups of potential contaminants:

- **Heavy Metals (HMs)** – 22 metals, including Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Selenium, Tin, Vanadium, Zinc, Titanium and Thallium;
- **Inorganic Parameters** (ammonium, chlorides, iron, calcium, potassium, sodium, magnesium, phosphorus), pH and electrical conductivity (EC), Total Organic Carbon (TOC), Sulphates, Fluorides, Cyanides, Asbestos fibres.

In order to evaluate the potential for leaching of metals from soil into groundwater, five soil samples collected at Cinkarna Celje site were additionally analyzed. A parallel analysis was performed for five soil samples collected while execution of boreholes at Cinkarna Celje site.

In laboratory, each of selected soil samples was dried, homogenized and two analyses were performed: analysis of heavy metals contents in dry weight (extractable with Aqua Regia), and analysis of heavy metals in water leachate (24-hour leaching of a soil sample with distilled water in a proportion of 1:10 (soil to water). This analysis was performed for five soil samples collected from different areas of Cinkarna Celje site, i.e. for soil samples: 2-3 at 2.0 m-bgl, 3-1 at 2.5 m-bgl, 7-2 at 2.0 m-bgl, 8-3 at 1.4 m-bgl and 13-2 at 2.0 m-bgl.

“i2 Analytical Sp. z o.o.” holds a United Kingdom Accreditation Service accreditation which was last validated on June 6, 2014. The latest „Certificate of Accreditation” of the laboratory is presented in Appendix G to this Report.

3.8 Sampling strategy

An inventory of collected soil and groundwater samples, with GPS coordinates of each sampling location, number and depth of collected samples and scope of laboratory analyses performed for each collected soil and groundwater sample is given in a table below:

Used abbreviations indicate:

- Comprehensive QRA – Comprehensive Quantitative Risk Assessment;
- TI – Thallium;
- Ti – Titanium;
- F – Fluorides.

Borehole No.	Coordinates	Collected samples [m bgl.]	Scope of Performed Analysis
1-1	46°14'13.89"N 15°16'52.77"E	Soil samples: 1.4 m-bgl; 3.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
1-2	46°14'13.71"N 15°16'56.57"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
1-3	46°14'12.07"N 15°16'49.22"E	Soil samples: 1.0 m-bgl; 4.4 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
1-4	46°14'11.92"N 15°16'52.52"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
1-5	46°14'11.84"N 15°16'56.24"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
2-1	46°14'15.02"N 15°16'59.04"E	Soil samples: 1.0 m-bgl; 2.5 m-bgl; 3.5 m-bgl GW sample	Soil sample (2.5 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
2-2	46°14'14.38"N 15°16'59.87"E	Soil samples: 1.0 m-bgl; 2.5 m-bgl; 3.5 m-bgl	Soil sample (2.5 m bgl.): Heavy Metals + Inorganics

			Remaining soil samples: Comprehensive QRA + TI + Ti + F
2-3	46°14'14.43"N 15°17'3.59"E	Soil samples: 1.0 m-bgl; 2.0 m-bgl; 3.0 m-bgl	Soil sample (2.0 m bgl.): Heavy Metals + Inorganics Remaining soil samples: Comprehensive QRA + TI + Ti + F
2-4	46°14'16.03"N 15°17'2.57"E	Soil samples: 1.0 m-bgl; 3.8 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
2-5	46°14'16.12"N 15°16'59.18"E	Soil samples: 0.8 m-bgl; 3.0 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
2-6	46°14'14.31"N 15°17'5.03"E	Soil samples: 1.0 m-bgl; 3.4 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
2-7	46°14'16.32"N 15°17'5.56"E	Soil samples: 0.7 m-bgl; 3.7 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
3-1	46°14'13.78"N 15°17'4.43"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
3-2	46°14'13.48"N 15°17'5.01"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl	All soil and GW samples: Comprehensive QRA + TI + Ti + F
4-1	46°14'12.00"N 15°16'59.95"E	Soil samples: 1.5 m-bgl; 3.8 m-bgl GW sample	Soil sample (3.8 m bgl.): Heavy Metals + Inorganics Remaining oil and GW samples: Comprehensive QRA + TI + Ti + F
5-1	46°14'11.77"N 15°17'2.86"E	Soil samples: 1.0 m-bgl; 3.4 m-bgl GW sample	Soil sample (3.4 m bgl.): Heavy Metals + Inorganics Remaining oil and GW samples: Comprehensive QRA + TI + Ti + F
6-1	46°14'14.60"N 15°17'8.45"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
6-2	46°14'16.51"N 15°17'8.66"E	Soil samples: 1.0 m-bgl; 2.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
6-3	46°14'16.56"N 15°17'11.41"E	Soil samples: 1.2 m-bgl; 3.2 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F

7-1	46°14'13.03"N 15°17'10.97"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl GW sample	Soil sample (3.0 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
7-2	46°14'13.17"N 15°17'8.49"E	Soil samples: 0.6 m-bgl; 2.5 m-bgl; 3.0 m-bgl; 3.6 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
8-1	46°14'10.90"N 15°17'28.36"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
8-2	46°14'10.96"N 15°17'24.76"E	Soil samples: 0.7 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
8-3	46°14'11.09"N 15°17'22.32"E	Soil samples: 0.7 m-bgl; 3.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
8-4	46°14'11.57"N 15°17'15.96"E	Soil samples: 1.0 m-bgl; 2.8 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
8-5	46°14'13.48"N 15°17'16.39"E	Soil samples: 1.0 m-bgl; 2.0 m-bgl GW sample	Soil sample (2.0 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
8-6	46°14'12.77"N 15°17'23.98"E	Soil samples: 1.0 m-bgl; 2.7 m-bgl GW sample	Soil sample (2.7 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
8-7	46°14'15.67"N 15°17'21.82"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
8-8	46°14'13.41"N 15°17'27.97"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
9-1	46°14'10.91"N 15°17'13.51"E	Soil samples: 1.0 m-bgl; 2.3 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
9-2	46°14'8.47"N 15°17'13.15"E	Soil samples: 1.0 m-bgl; 2.5 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
10-1	46°14'8.34"N 15°17'15.95"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F

10-2	46°14'8.24"N 15°17'18.68"E	Soil samples: 0.5 m-bgl; 1.7 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
10-3	46°14'6.72"N 15°17'15.77"E	Soil samples: 1.0 m-bgl; 1.8 m-bgl GW sample	Soil sample (1.8 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
10-4	46°14'6.46"N 15°17'18.37"E	Soil samples: 1.0 m-bgl; 2.1 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
11-1	46°14'6.80"N 15°17'24.71"	Soil samples: 1.0 m-bgl; 2.5 m-bgl GW sample	Soil sample (1.0 m-bgl) and GW sample: Comprehensive QRA + TI + Ti + F Soil sample (2.5 m bgl.): Heavy Metals + Inorganics
12-1	46°14'11.84"N 15°17'31.42"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-3	46°14'13.06"N 15°17'31.88"E	Soil samples: 0.8 m-bgl; 3.0 m-bgl GW sample	Soil sample (3.0 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
12-4	46°14'12.11"N 15°17'34.08"E	Soil samples: 0.8 m-bgl; 2.7 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-5	46°14'10.16"N 15°17'31.12"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-6	46°14'10.01"N 15°17'33.32"E	Soil samples: 1.0 m-bgl; 2.8 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-7	46°14'8.80"N 15°17'35.20"E	Soil samples: 0.5 m-bgl; 2.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-8	46°14'9.23"N 15°17'36.70"E	Soil samples: 1.0 m-bgl; 2.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-9	46°14'9.28"N 15°17'38.42"E	Soil samples: 0.5 m-bgl; 2.7 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-10	46°14'10.22"N 15°17'37.40"E	Soil samples: 0.5 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-11	46°14'10.09"N 15°17'39.53"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl GW sample	Soil sample (3.0 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F

12-12	46°14'11.41"N 15°17'39.79"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
12-13	46°14'11.80"N 15°17'37.38"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl GW sample	All soil and GW samples: Comprehensive QRA + TI + Ti + F
13-1	46°14'16.09"N 15°17'30.86"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl GW sample	Soil sample (3.0 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
13-2	46°14'15.88"N 15°17'32.63"E	Soil samples: 1.0 m-bgl; 2.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
14-1	46°14'6.37"N 15°17'7.59"E	Soil samples: 1.0 m-bgl; 2.5 m-bgl GW sample	Soil sample (2.5 m bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
15-1	46°14'16.53"N 15°17'45.42"E	Soil samples: 0.5 m-bgl; 2.3 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
15-2	46°14'16.67"N 15°17'42.94"E	Soil samples: 0.5 m-bgl; 1.5 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
15-3	46°14'15.72"N 15°17'43.98"E	Soil samples: 0.5 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
16-1	46°14'6.84"N 15°17'44.07"E	Soil samples: 1.0 m-bgl; 3.5 m-bgl GW sample	Soil sample (3.5 m-bgl.): Heavy Metals + Inorganics Remaining soil and GW samples: Comprehensive QRA + TI + Ti + F
MO-1	46°20'19.31"N 14°58'27.80"E	Soil samples: 0.7 m-bgl; 2.2 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
MO-2	46°20'18.15"N 14°58'29.16"E	Soil samples: 0.5 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
MO-3	46°20'20.10"N 14°58'23.56"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
BS-1	46°14'18.74"N 15°18'53.79"E	Soil samples: 1.0 m-bgl; 2.7 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
BS-2	46°14'18.09"N 15°18'51.60"E	Soil samples: 1.0 m-bgl; 3.8 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
BS-3	46°14'9.78"N 15°18'54.30"E	Soil samples: 1.0 m-bgl; 4.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F

BG-1	46°14'11.35"N 15°19'7.20"E	Soil samples: 1.0 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
BG-2	46°14'10.02"N 15°19'0.77"E	Soil samples: 1.0 m-bgl; 4.2 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
BG-3	46°13'48.64"N 15°19'8.16"E	Soil samples: 0.7 m-bgl; 3.3 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
ZG-1	46°14'18.44"N 15°19'56.41"E	Soil samples: 0.7 m-bgl; 3.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
ZG-2	46°14'12.40"N 15°19'53.74"E	Soil samples: 0.7 m-bgl; 2.0 m-bgl	All soil samples: Comprehensive QRA + TI + Ti + F
ZG-3	46°13'37.16"N 15°20'4.20"E	Soil samples: 0.7 m-bgl; 2.3 m-bgl	Comprehensive QRA + TI + Ti + F
FIE-1	46°14'28.38"N 15°19'44.17"E	Soil sample: 1.0 m-bgl	Comprehensive QRA + TI + Ti + F
FIE-2	46°14'35.19"N 15°18'57.93"E	Soil sample: 1.0 m-bgl	Comprehensive QRA + TI + Ti + F
FIE-3	46°14'24.40"N 15°18'58.19"E	Soil sample: 1.0 m-bgl	Comprehensive QRA + TI + Ti + F
GYP-1	Collected in a dewatering unit at Za Travnikom landfill	Waste gypsum sample	Comprehensive QRA + TI + Ti + F
Z-1A	46°13'37.16"N 15°20'4.20"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
ZT-1A	46°14'18.43"N 15°19'56.99"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
ZT-2A	46°14'12.40"N 15°19'53.74"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
TV-1A	46°14'6.00"N 15°19'52.08"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
BUK-1	46°13'49.30"N 15°19'7.74"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
BUK-2	46°14'10.41"N 15°19'10.91"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F

K-10	46°14'9.26"N 15°19'1.02"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
K-11	46°14'9.69"N 15°19'1.10"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
BUK-3	46°14'13.16"N 15°18'53.71"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
N-3	46°14'9.74"N 15°18'58.67"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
P-4	46°14'10.38"N 15°19'1.27"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
A-1	46°14'20.34"N 15°18'53.96"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
A-2	46°14'19.89"N 15°18'56.52"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F
A-3	46°14'18.87"N 15°18'59.50"E	Groundwater sample from a permanent monitoring well	Comprehensive QRA + TI + Ti + F

4 Details of ground conditions

Geological conditions observed during the drilling works, performed by ENVIRON Poland Sp. z o.o. on August 19-28, 2014, are described in sub-sections below. Details of geological strata and hydrogeological conditions are presented in Appendix A – Borehole Data Sheets.

4.1 Cinkarna Celje

The Cinkarna Celje facility is located on the left bank of the Hudinja and Vzhodna Ložnica rivers, to the east from centre of Celje town which is situated in the quaternary basin and the confluence area of Savinja, Hudinja, Vzhodna Ložnica, and Voglajna rivers. The site area is located in the Quaternary basin, and spreads over Quaternary alluvial sediments deposited over Oligocene and Miocene strata.

The natural surface of the area was observed to be levelled with various fillings ranging from 0.5 to 3.5 m thickness. The natural quaternary sediments closest to the surface mainly consist of interbedded fine sediment layers such as silty clays, and clayey silts to an average depth of 2.0 to 4.0 m. The thickness of these layers is generally increasing from the west side of the site to the east, ranging from 1.5 to over 4.0 m. In some locations the fine sediments are missing and the man-made filling material levels are located above the aquifer bearing formations. Usually below the fine sediment formations some coarse grained alluvial deposits are located, consisting mainly of sandy gravels occasionally interbedded with some fine sand sediments. The coarse grained sediments were localized generally from a depth of 2.0-3.5 to 6.5 meters below ground level (the maximum depth reached by this investigation). Most probably the basement of these formations are the Oligocene and Miocene strata expected at depths below 8-10 m. The Oligocen and Miocen formations are represented by low permeable clastic layers (silty sand) and Oligocene's andesite tuffs and Miocene's conglomerates, sandstones and marls.

In the area the first aquifer is represented by Quaternary clastic alluvial deposits consisting of sandy silty formations. The basement of this aquifer is represented by Miocene and Oligocene strata which appear less permeable than Quaternary alluvium, in general they represent a hydro-geological barrier. This aquifer in most of the Cinkarna Celje facility appears to be a non-confined aquifer, but in the eastern side of the facility there is a confined aquifer under thick argillaceous layers. Based on the field investigation the uppermost groundwater levels are located at an elevation between 234 m and 237 m above sea level (at a depth of 1.0-1.5 to 4 meters below the surface). The variation of the groundwater level of the aquifer formation is mainly influenced by the water level of the nearby rivers and also by precipitations and other infiltrations occurring in the area.

Based on measurements of groundwater table elevation, performed in 22 temporary monitoring wells on August 29, 2014, a Map of Groundwater Table Depth was prepared by ENVIRON. The direction of groundwater flow was determined to be directed towards north-west. The Map of Groundwater Table Depth is presented as Figure 7.

4.2 Cinkarna Mozirje

The Cinkarna Mozirje facility is located on the confluence area of three water courses: Savinja River (located adjacent south of the site), Ljubija creek (crossing the site area from north to south) and Struga creek (crossing the site area from north-west to south-east).

During the performed drilling works it was observed that the natural layers encountered at the site comprised not sorted gravels mixed with sands or gravels with clayey filling, present to the maximum depth of drilling (4.7 m-bgl in borehole MO-3).

Unconfined aquifer was observed in a layer of gravel at a depth of 2.25 m-bgl in borehole MO-1, 3.12 m-bgl in borehole MO-2 and 3.66 m-bgl in borehole MO-3. Because of the location of the boreholes (on different sides of Struga creek and located in a line), determination of groundwater flow direction was not feasible.

4.3 Bukovžlak and Za Travnik Landfills

Landfills Bukovžlak and Za Travnikom are placed over Quaternary slope sediments, which are similar to alluvial sediments, consisting mainly of silt and intersected with clayey layers. Besides relatively impermeable silty and clayey sediments, appearance of permeable layers is also recorded.

During the performed drillings, presence of exclusively natural layers (sand, silty sand, silty clay, clay and clayey silt) was observed in all boreholes at Bukovžlak landfill for solid wastes, Bukovžlak landfill for gypsum and Za Travnikom landfill for gypsum, except for three boreholes:

- BG-2 (located in the southern part of Bukovžlak landfill for solid wastes, several meters north of the foot of the embankment of Bukovžlak landfill for gypsum): presence of man-made fill was observed between 0.2 and 5.0 m-bgl. Between 0.2 and 1.5 m-bgl, a layer of silty, clayey filling was present, and between 1.5 m-bgl and the bottom of the borehole (5.0 m-bgl), silty, red-colored industrial waste ("pyrite waste") was present;
- BS-1 (located in the northern part of Bukovžlak landfill for solid wastes, on the slope of the embankment of Bukovžlak landfill for solid wastes): presence of man-made fill was observed between 0.2 and 0.6 m-bgl in a form of brown, clayey sand;
- BS-2 (located in the northern part of Bukovžlak landfill for solid wastes, beneath the slope of the embankment of Bukovžlak landfill for solid wastes): presence of man-made fill was observed between 0.2 and 1.0 m-bgl in a form of silty, red-colored industrial waste ("pyrite waste").

5 Soil and Groundwater Screening Values

In Slovenia, a **Decree on limit values, alert thresholds and critical levels of dangerous substances into the soil (Official Gazette of the RS no. 68/1996, 41/2004)** defines the limit, warning and critical values of heavy metals concentrations in soil. The **limit value** is the concentration of a certain harmful substance, which still ensures acceptable living conditions for plants and animals, where groundwater quality or soil fertility does not deteriorate, and effects on humans and the environment are still acceptable. The **warning value** represents the concentration of a harmful substance where in some cases of ground use damaging effects on human health or the environment might occur. The concentration of a harmful substance that reaches **critical value** can have damaging effects on human population or the environment and polluted grounds are no longer appropriate for crop production and water retention and filtration (Official Gazette of the RS no. 68/1996, 41/2004).

A Government Decree of Slovenia of 1996 defined the limit of the specific dangerous substances in soil, as well as their warning and critical concentration values (total contents), except for radioactive substances, and throughout the entire territory of the Republic regardless of the soil composition or type of its use. Cultivation of plants intended for human or animal consumption, and water retaining or filtering is prohibited in areas of critical concentration values. Warning values indicate in certain soil use types the probability of damaging effects or influence on human health or the environment. At the limit values, their effects and influence on human health or the environment are still acceptable.

Table 1: Limit, Warning and Critical Concentrations of Dangerous Substances in Soils.

Limit, warning, and critical concentration of dangerous substances in soil (mg/kg dry soil) [14]

Dangerous substance	Limit value	Warning value	Critical value
Metals extracted by aqua regia (except for Cr ⁶⁺)			
Cadmium and its compounds, expressed as Cd	1	2	12
Copper and its compounds, expressed as Cu	60	100	300
Nickel and its compounds, expressed as Ni	50	70	210
Lead and its compounds, expressed as Pb	85	100	530
Zinc and its compounds, expressed as Zn	200	300	720
Total chromium Cr	100	150	380
Six valent chromium Cr ⁶⁺			25
Mercury and its compounds, expressed as Hg	0.8	2	10
Cobalt and its compounds, expressed as Co	20	50	240
Molybdenum and its compounds, expressed as Mo	10	40	200
Arsenic and its compounds, expressed as As	20	30	55

Decree on the state of groundwater (Uradni list RS, št. 25/09, 68/12) lays down procedure for determining threshold values for groundwater quality, parameters specifying the chemical and quantitative status, groundwater quality standards, threshold values for groundwater quality, conditions of good quantitative and chemical status, criteria for the identification of significant trends in pollution, additional requirements for preparing an action plan for groundwater. For these provisions groundwater quality standard means the standard

of environmental quality, expressed as the concentration of a particular pollutant, group of pollutants or indicator of pollution in underground water, to protect public health and the environment. Annex 2 of the Decree includes inorganic parameters and organic parameters.

Table 2: Parameters for which quality standards are specified.

Parameter	Enota	Standard kakovosti
Nitrati	mg NO ₃ /L	50
Posamezen pesticid in njegovi relevantni ¹ razgradni produkti	µg/L	0,1 ²
Vsota vseh izmerjenih pesticidov in njihovih relevantnih razgradnih produktov ³	µg/L	0,5

Table 3: Parameters for which a threshold value is given.

Parameter	Enota	Standard kakovosti
Diklorometan	µg/l	2
Tetraklorometan	µg/l	2
1,2-Dikloroetan	µg/l	3
1,1-Dikloroeten	µg/l	2
Trikloroeten	µg/l	2
Tetrakloroeten	µg/l	2
Vsota lahkohlapnih alifatskih halogeniranih ogljikovodikov ⁴	µg/l	10

Additionally, the results of the laboratory analysis of soil and groundwater samples were compared with the values set in the "Soil Remediation Circular" issued by the Dutch Ministry of Environment (Ministerie van Volkshuiving Ruimtelijke Ordening en Milieubeheer) in 2009 – so-called "Dutch Values". "Dutch Values" are commonly used in Europe for the purpose of the assessment of soil and groundwater quality. In particular, "Dutch Values" are very often used by foreign investors while assessing condition of Sites located in Central and Eastern European Countries. "Dutch Values" are given separately for groundwater and soil. According to the original definition of the document, **Intervention Values** indicate when the functional properties of the soil for humans, plant and animal life is seriously impaired or threatened. They are representative of the level of contamination above which there is a serious case of soil contamination deemed to exist.

Table 4: Parameters for which Dutch List Intervention Values are given:

Soil Remediation Circular 2009

Table 1 Groundwater target values and soil and groundwater intervention values⁹

Concentrations in soil are shown for standard soil (10% organic matter and 25% clay)

Substance	Target value	National background concentration groundwater (BC) deep (> 10 m –gl) (µg/l)	Target value	Intervention values	
	groundwater ⁷ shallow (< 10 m –gl) (µg/l)		groundwater ⁷ (incl. BC) deep (> 10 m –gl) (µg/l)	soil (mg/kg d.s.)	groundwater (µg/l)
1 Metals					
Antimony	-	0.09	0.15	22	20
Arsenic	10	7	7.2	76	60
Barium	50	200	200	8	625
Cadmium	0.4	0.06	0.06	13	6
Chromium	1	2.4	2.5	-	30
Chromium III	-	-	-	180	-
Chromium VI	-	-	-	78	-
Cobalt	20	0.6	0.7	190	100
Copper	15	1.3	1.3	190	75
Mercury	0.05	-	0.01	-	0.3
Mercury (inorganic)	-	-	-	36	-
Mercury (organic)	-	-	-	4	-
Lead	15	1.6	1.7	530	75
Molybdenum	5	0.7	3.6	190	300
Nickel	15	2.1	2.1	100	75
Zinc	65	24	24	720	800

Concentrations in soil are shown for standard soil (10% organic matter and 25% clay)

Substance	Target value	Intervention values	
	groundwater ⁷ (µg/l)	soil (mg/kg d.s.)	groundwater (µg/l)
2. Other inorganic substances			
Chloride (mg Cl/l)	100 mg/l	-	-
Cyanide (free)	5	20	1,500
Cyanide (complex)	10	50	1,500
Thiocyanate	-	20	1,500
3. Aromatic compounds			
Benzene	0.2	1.1	30
Ethylbenzene	4	110	150
Toluene	7	32	1,000
Xylenes (sum) ¹	0.2	17	70
Styrene (vinylbenzene)	6	86	300
Phenol	0.2	14	2,000
Cresols (sum) ¹	0.2	13	200

Table 1 (continued) Target values for groundwater and intervention values for soil and groundwater

Concentrations in soil are shown for standard soil (10% organic matter and 25% clay)

Substance	Target value groundwater ⁷ (µg/l)	Intervention values	
		soil (mg/kg d.s.)	groundwater (µg/l)
4. Polycyclic Aromatic Hydrocarbons (PAHs)⁵			
Naphthalene	0.01	-	70
Phenanthrene	0.003*	-	5
Anthracene	0.0007*	-	5
Fluoranthene	0.003	-	1
Chrysene	0.003*	-	0.2
Benzo(a)anthracene	0.0001*	-	0.5
Benzo(a)pyrene	0.0005*	-	0.05
Benzo(k)fluoranthene	0.0004*	-	0.05
Indeno(1,2,3cd)pyrene	0.0004*	-	0.05
Benzo(ghi)perylene	0.0003	-	0.05
PAHs (total) (sum 10) ¹	-	40	-
5. Chlorinated hydrocarbons			
a. (volatile) hydrocarbons			
Monochloroethene (Vinylchloride) ²	0.01	0.1	5
Dichloromethane	0.01	3.9	1,000
1,1-dichloroethane	7	15	900
1,2-dichloroethane	7	6.4	400
1,1-dichloroethene ²	0.01	0.3	10
1,2-dichloroethene (sum) ¹	0.01	1	20
Dichloropropanes (sum) ¹	0.8	2	80
Trichloromethane (chloroform)	6	5.6	400
1,1,1-trichloroethane	0.01	15	300
1,1,2-trichloroethane	0.01	10	130
Trichloroethene (Tri)	24	2.5	500
Tetrachloromethane (Tetra)	0.01	0.7	10
Tetrachloroethene (Per)	0.01	8.8	40
b. chlorobenzenes⁵			
Monochlorobenzene	7	15	180
Dichlorobenzenes (sum) ¹	3	19	50
Trichlorobenzenes (sum) ¹	0.01	11	10
Tetrachlorobenzenes (sum) ¹	0.01	2.2	2.5
Pentachlorobenzenes	0.003	6.7	1
Hexachlorobenzene	0.00009*	2.0	0.5
c. chlorophenols⁵			
Monochlorophenols (sum) ¹	0.3	5.4	100
Dichlorophenols (sum) ¹	0.2	22	30
Trichlorophenols (sum) ¹	0.03*	22	10
Tetrachlorophenols (sum) ¹	0.01*	21	10
Pentachlorophenol	0.04*	12	3
d. polychlorobiphenyls (PCBs)			
PCBs (sum 7) ¹	0.01*	1	0.01

Table 1 (continued) Target values for groundwater and intervention values for soil and groundwater

Concentrations in soil are shown for standard soil (10% organic matter and 25% clay)

Substance	Target value groundwater ⁷ (µg/l)	Intervention values soil (mg/kg d.s.)	Intervention values groundwater (µg/l)
e. Other chlorinated hydrocarbons			
Monochloroanilines (sum) ¹	-	50	30
Dioxin (sum I-TEQ) ¹	-	0.00018	N/A ⁶
Chloronaphthalene (sum) ¹	-	23	6
6. Pesticides			
a. organochlorine pesticides			
Chlorodane (sum) ¹	0.02 ng/l*	4	0.2
DDT (sum) ¹	-	1.7	-
DDE (sum) ¹	-	2.3	-
DDD (sum) ¹	-	34	-
DDT/DDE/DDD (sum) ¹	0.004 ng/l*	-	0.01
Aldrin	0.009 ng/l*	0.32	-
Dieldrin	0.1 ng/l*	-	-
Endrin	0.04 ng/l*	-	-
Drins (sum) ¹	-	4	0.1
α-endosulphan	0.2 ng/l*	4	5
α-HCH	33 ng/l	17	-
β-HCH	8 ng/l	1.6	-
γ-HCH (lindane)	9 ng/l	1.2	-
HCH-compounds (sum) ¹	0.05	-	1
Heptachlor	0.005 ng/l*	4	0.3
Heptachlor epoxide (sum) ¹	0.005 ng/l*	4	3
b. organophosphorous pesticides			
-			
c. organotin pesticides			
Organotin compounds (sum) ¹	0.05* – 16 ng/l	2.5	0.7
d. chlorophenoxy-acetic acid herbicides			
MCPA	0.02	4	50
e. other pesticides			
Atrazine	29 ng/l	0.71	150
Carbaryl	2 ng/l*	0.45	50
Carbofuran ²	9 ng/l	0.017	100

Table 1 (continued) Target values for groundwater and intervention values for soil and groundwater

Concentrations in soil are shown for standard soil (10% organic matter and 25% clay)

Substance	Target value groundwater ⁷ (µg/l)	Intervention values	
		soil (mg/kg d.s.)	groundwater (µg/l)
7. Other substances			
Asbestos ³	-	100	-
Cyclohexanone	0.5	150	15,000
Dimethyl phthalate	-	82	-
Diethyl phthalate	-	53	-
Di-isobutyl phthalate	-	17	-
Dibutyl phthalate	-	36	-
Butyl benzyl phthalate	-	48	-
Dihexyl phthalate	-	220	-
Di(2-ethylhexyl)phthalate	-	60	-
Phthalates (sum) ¹	0.5	-	5
Mineral oil ⁴	50	5,000	600
Pyridine	0.5	11	30
Tetrahydrofuran	0.5	7	300
Tetrahydrothiophene	0.5	8.8	5,000
Tribromomethane (bromoform)	-	75	630

* Numeric value below the detection level/no lower detection limit or measurement method available.

¹ See annex N of the Soil Quality Regulations (Ministry of Housing, Spatial Planning and the Environment 2007) for the composition of the aggregate parameters. The results below the required reporting limit AS3000 are multiplied by 0.7 when calculating a sum value for the individual components. If all individual values as part of the calculated value have a result below the required reporting limit AS3000, the assessor may assume that the soil or groundwater quality complies with the target value. If there are one or more measured contents (without < sign) for one or more individual components, then the calculated value has to be checked against the applicable standard value. This rule also applies if the measured contents are lower than the required reporting limit. The check result obtained on the basis of a calculated sum value, whereby one or more individual components have been defined as 0.7 times the reporting limit, is not binding. The assessor is free to conclude that the sample in question is not as contaminated as the check result shows, provided he supplies good reasons for such a conclusion. This is for instance the standard approach if a PAH measurement in the groundwater reveals only naphthalene in a slightly increased concentration, and if the other PAHs have a value below the required reporting limit AS3000. Relatively high contents will then be calculated for the other PAHs (by multiplying by 0.7), of which it can be substantiated that such levels will not be present in the groundwater in view of the immobility of the relevant substances.

² The Intervention value for soil in respect of these substances equals or is lower than the limit of quantification (intralaboratory reproducibility). The risks must be examined in greater detail if the substance is detected. The groundwater must also be surveyed if vinyl chloride or 1,1-dichloroethene is detected in the soil.

- 3 Weighted standard (concentration of serpentine + 10 x concentration of amphibole
4 asbestos)
- 4 'Mineral oil' is defined in the analysis standard. Where the contamination is composed of
mixtures (e.g. petrol or domestic heating oil), the concentration of aromatic and/or
polycyclic aromatic hydrocarbons must be determined in addition to the alkane
concentration. This aggregate parameter has been adopted for practical reasons. Further
5 toxicological and chemical differentiation is under study.
- 5 In the case of groundwater, effects of PAHs, chlorobenzenes and chlorophenols are
indirectly additive and are expressed as a fraction of the individual intervention value (i.e.
0.5 of the intervention value of substance A has the same effect as 0.5 of the intervention
value of substance B). This means that an addition formula must be used to determine
whether an intervention value has been exceeded. The intervention value for the sum of
a group of substances is exceeded if $\sum(C_i/I_i) > 1$, where C_i = measured concentration of a
substance in the group of substances in question and I_i = intervention value for the
substance concerned in the group.
- 6 There is an indicative level for serious contamination
- 7 The Groundwater target values for a number of substances are lower than the required
reporting limit in AS3000. This means that these Target values are more stringent than
the level at which reliable (routine) measurements can be made. The laboratories must at
least comply with the required reporting limit in AS3000. Providing the analytical method
complies with AS3000, a more stringent reporting limit is also permitted. If the
assessment measurement result is < reporting limit AS3000, the assessor may assume
that groundwater quality complies with the Target value. If the laboratory reports a
measured content (without a < sign), this concentration has to be checked against the
target values, even if this concentration is lower than the required reporting limit AS3000.
- 8 The barium standard has been repealed because the intervention value for barium
proved to be lower than the concentration naturally occurring in the soil. In the case of
increased barium concentrations compared to the natural background due to an
anthropogenic source, this concentration can be assessed on the basis of the former
intervention value for barium of 920 mg/kg d.s. This former intervention value is
substantiated in the same manner as the intervention values for most of the other metals,
and for barium it includes a natural background concentration of 190 mg/kg d.s.
- 9 If the laboratory reports a value below an increased reporting limit (i.e. higher than the
reporting limit AS3000), the increased reporting limit concerned must be multiplied by 0.7.
The value obtained in this manner is then checked against the applicable standard value.
Such an increase in the reporting limit may occur when analysing a seriously
contaminated sample or a sample with a non-standard composition. The check results
obtained in this manner are not binding. The assessor is free to conclude that the sample
cannot be assessed properly, provided he supplies good reasons for such a conclusion.

6 Details of chemical analysis results

6.1 QA/QC procedure

A QA/QC procedure was applied in order to verify potential impacts on quality of samples resulting from conditions of sampling and transportation of samples. QA/QC procedure included shipment of two soil Trip Blank samples and one groundwater Trip Blank sample. Trip Blank samples containing zero concentrations of given parameters were transported and stored in the same way as containers used for collecting samples and samples after their collection. Trip Blank samples covered the same route as packaging used for collecting samples, i.e. a road transport from "i2 Analytical" laboratory in Poland to the site in Celje, storage of samples in refrigerators in Cinkarna Celje and road transport of samples from Celje to "i2 Analytical" laboratory in Poland.

Trip Blank samples were analysed for presence of heavy metals and Petroleum Hydrocarbons (TPH fraction C6-C12 and C12-C35). Results of Trip Blank samples analyses are included in Appendix B – Results of Laboratory Analysis and Appendix C – Certificates of Analysis.

In groundwater Trip Blank sample (sample ID 370114), all the concentrations of analysed heavy metals were below the laboratory's level of detection, except for Copper. The detected concentration of Copper was 0.7 µg/l, while the laboratory's level of detection is 0.5 µg/l. This result indicates a minor impact of sampling and transportation conditions on the quality of analytical result and the obtained results of groundwater analysis can be treated as reliable.

In soil Trip Blank samples (sample ID 370231 and 370232); all the concentrations of analysed heavy metals were below the laboratory's level of detection, except for:

- Barium: the detected concentrations were 2.0 mg/kg in both samples, while the laboratory's level of detection is 1.0 mg/kg;
- Copper. The detected concentrations were 1.3 and 1.7 mg/kg, while the laboratory's level of detection is 1.0 mg/kg;
- Lead: the detected concentration was 1.1 mg/kg in sample ID 370232 (and below <1.0 mg/kg in the other sample), while the laboratory's level of detection is 1.0 mg/kg;
- Zinc: the detected concentrations were 2.8 and 1.6 mg/kg, while the laboratory's level of detection is 1.0 mg/kg;

These results indicate a minor impact of sampling and transportation conditions on the quality of analytical result and the obtained results of groundwater analysis can be treated as reliable.

6.2 Comparison of results of analysis against screening values

Results of laboratory analysis are given below. In each section, a summary of analytical results for soil and groundwater is given, for each of analysed areas of sampling. Cases when either Slovenian Critical Values for soil (according to Decree on limit values, alert thresholds and critical levels of dangerous substances into the soil (Official Gazette of the RS no. 68/1996, 41/2004)), Slovenian Threshold Value or Quality Standards (according to Decree on the state of groundwater (Uradni list RS, št. 25/09, 68/12)) or Dutch List Intervention Values were exceeded are noted.

A detailed summary of laboratory analysis results of soil and groundwater samples is given in:

- Appendix B – Results of Laboratory Analysis;
- Appendix C – Certificates of Analysis;
- Appendix D – Heavy Metals in Soils – Charts with Screening Values;
- Appendix E – Heavy Metals in Groundwater – Charts with Screening Values.

Location of boreholes and temporary groundwater monitoring wells with the highest concentrations of contaminants are presented on Figure 5 (for soil samples) and Figure 6 (for groundwater samples).

Area 1

Ten soil samples collected in Area 1 were analyzed in the Comprehensive QRA Scope.

The highest concentrations of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, were observed in two soil samples: 1-2 at 3.5 m-bgl (290 mg/kg) and 1-3 at 1.0 m-bgl (39 mg/kg). Critical Value is not specified for Antimony.

The highest concentrations of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, were observed in three soil samples: 1-1 at 1.4 m-bgl (170 mg/kg), 1-2 at 1.0 m-bgl (110 mg/kg) and 1-3 at 1.0 m-bgl (150 mg/kg).

The highest concentrations of **Barium**, exceeding Dutch List Intervention Value of 920 mg/kg, were observed in two soil samples: 1-4 at 1.0 m-bgl (1,500 mg/kg) and 1-4 at 3.5 m-bgl (3,200 mg/kg). Critical Value is not specified for Barium.

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in five soil samples: 1-1 at 1.4 m-bgl (660 mg/kg), 1-1 at 3.5 m-bgl (70 mg/kg), 1-2 at 1.0 m-bgl (21 mg/kg), 1-3 at 1.0 m-bgl (130 mg/kg) and 1-4 at 1.0 m-bgl (17 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in five soil samples: 1-1 at 1.4 m-bgl (160,000 mg/kg), 1-1 at 3.5 m-bgl (300 mg/kg), 1-2 at 1.0 m-bgl (770 mg/kg), 1-2 at 3.5 m-bgl (230 mg/kg) and 1-3 at 1.0 m-bgl (1,100 mg/kg).

The highest concentrations of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, were observed in five soil samples: 1-1 at 1.4 m-bgl (7,600 mg/kg), 1-1 at 3.5 m-bgl (3,500 mg/kg), 1-2 at 1.0 m-bgl (1,400 mg/kg), 1-2 at 3.5 m-bgl (2,400 mg/kg) and 1-3 at 1.0 m-bgl (10,000 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in eight soil samples: 1-1 at 1.4 m-bgl (96,000 mg/kg), 1-1 at 3.5 m-bgl (83,000 mg/kg), 1-2 at 1.0 m-bgl (13,000 mg/kg), 1-2 at 3.5 m-bgl (3,500 mg/kg), 1-3 at 1.0 m-bgl (47,000 mg/kg), 1-4 at 1.0 m-bgl (2,200 mg/kg), 1-4 at 3.5 m-bgl (1,100 mg/kg) and 1-5 at 1.0 m-bgl (920 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

All elevated concentrations of heavy metals were observed in soil samples collected from layers of man-made fill (except for 1-2 at 3.5 m-bgl: gravel and 1-4 at 3.5 m-bgl: sand):

- 1-1 at 1.4 m-bgl: black, metallurgical waste mixed with construction waste material;
- 1-1 at 3.5 m-bgl: black, clay with gravel, with large sized gravel at the bottom);
- 1-2 at 1.0 m-bgl: brown to black, industrial and communal waste with some levels of coal;
- 1-3 at 1.0 m-bgl: construction and industrial waste filling;
- 1-4 at 1.0 m-bgl: construction and industrial waste filling;
- 1-5 at 1.0 m-bgl: gravel, blocks with industrial waste.

One **groundwater sample** collected from Area 1 was analyzed (from temporary monitoring well 1-5). The results did not indicate elevated concentrations of heavy metals and organic compounds in concentrations exceeding Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 2

14 soil samples collected in Area 2 were analyzed in the Comprehensive QRA Scope and three additional soil samples (2-1 at 2.5 m-bgl, 2-2 at 2.5 m-bgl and 2-3 at 2.0 m-bgl) were analyzed for presence of Inorganic Compounds and Heavy Metals.

The highest concentrations of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, were observed in six soil samples: 2-1 at 1.0 m-bgl (120 mg/kg), 2-1 at 3.5 m-bgl (140 mg/kg), 2-2 at 1.0 m-bgl (140 mg/kg), 2-5 at 0.8 m-bgl (270 mg/kg), 2-5 at 3.0 m-bgl (53 mg/kg) and 2-7 at 0.7 m-bgl (170 mg/kg). Critical Value is not specified for Antimony.

The highest concentrations of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, were observed in eight soil samples: 2-1 at 1.0 m-bgl (200 mg/kg), 2-1 at 2.5 m-bgl (630 mg/kg), 2-1 at 3.5 m-bgl (3,000 mg/kg), 2-2 at 1.0 m-bgl (2,500 mg/kg), 2-3 at 2.0 m-bgl (460 mg/kg), 2-5 at 0.8 m-bgl (63 mg/kg), 2-5 at 3.0 m-bgl (370 mg/kg) and 2-7 at 0.7 m-bgl (110 mg/kg).

The highest concentration of **Barium**, exceeding Dutch List Intervention Value of 920 mg/kg, was observed in a soil sample 2-1 at 3.5 m-bgl (940 mg/kg). Critical Value is not specified for Barium.

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in eight soil samples: 2-1 at 1.0 m-bgl (160 mg/kg), 2-1 at 2.5 m-bgl (190 mg/kg), 2-1 at 3.5 m-bgl (150 mg/kg), 2-2 at 1.0 m bgl (41 mg/kg), 2-3 at 2.0 m-bgl (36 mg/kg), 2-5 at 0.8 m-bgl (95 mg/kg), 2-5 at 3.0 m-bgl (160 mg/kg) and 2-7 at 0.7 m-bgl (30 mg/kg).

The highest concentration of **Cobalt**, exceeding both Dutch List Intervention Value of 190 mg/kg and a Critical Value of 240 mg/kg, were observed in soil sample 2-1 at 3.5 m bgl (770 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in eight soil samples: 2-1 at 1.0 m-bgl (1,600 mg/kg), 2-1 at 2.5 m-bgl (3,300 mg/kg), 2-1 at 3.5 m-bgl (8,600 mg/kg), 2-2 at 1.0 m-bgl (2,000 mg/kg), 2-3 at 2.0 m-bgl (8,100 mg/kg), 2-5 at 0.8 m-bgl (1,900 mg/kg), 2-5 at 3.0 m-bgl (5,400 mg/kg) and 2-7 at 0.7 m-bgl (920 mg/kg).

The highest concentrations of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, were observed in eight soil samples: 2-1 at 1.0 m-bgl (4,400 mg/kg), 2-1 at 2.5 m-bgl (45,000 mg/kg), 2-1 at 3.5 m-bgl (5,000 mg/kg), 2-2 at 1.0 m-bgl (12,000 mg/kg), 2-3 at 2.0 m-bgl (8,500 mg/kg), 2-5 at 0.8 m-bgl (25,000 mg/kg), 2-5 at 3.0 m-bgl (4,300 mg/kg) and 2-7 at 0.7 m-bgl (3,800 mg/kg).

The highest concentrations of **Nickel**, exceeding Dutch List Intervention Value of 100 mg/kg and a Critical Value of 210 mg/kg, were observed in two soil samples: 2-1 at 3.5 m-bgl (670 mg/kg) and 2-2 at 1.0 m-bgl (250 mg/kg).

The highest concentrations of **Mercury**, exceeding a Critical Value of 10 mg/kg, were observed in two soil samples: 2-5 at 0.8 m-bgl (19 mg/kg) and 2-7 at 0.7 m-bgl (28 mg/kg).

The highest concentration of **Molybdenium**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 200 mg/kg, was observed in one soil sample: 2-1 at 2.5 m-bgl in a concentration of 230 mg/kg.

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in thirteen soil samples: 2-1 at 1.0 m-bgl (20,000 mg/kg), 2-1 at 2.5 m-bgl (140,000 mg/kg), 2-1 at 3.5 m-bgl (140,000 mg/kg), 2-2 at 1.0 m-bgl (8,200 mg/kg), 2-2 at 2.5 m-bgl (3,500 mg/kg), 2-2 at 3.5 m-bgl (2,100 mg/kg), 2-3 at 1.0 m-bgl (810 mg/kg), 2-3 at 2.0 m-bgl (80,000 mg/kg), 2-3 at 3.0 m-bgl (1,100 mg/kg), 2-4 at 1.0 m-bgl (1,100 mg/kg), 2-5 at 0.8 m-bgl (170,000 mg/kg), 2-5 at 3.0 m-bgl (140,000 mg/kg) and 2-7 at 0.7 m-bgl (55,000 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

All elevated concentrations of heavy metals were observed in soil samples collected from layers of man-made fill (except for 2-2 at 3.5 m-bgl: sand and 2-3 at 3.0 m-bgl: sand):

- 2-1 at 1.0 m-bgl: brown to black, consisting mainly by gravel and clay;
- 2-1 at 2.5 m-bgl: black to brown, metallurgical waste with gravel, with some clayey levels;
- 2-1 at 3.5 m-bgl: black to brown, metallurgical waste with gravel, with some clayey levels;
- 2-2 at 1.0 m-bgl: black and red colored industrial waste filling;
- 2.2 at 2.5 m-bgl: black and red colored industrial waste filling;

- 2-3 at 1.0 m-bgl: brown to black, gravel and sand sized material with coal grains, clayey on some small levels;
- 2-3 at 2.0 m-bgl: brown to black, gravel and sand sized material with coal grains, clayey on some small levels;
- 2-3 at 3.0 m-bgl: yellowish brown, fine graded small to medium sized;
- 2-4 at 1.0 m-bgl: black gravel sized industrial waste with gravel and sand;
- 2-5 at 0.8 m-bgl: black colored, metallurgical waste with gravel and sand sized material;
- 2-5 at 3.0 m-bgl: black colored, metallurgical waste with gravel and sand sized material;
- 2-7 at 0.7 m-bgl: grey to brown, industrial and construction waste.

Two **groundwater samples** collected from Area 2 were analyzed (from temporary monitoring wells 2-1 and 2-5).

In groundwater sample 2-1, **Cadmium** concentration was 22 µg/l (exceeding Dutch List Intervention Value of 6 µg/l), **Copper** concentration was 120 µg/l (exceeding Dutch List Intervention Value of 75 µg/l) and **Zinc** concentration was 25,000 µg/l (exceeding Dutch List Intervention Value of 800 µg/l).

In groundwater sample 2-5, **Cadmium** concentration was 9.8 µg/l (exceeding Dutch List Intervention Value of 6 µg/l) and **Zinc** concentration was 34,000 µg/l (exceeding Dutch List Intervention Value of 800 µg/l).

Thallium was detected in one underground water sample 2-5 in a concentration of 8,0 µg/l. Dutch List Intervention Values or Slovenian Threshold Values are not determined for Thallium.

Concentrations of the remaining analyzed parameters in groundwater did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 3

Four soil samples collected in Area 3 were analyzed in the Comprehensive QRA Scope.

The highest concentration of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, was observed in one soil sample 3-1 at 3.0 m-bgl (530 mg/kg). Critical Value is not specified for Antimony.

The highest concentration of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, was observed in one soil sample 3-2 at 1.0 m-bgl (100 mg/kg).

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in three soil samples 3-1 at 1.0 m-bgl (35 mg/kg), 3-1 at 3.0 m-bgl (120 mg/kg), 3-2 at 1.0 m-bgl (19 mg/kg).

The highest concentrations of **Cobalt**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 240 mg/kg, was observed in one soil sample 3-1 at 3.0 m-bgl (460 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in two soil samples: 3-1 at 3.0 m-bgl (340 mg/kg) and 3-2 at 1.0 m-bgl (450 mg/kg).

The highest concentration of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, was observed in one soil sample 3-2 at 1.0 m-bgl (of 1,100 mg/kg).

The highest concentration of **Nickel**, exceeding Dutch List Intervention Value of 100 mg/kg and a Critical Value of 210 mg/kg, was observed in one soil sample 3-1 at 3.0 m-bgl (360 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in three soil samples: 3-1 at 1.0 m-bgl (81,000 mg/kg), 3-1 at 3.0 m-bgl (76,000 mg/kg) and 3-2 at 1.0 m-bgl (31,000 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Compounds belonging to the group of **Polycyclic Aromatic Hydrocarbons** were detected in two out of four soil samples collected in Area 3. In a soil sample 3-1 at 1.0 m-bgl, a concentration of the sum of PAHs was 52.8 mg/kg, which exceeded a Dutch List Intervention Value of 40 mg/kg. Critical Value is not specified for the sum of PAHs.

Heavy fraction of Petroleum Hydrocarbons (TPH C12-C35) was detected in all four soil samples. In one soil sample (3-1 at 3.0 m-bgl) a detected concentration of heavy fraction of Petroleum Hydrocarbons (6,700 mg/kg) exceeded a Dutch List Intervention Value of 5,000 mg/kg and a Critical Value of 5,000 mg/kg.

All elevated concentrations of heavy metals (and a high concentration of heavy fraction of Petroleum Hydrocarbons (TPH C12-C35)) were observed in soil samples collected from layers of man-made fill:

- 3-1 at 1.0 m-bgl: brown clayey sand and gravel and some black, reddish-black waste on the bottom;
- 3-1 at 3.0 m-bgl: grey clayey on the top, becoming black, black-reddish with sand and gravel on the bottom;
- 3-2 at 1.0 m-bgl: gravel, sand and clay, red-blackish to the bottom.

One **groundwater sample** collected from Area 3 was analyzed (from temporary monitoring well 3-1). In groundwater sample 3-1, **Cobalt** concentration was 110 µg/l (exceeding Dutch List Intervention Value of 100 µg/l), **Mercury** concentration was 0.93 µg/l (exceeding Dutch List Intervention Value of 0.3 µg/l) and **Zinc** concentration was 120,000 µg/l (exceeding Dutch List Intervention Value of 800 µg/l). Concentrations of the remaining analyzed parameters in groundwater did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 4

Two soil samples were collected in Area 4. One sample (4-1 at 1.5 m-bgl) was analyzed in the Comprehensive QRA Scope and another sample (4-1 at 3.8 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

The results did not indicate elevated concentrations of heavy metals and organic compounds that exceeding Dutch List Intervention Values or Slovenian Critical Values in soil samples collected in Area 4.

One **groundwater sample** collected from Area 4 was analyzed (from temporary monitoring well 4-1). In groundwater sample 4-1, **Zinc** concentration was 1,700 µg/l (exceeding Dutch List Intervention Value of 800 µg/l). Concentrations of the remaining analyzed parameters in groundwater did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 5

Two soil samples were collected in Area 5. One sample (5-1 at 1.0 m-bgl) was analyzed in the Comprehensive QRA Scope and another sample (5-1 at 3.4 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

No elevated concentrations of **heavy metals** were detected in soil samples collected in Area 5, except for concentration of **Zinc** in soil samples 5-1 at 1.0 m-bgl (1,300 mg/kg) and 5-1 at 3.4 m-bgl (730 mg/kg), exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg). Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

An elevated concentration of **Zinc** occurred in soil sample collected from a layer of man-made fill: 5-1 at 1.0 m-bgl: black to brown, industrial waste filling with gravel and a soil sample collected from a layer of sand, brown, coarse with small sized gravel on the bottom: 5-1 at 3.4 m-bgl.

One **groundwater sample** collected from Area 5 was analyzed (from temporary monitoring well 5-1). In groundwater sample 5-1, **Zinc** concentration was 7,700 µg/l, exceeding Dutch List Intervention Value of 800 µg/l. Concentrations of the remaining analyzed parameters in groundwater did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 6

Six soil samples collected in Area 6 were analyzed in the Comprehensive QRA Scope.

The highest concentration of **Arsenic** exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg was observed in one soil sample: 6-1 at 1.0 m-bgl (86 mg/kg).

The highest concentration of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, was observed in one soil sample: 6-1 at 1.0 m-bgl (300 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in two soil samples: 6-1 at 1.0 m-bgl (4,400 mg/kg) and 6-2 at 1.0 m-bgl (5,100 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

All elevated concentrations of heavy metals were observed in soil samples collected from layers of man-made fill:

- 6-1 at 1.0 m-bgl: black with coal grains and gravel;
- 6-2 at 1.0 m-bgl: black with coal grains and gravel.

Two **groundwater samples** collected from Area 6 were analyzed (from temporary monitoring wells 6-1 and 6-3).

In both groundwater samples (6-1 and 6-3), concentrations of both heavy metals and organic compounds were not significant and did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 7

Five soil samples collected in Area 7 (from two boreholes) were analyzed in the Comprehensive QRA Scope and one soil sample (7-1 at 3.0 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and exceeding a Critical Value of 300 mg/kg, was observed in two soil samples 7-1 at 1.0 m-bgl (350 mg/kg) and 7-2 at 3.6 m-bgl (470 mg/kg). Additionally, the **Copper** concentration in the soil sample 7-2 at 3.0 m bgl (220 mg/kg) exceeded Dutch Intervention Value of 190 mg/kg.

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in three soil samples: 7-1 at 1.0 m-bgl (4,700 mg/kg), 7-2 at 0.6 m-bgl (1,900 mg/kg) and 7-2 at 3.0 m-bgl (3,700 mg/kg).

Concentrations of remaining heavy metals and organic compounds in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of heavy metals were observed in two soil samples collected from layers of man-made fill:

- 7-1 at 1.0 m-bgl: brown to black, with construction and industrial waste material;
- 7-2 at 0.6 m-bgl: industrial waste.

Elevated concentrations of metals were observed also in two soil samples collected from natural layers in a borehole 7-2, which, however, seemed (based on organoleptic observations and PID measurements) to have been impacted with hydrocarbons:

- 7-2 at 3.0 m-bgl: grey, compact, plastic clay with "solvent" smell;
- 7-2 at 3.6 m-bgl: grey, compact, plastic clay with "solvent" smell.

Two **groundwater samples** collected from Area 7 were analyzed (from temporary monitoring wells 7-1 and 7-2).

In groundwater sample 7-1, **Zinc** concentration was 1,600 µg/l, exceeding Dutch List Intervention Value of 800 µg/l. Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 8

Fourteen soil samples collected in Area 8 were analyzed in the Comprehensive QRA Scope and two additional soil samples (8-5 at 2.0 m-bgl and 8-6 at 2.7 m-bgl) were analyzed for presence of Inorganic Compounds and Heavy Metals.

The highest concentrations of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, were observed in five soil samples: 8-2 at 0.7 m-bgl (150 mg/kg), 8-3 at 0.7 m-bgl (140 mg/kg), 8-4 at 1.0 m-bgl (160 mg/kg), 8-5 at 1.0 m-bgl (40 mg/kg) and 8-5 at 2.0 m-bgl (50 mg/kg). Critical Value is not specified for Antimony.

The highest concentrations of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, were observed in four soil samples: 8-2 at 0.7 m-bgl (1,700 mg/kg), 8-3 at 0.7 m-bgl (1,600 mg/kg), 8-4 at 1.0 m-bgl (1,200 mg/kg) and 8-5 at 1.0 m-bgl (340 mg/kg).

The highest concentration of **Barium**, exceeding Dutch List Intervention Value of 920 mg/kg of was observed in one soil sample 8-5 at 1.0 m-bgl (1,000 mg/kg). Critical Value is not specified for Barium.

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in four soil samples: 8-2 at 0.7 m-bgl (66 mg/kg), 8-3 at 0.7 m-bgl (39 mg/kg), 8-4 at 1.0 m-bgl (22 mg/kg) and 8-5 at 2.0 m-bgl (33 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in six soil samples: 8-1 at 1.0 m-bgl (440 mg/kg), 8-2 at 0.7 m-bgl (9,400 mg/kg), 8-3 at 0.7 m-bgl (8,500 mg/kg), 8-4 at 1.0 m-bgl (7,600 mg/kg), 8-5 at 1.0 m-bgl (1,400 mg/kg) and 8-5 at 2.0 m-bgl (430 mg/kg).

The highest concentrations of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, were observed in five soil samples: 8-2 at 0.7 m-bgl (20,000 mg/kg), 8-3 at 0.7 m-bgl (20,000 mg/kg), 8-4 at 1.0 m-bgl (19,000 mg/kg), 8-5 at 1.0 m-bgl (4,100 mg/kg) and 8-5 at 2.0 m-bgl (1,700 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in nine soil samples: 8-1 at 1.0 m-bgl (1,300 mg/kg), 8-2 at 0.7 m-bgl (180,000 mg/kg), 8-2 at 3.0 m-bgl (1,100 mg/kg), 8-3 at 0.7 m-bgl (87,000 mg/kg), 8-3 at 3.5 m-bgl (4,000 mg/kg), 8-4 at 1.0 m-bgl (100,000 mg/kg), 8-5 at 1.0 m-bgl (19,000 mg/kg), 8-5 at 2.0 m-bgl (74,000 mg/kg) and 8-6 at 1.0 m-bgl (730 mg/kg).

Concentrations of remaining heavy metals and organic compounds in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of heavy metals were observed in soil samples collected from the following geological strata:

- 8-1 at 1.0 m-bgl: Clay (grey, compact, plastic, silty to the bottom);
- 8-2 at 0.7 m-bgl: Man made fill (grey, clayey silt with gravel);
- 8-2 at 3.0 m-bgl: Sand (yellowish brown, fine to medium grained, medium sorted);
- 8-3 at 0.7 m-bgl: Man made fill (reddish-brown, industrial waste);
- 8-3 at 3.5 m-bgl: Clayey sand, sand (grey fine to medium sand, clayey in the upper part);
- 8-4 at 1.0 m-bgl: Man made fill (reddish-black, industrial waste material with gravel);
- 8-5 at 1.0 m-bgl: Man made fill (grey, mainly gravel, with industrial waste from 2 m bgl sandy to the bottom);
- 8-5 at 2.0 m-bgl: Man made fill (grey, mainly gravel, with industrial waste from 2 m bgl sandy to the bottom);
- 8-6 at 1.0 m-bgl: Clay, silty clay (yellowish brown, compact, plastic, silty to the bottom).

Three **groundwater samples** collected from Area 8 were analyzed (from temporary monitoring wells 8-5, 8-6 and 8-7). Organic compounds were not detected in any of the samples.

In groundwater samples 8-5 and 8-6, concentrations of heavy metals were not significant, except for **Zinc** which was observed in concentrations of 18,000 µg/l and 2,000 µg/l, exceeding Dutch List Intervention Value of 800 µg/l.

In groundwater sample 8-7, pH value was significantly higher than in all other groundwater samples (observed value of pH – 9.3). Concentrations of numerous heavy metals were significant and exceeded Dutch List Intervention Values for the following compounds: **Arsenic** – 362 µg/l (exceeding Dutch List Intervention Value of 60 µg/l), **Cadmium** – 9.8 µg/l (exceeding Dutch List Intervention Value of 6 µg/l), **Chromium** – 80 µg/l (exceeding Dutch List Intervention Value of 30 µg/l), **Copper** – 200 µg/l (exceeding Dutch List Intervention Value of 75 µg/l), **Lead** 420 µg/l (exceeding Dutch List Intervention Value of 75 µg/l), **Mercury** – 2.72 µg/l (exceeding Dutch List Intervention Value of 0.3 µg/l), **Molybdenum** – 300 µg/l (exceeding Dutch List Intervention Value of 300 µg/l), **Nickel** – 110 µg/l (exceeding Dutch List Intervention Value of 75 µg/l) and **Zinc** – 1700 µg/l (exceeding Dutch List Intervention Value of 800 µg/l).

Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 9

Four soil samples collected in Area 9 (from two boreholes) were analyzed in the scope of Comprehensive QRA.

The highest concentration of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, was observed in one soil sample 9-1 at 1.0 m-bgl (170 mg/kg). The remaining

concentrations of Antimony were below 20 mg/kg. Critical Value is not specified for Antimony.

The highest concentrations of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, were observed in two soil samples: 9-1 at 1.0 m-bgl (2,400 mg/kg) and 9-2 at 1.0 m-bgl (170 mg/kg).

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in three soil samples: 9-1 at 1.0 m-bgl (36 mg/kg), 9-1 at 2.3 m-bgl (16 mg/kg) and 9-2 at 1.0 m-bgl (30 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in two soil samples: 9-1 at 1.0 m-bgl (12,000 mg/kg) and 9-2 at 1.0 m-bgl (860 mg/kg).

The highest concentration of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, was observed in a soil sample 9-1 at 1.0 m-bgl (14,000 mg/kg).

The highest concentration of **Nickel**, exceeding Dutch List Intervention Value of 100 mg/kg (Critical Value of 210 mg/kg was not exceeded) was observed in a soil sample 9-1 at 1.0 m-bgl (120 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in three soil samples: 9-1 at 1.0 m-bgl (150,000 mg/kg), 9-1 at 2.3 m-bgl (1,500 mg/kg) and 9-2 at 1.0 m-bgl (8,500 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

The highest concentration of TPH (C12-C35), exceeding Dutch List Intervention Value of 5,000 mg/kg and a Critical Value of 5,000 mg/kg, was observed in one soil sample, 9-2 at 1.0 m bgl (77,000 mg/kg).

Elevated concentrations of heavy metals and TPH were observed in soil samples collected from the following geological strata:

- 9-1 at 1.0 m-bgl: Man made fill (brown to reddish brown, gravel and sand, clayey to the bottom);
- 9-1 at 2.3 m-bgl: Silty sand (yellowish brown, loose with fine sand);
- 9-2 at 1.0 m-bgl: Man made fill (clayey gravel, angular shaped mainly carbonatic grains).

One **groundwater sample** collected from Area 9 was analyzed (from temporary monitoring well 9-2). Concentrations of all heavy metals and organic compounds were not significant and did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 10

Seven soil samples collected in Area 10 (from four boreholes) were analyzed in the scope of Comprehensive QRA and one soil sample (10-3 at 1.8 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

The highest concentration of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, of 39 mg/kg, was observed in one soil sample 10-3 at 1.0 m-bgl.

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in two soil samples: 10-2 at 0.5 m-bgl (2,400 mg/kg) and 10-3 at 1.0 m-bgl (3,900 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of heavy metals were observed in soil samples collected from the following geological strata:

- 10-2 at 0.5 m-bgl: Man made fill (road pavement, sand and gravel);
- 10-3 at 1.0 m-bgl: Clayey silt, clayey sand (grey, plastic on the top, with fine sand fraction to the bottom).

Concentrations of all heavy metals and organic compounds were not significant and did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 11

Two soil samples were collected from one borehole in Area 11. One sample (11-1 at 1.0 m-bgl) was analyzed in the Comprehensive QRA Scope and another sample (11-1 at 2.5 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

No elevated concentrations of **heavy metals** were detected in soil samples collected in Area 11, except for concentrations of **Zinc**: 2,000 mg/kg in soil sample 11-1 at 1.0 m-bgl and 1,900 mg/kg at 2.5 m-bgl, both exceeding Dutch List Intervention Value of 720 mg/kg and Critical Value of 720 mg/kg.

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of **Zinc** were observed in soil samples collected from the following geological strata:

- 11-1 at 1.0 m-bgl: Silty clay (grey, compact, plastic-silty to the bottom);
- 11-1 at 2.5 m-bgl: Sand (yellowish brown, medium sorted medium sand).

One **groundwater sample** collected from Area 11 was analyzed (from temporary monitoring well 11-1). In groundwater sample 11-1, concentrations of heavy metals were not significant, except for **Zinc** concentration of 1,000 µg/l, exceeding Dutch List Intervention Value of 800 µg/l. Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 12

Twenty-two soil samples were collected in Area 12 from twelve boreholes and were analyzed in the Comprehensive QRA Scope and two additional soil samples (12-3 at 3.0 m-bgl and 12-11 at 3.0 m-bgl) were analyzed for presence of Inorganic Compounds and Heavy Metals.

The highest concentrations of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, were observed in four soil samples: 12-1 at 1.0 m-bgl (98 mg/kg), 12-8 at 1.0 m-bgl (70 mg/kg), 12-10 at 3.0 m-bgl (59 mg/kg) and 12-13 at 3.5 m-bgl (130 mg/kg). Critical Value is not specified for Antimony.

The highest concentrations of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, were observed in eight soil samples: 12-1 at 1.0 m-bgl (1,900 mg/kg), 12-8 at 1.0 m-bgl (1,400 mg/kg), 12-8 at 2.5 m-bgl (130 mg/kg), 12-9 at 0.5 m-bgl (110 mg/kg) 12-10 at 0.5 m-bgl (250 mg/kg), 12-10 at 3.0 m-bgl (800 mg/kg), 12-13 at 1.0 m-bgl (94 mg/kg) and 12-13 at 3.5 m-bgl (10,000 mg/kg). Only Critical Value of 55 mg/kg was exceeded in one sample, 12-7 at 2.5 m bgl (74 mg/kg).

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in three soil samples: 12-1 at 1.0 m-bgl (47 mg/kg) and 12-13 at 3.5 m-bgl (37 mg/kg) and 12-8 at 1.5 m bgl (14 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in eight soil samples: 12-1 at 1.0 m-bgl (3,800 mg/kg), 12-8 at 1.0 m-bgl (2,500 mg/kg), 12-8 at 2.5 m-bgl (460 mg/kg), 12-9 at 0.5 m-bgl (490 mg/kg) 12-10 at 0.5 m-bgl (710 mg/kg), 12-10 at 3.0 m-bgl (510 mg/kg), 12-13 at 1.0 m-bgl (500 mg/kg) and 12-13 at 3.5 m-bgl (1,600 mg/kg).

The highest concentrations of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, were observed in six soil samples: 12-1 at 1.0 m-bgl (6,100 mg/kg), 12-8 at 1.0 m-bgl (960 mg/kg), 12-10 at 0.5 m-bgl (2,300 mg/kg), 12-10 at 3.0 m-bgl (970 mg/kg), 12-13 at 1.0 m-bgl (540 mg/kg) and 12-13 at 3.5 m-bgl (2,000 mg/kg).

The highest concentration of **Mercury**, exceeding a Critical Value of 10 mg/kg, was observed in one soil sample: 12-10 at 3.0 m-bgl (12 mg/kg).

The highest concentration of **Nickel**, exceeding Dutch List Intervention Value of 100 mg/kg and a Critical Value of 210 mg/kg, was observed in one soil sample 12-13 at 3.5 m-bgl (400 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in eleven soil samples: 12-1 at 1.0 m-bgl (36,000 mg/kg), 12-3 at 0.8 m-bgl (1,600 mg/kg), 12-4 at 0.8 m-bgl (1,100 mg/kg), 12-7 at 0.5 m bgl (1,900 mg/kg), 12-8 at 1.0 m-bgl (5,600 mg/kg), 12-8 at 2.5 m-bgl (880 mg/kg), 12-9 at 0.5 m-bgl (4,300 mg/kg), 12-10 at 0.5 m-bgl (9,000 mg/kg), 12-10 at 3.0 m-bgl (1,700 mg/kg), 12-13 at 1.0 m-bgl (4,400 mg/kg) and 12-13 at 3.5 m-bgl (5,200 mg/kg).

Thallium was detected in one soil sample (12-1 at 1.0 m-bgl) in a concentration of 34 mg/kg. Dutch List Intervention Values or Slovenian Critical Values are not determined for Thallium.

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of heavy metals were observed in soil samples collected from the following geological strata:

- 12-1 at 1.0 m-bgl: Man made fill (brown, industrial waste material);
- 12-3 at 3.0 m-bgl: Clayey sand (grey);
- 12-4 at 0.8 m-bgl: Man made fill (gravel and industrial waste);
- 12-7 at 0.5 m-bgl: Man made fill (compacted gravel and construction waste);
- 12-8 at 1.0 m-bgl: Man made fill (red industrial waste material);
- 12-8 at 2.5 m-bgl: Sand, sand with gravel (yellowish brown, poorly sorted medium to coarse sized);
- 12-9 at 0.5 m-bgl: Man made fill (black and brown, mainly gravel with industrial filling);
- 12-10 at 0.5 m-bgl: Man made fill (reddish-brown, industrial waste and gravel);
- 12-10 at 3.0 m-bgl: Man made fill (red, silty industrial waste);
- 12-13 at 1.0 m-bgl: Man made fill (black, mainly clayey gravel and some industrial waste filling);
- 12-13 at 3.5 m-bgl: Man made fill (red, silty, industrial waste material).

Three **groundwater samples** collected from Area 12 were analyzed (from temporary monitoring wells 12-3, 12-11 and 12-13).

In groundwater sample 12-3, elevated concentrations of heavy metals were detected for: **Cadmium** - concentration of 13 µg/l (exceeding Dutch List Intervention Value of 6 µg/l), and **Zinc** - concentration of 8,400 µg/l (exceeding Dutch List Intervention Value of 800 µg/l). Organic compounds were not detected in sample 12-3.

In groundwater sample 12-11, elevated concentrations of heavy metals were detected for: **Arsenic** - concentration of 61.6 µg/l (exceeding Dutch List Intervention Value of 60 µg/l), **Cobalt** – concentration of 240 µg/l (exceeding Dutch List Intervention Value of 100 µg/l), **Nickel** – concentration of 260 µg/l (exceeding Dutch List Intervention Value of 75µg/l) and **Zinc** - concentration of 1,600 µg/l (exceeding Dutch List Intervention Value of 800 µg/l).

In groundwater sample 12-13, elevated concentrations of heavy metals were detected for: **Arsenic** - concentration of 2200 µg/l (exceeding Dutch List Intervention Value of 60 µg/l) and **Nickel** – concentration of 80 µg/l (exceeding Dutch List Intervention Value of 75 µg/l) and **Zinc** - concentration of 2,400 µg/l (exceeding Dutch List Intervention Value of 800 µg/l).

Thallium was detected in all three groundwater samples collected in Area 12: in groundwater sample 12-3 in a concentration of 7.8 µg/l, in groundwater sample 12-11 in a concentration of 2.6 µg/l and in groundwater sample 12-13 in a concentration of 23 µg/l. Dutch List Intervention Value is not determined for Thallium.

Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 13

Three soil samples collected in Area 13 (from two boreholes) were analyzed in the Comprehensive QRA Scope and one soil sample (13-1 at 3.0 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

The highest concentration of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, was observed in a soil sample 13-2 at 2.0 m-bgl (of 150 mg/kg). Critical Value is not specified for Antimony.

The highest concentration of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg, was observed in two soil samples 13-2 at 1.0 m bgl (81 mg/kg) and 13-2 at 2.0 m-bgl (of 1,400 mg/kg).

The highest concentration of **Barium**, exceeding Dutch List Intervention Value of 920 mg/kg, was observed in a soil sample 13-2 at 1.0 m-bgl (1,400 mg/kg). Critical Value is not specified for Barium.

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg, were observed in two soil samples: 13-2 at 1.0 m-bgl (20 mg/kg) and 13-2 at 2.0 m-bgl (33 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg, were observed in two soil samples: 13-2 at 1.0 m-bgl (350 mg/kg) and 13-2 at 2.0 m-bgl (4,000 mg/kg).

The highest concentration of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg, was observed in two soil samples 13-2 at 1.0 m bgl (590 mg/kg) and 13-2 at 2.0 m-bgl (1,500 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg, were observed in two soil samples: 13-2 at 1.0 m-bgl (6,600 mg/kg) and 13-2 at 2.0 m-bgl (9,600 mg/kg).

Concentrations of remaining heavy metals in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of heavy metals were observed in soil samples collected from the following geological strata:

- 13-2 at 1.0 m-bgl: Man made fill (clayey, silty and mixed with industrial and communal waste material);
- 13-2 at 2.0 m-bgl: Man made fill (red, silty, industrial waste material).

One **groundwater sample** collected from Area 13 was analyzed (from temporary monitoring well 13-1). Concentrations of all analyzed heavy metals and organic compounds in groundwater did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 14

Two soil samples were collected from one borehole in Area 14. One sample (14-1 at 1.0 m-bgl) was analyzed in the Comprehensive QRA Scope and another sample (14-1 at 2.5 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

Concentrations of heavy metals in soil samples collected in Area 14 were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

One **groundwater sample** collected from Area 14 was analyzed (from temporary monitoring well 14-1). Concentrations of all analyzed heavy metals and organic compounds in groundwater did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 15

Six soil samples collected in Area 15 (from three boreholes) were analyzed in the scope of Comprehensive QRA.

The highest concentrations of **Antimony**, exceeding Dutch List Intervention Value of 22 mg/kg, were observed in two soil samples: 15-1 at 2.3 m-bgl (95 mg/kg) and 15-2 at 1.5 m-bgl (38 mg/kg). Critical Value is not specified for Antimony.

The highest concentrations of **Arsenic**, exceeding Dutch List Intervention Value of 76 mg/kg and Critical Value of 55 mg/kg, were observed in two soil samples: 15-1 at 2.3 m-bgl (810 mg/kg) and 15-2 at 1.5 m-bgl (290 mg/kg).

The highest concentration of **Barium**, exceeding Dutch List Intervention Value of 920 mg/kg, was observed in one soil sample 15-2 at 1.5 m-bgl (990 mg/kg). Critical Value is not specified for Barium.

The highest concentrations of **Cadmium**, exceeding Dutch List Intervention Value of 13 mg/kg and Critical Value of 12 mg/kg, were observed in two soil samples: 15-1 at 2.3 m-bgl (27 mg/kg) and 15-3 at 0.5 m-bgl (18 mg/kg).

The highest concentrations of **Copper**, exceeding Dutch List Intervention Value of 190 mg/kg and Critical Value of 300 mg/kg, were observed in three soil samples: 15-1 at 0.5 m-bgl (300 mg/kg), 15-1 at 2.3 m-bgl (5,900 mg/kg) and 15-2 at 1.5 m-bgl (1,100 mg/kg).

The highest concentration of **Lead**, exceeding Dutch List Intervention Value of 530 mg/kg and Critical Value of 530 mg/kg, was observed in 15-1 at 2.3 m-bgl (3,500 mg/kg).

The highest concentrations of **Zinc**, exceeding Dutch List Intervention Value of 720 mg/kg and Critical Value of 720 mg/kg, were observed in all six soil samples: 15-1 at 0.5 m-bgl (3,000 mg/kg), 15-1 at 2.3 m-bgl (37,000 mg/kg), 15-2 at 0.5 m-bgl (800 mg/kg), 15-2 at 1.5 m-bgl (2,600 mg/kg), 15-3 at 0.5 m-bgl (2,000 mg/kg) and 15-3 at 3.0 m-bgl (1,100 mg/kg).

Concentrations of remaining heavy metals and organic compounds in soil samples were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

Elevated concentrations of heavy metals were observed in soil samples collected from the following geological strata:

- 15-1 at 0.5 m-bgl: Man made fill (clay, sand, gravel with red colored industrial waste);
- 15-1 at 2.3 m-bgl: Man made fill (mostly gravel and construction waste with sand);
- 15-2 at 0.5 m-bgl: Man made fill (mostly gravel with sandy and clayey material, with red industrial waste);
- 15-2 at 1.5 m-bgl: Man made fill (mostly gravel with sandy and clayey material, with red industrial waste);
- 15-3 at 0.5 m-bgl: Clay, silty clay (grey);
- 15-3 at 3.0 m-bgl: Man made fill (clayey with sand, with some red colored industrial waste levels).

Three **groundwater samples** collected from Area 15 were analyzed (from temporary monitoring wells 15-1, 15-2 and 15-3).

In groundwater sample 15-1, concentrations of heavy metals were not significant, except for **Mercury** concentration of 0.93 µg/l (exceeding Dutch List Intervention Value of 0.3 µg/l). Concentrations of organic compounds were below the laboratory's detection limit.

In groundwater sample 15-2, concentrations of heavy metals were not significant, except for **Mercury** concentration of 0.76 µg/l (exceeding Dutch List Intervention Value of 0.3 µg/l).

In groundwater sample 15-3, concentrations of heavy metals were not significant, except for **Mercury** concentration of 1.44 µg/l (exceeding Dutch List Intervention Value of 0.3 µg/l) and **Arsenic** concentration of 108 µg/l (exceeding Dutch List Intervention Value of 60 µg/l).

Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Area 16

Two soil samples were collected from one borehole in Area 16. One sample (16-1 at 1.0 m-bgl) was analyzed in the Comprehensive QRA Scope and another sample (16-1 at 3.5 m-bgl) was analyzed for presence of Inorganic Compounds and Heavy Metals.

Concentrations of both heavy metals and organic compounds in soil samples collected in Area 16 were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

One **groundwater sample** collected from Area 16 was analyzed (from temporary monitoring well 16-1). In groundwater sample 16-1, concentrations of all analyzed parameters were not significant and did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Cinkarna Mozirje

Six soil samples collected in the Cinkarna Mozirje (from three boreholes) were analyzed in the scope of Comprehensive QRA.

No elevated concentrations of **heavy metals** were detected in soil samples collected in the Cinkarna Mozirje, except for **Zinc** concentration in soil sample MO-1 at 2.2 m-bgl (850 mg/kg, exceeding Dutch List Intervention Value of 720 mg/kg and Critical Value of 720 mg/kg) in one soil sample collected from a layer of man-made fill (gravel mixed with construction waste).

Three **groundwater samples** collected from the area of the Cinkarna Mozirje were analyzed (from temporary monitoring wells MO-1, MO-2 and MO-3). In all three groundwater samples, concentrations of all analyzed parameters were not significant and did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Bukovžlak Landfill for Solid Wastes

Six soil samples collected in Bukovžlak Landfill for Solid Wastes (from three boreholes) were analyzed in the scope of Comprehensive QRA.

Elevated concentrations of heavy metals were detected in one soil sample: BS-2 at 1.0 m-bgl and were observed for: **Antimony** (48 mg/kg, exceeding Dutch List Intervention Value of 22 mg/kg), **Arsenic** (1,200 mg/kg, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg), **Cadmium** (15 mg/kg, exceeding Dutch List Intervention Value of 13 mg/kg and a Critical Value of 12 mg/kg), **Copper** (3,200 mg/kg, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg) and **Zinc** (4,100 mg/kg, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg), in a soil sample collected from a layer of man-made fill (red-colored, silty industrial waste – “pyrite waste”).

At Bukovžlak Landfill for Solid Wastes, groundwater samples were collected from six permanent monitoring wells: BUK-3, N-3 and P-4 (located up-gradient of the landfill) and monitoring wells A-1, A-2 and A-3 (located down-gradient of the landfill).

In groundwater samples collected from monitoring wells located down-gradient of the Bukovžlak Landfill for Solid Wastes, increased concentrations of heavy metals were observed in monitoring well A-3 (**Cobalt** concentration of 220 µg/l, exceeding Dutch List Intervention Value of 100 µg/l, **Nickel** concentration of 140 µg/l, exceeding Dutch List Intervention Value of 75 µg/l) and **Zinc** concentration of 9200 µg/l, exceeding Dutch List Intervention Value of 800 µg/l. In a groundwater sample collected from monitoring well A-1, **Thallium** was detected in a concentration of 6.7 µg/l (Dutch List Intervention Value is not determined for Thallium).

In the groundwater samples collected from monitoring wells located up-gradient of the Bukovžlak Landfill for Solid Wastes (BUK-3, N-3 and P-4), increased concentrations of heavy metals were observed in monitoring well P-4 (**Zinc** concentration of 4,700 µg/l, exceeding Dutch List Intervention Value of 800 µg/l, **Cadmium** concentration of 9.9 µg/l, exceeding Dutch List Intervention Value of 6 µg/l and **Copper** concentration of 110 µg/l, exceeding Dutch List Intervention Value of 75 µg/l). Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold

Values for groundwater. **Thallium** was detected in two groundwater samples located up-gradient of Bukovžlak Landfill for Solid Wastes: in P-4 sample in a concentration of 2.6 µg/l and in N-3 sample in a concentration of 17 µg/l (Dutch List Intervention Value is not determined for Thallium).

Bukovžlak Landfill for Gypsum

Six soil samples collected in Bukovžlak Landfill for Gypsum (from three boreholes) were analyzed in the scope of Comprehensive QRA.

Elevated concentrations were detected in one soil sample: BG-2 at 4.2 m-bgl and were observed for: **Antimony** (54 µg/l, exceeding Dutch List Intervention Value of 22 µg/l), **Arsenic** (2,000 mg/kg, exceeding Dutch List Intervention Value of 76 mg/kg and a Critical Value of 55 mg/kg), **Copper** (1,800 mg/kg, exceeding Dutch List Intervention Value of 190 mg/kg and a Critical Value of 300 mg/kg), **Lead** (910 mg/kg, exceeding Dutch List Intervention Value of 530 mg/kg and a Critical Value of 530 mg/kg) and **Zinc** (2,400 mg/kg, exceeding Dutch List Intervention Value of 720 mg/kg and a Critical Value of 720 mg/kg), in a soil sample collected from a layer of man-made fill (red-colored, silty industrial waste – “pyrite waste”).

At the Bukovžlak Landfill for Gypsum, **groundwater samples** were collected from four permanent monitoring wells: from monitoring well BUK-1 (located up-gradient of the landfill) and monitoring wells BUK-2, K-10 and K-11 (all located down-gradient of the landfill).

In the groundwater samples collected from monitoring wells located down-gradient of the Bukovžlak Landfill for Gypsum (BUK-2, K-10 and K-11), increased concentrations of heavy metals were observed in monitoring well K-10 (**Zinc** concentration of 990 µg/l, exceeding Dutch List Intervention Value of 800 µg/l and **Arsenic** concentration of 1,550 µg/l, exceeding Dutch List Intervention Value of 60 µg/l) and K-11 (**Zinc** concentration of 8,400 µg/l, exceeding Dutch List Intervention Value of 800 µg/l, **Cadmium** concentration of 43 µg/l, exceeding Dutch List Intervention Value of 6 µg/l, **Cobalt** concentration of 210 µg/l, exceeding Dutch List Intervention Value of 100 µg/l and **Nickel** concentration of 140 µg/l, exceeding Dutch List Intervention Value of 75 µg/l). In a groundwater sample collected from monitoring well BUK-2, **Thallium** was detected in a concentration of 8.2 µg/l (Dutch List Intervention Value is not determined for Thallium).

In the groundwater sample collected from a monitoring well located up-gradient of the Bukovžlak Landfill for Gypsum (BUK-1), no increased concentrations of heavy metals were detected. Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Za Travnikom Landfill for Gypsum

Six soil samples collected in the Za Travnikom Landfill for Gypsum (from three boreholes) were analyzed in the scope of Comprehensive QRA.

Concentrations of all analyzed parameters in soil samples collected in Za Travnikom Landfill for Gypsum were not significant and did not exceed Dutch List Intervention Values or Slovenian Critical Values.

At the Za Travnikom Landfill for Gypsum, **groundwater samples** were collected from four permanent monitoring wells: Z-1A (located up-gradient of the landfill) and monitoring wells TV-1A, ZT-1A and ZT-2A (all located down-gradient of the landfill).

In the groundwater samples collected from monitoring wells located down-gradient of the Za Travnikom Landfill for Gypsum (ZT-1A, ZT-2A and TV-1A), increased concentrations of heavy metals were observed in monitoring well TV-1A (**Zinc** concentration of 9,000 µg/l, exceeding Dutch List Intervention Value of 800 µg/l, **Cobalt** concentration of 1,700 µg/l, exceeding Dutch List Intervention Value of 100 µg/l and **Nickel** concentration of 430 µg/l, exceeding Dutch List Intervention Value of 75 µg/l).

In the groundwater sample collected from a monitoring well located up-gradient of the Za Travnikom Landfill for Gypsum (Z-1A), no increased concentrations of heavy metals were detected.

Concentrations of the remaining analyzed parameters did not exceed Dutch List Intervention Values or Slovenian Threshold Values for groundwater.

Farming land located north of Bukovžlak landfill

Three soil samples were collected in the area located north of Bukovžlak landfill. Two soil samples (named FIE-2 and FIE-3) were collected from farming land (samples collected at a depth of 1 m bgl) in order to observe whether the soils in farming use have been impacted with the uncontrolled release from Bukovžlak landfill. An additional soil sample (named FIE-1) was collected in a mixed farming-woodland area located 1 km (sample collected also at a depth of 1.0 m-bgl). All soil samples were analyzed in the scope of Comprehensive QRA.

The results of chemical analysis revealed presence of 19 out of 22 analyzed heavy metals. Selenium, Thallium and Tin were not detected in any of the samples. No elevated concentrations of **heavy metals** were identified in any of the soil samples collected at farming land. No organic compounds were detected in any of the soil samples collected at farming land.

6.3 Leachate tests of selected soil samples

In order to evaluate the potential for leaching of metals from soil into groundwater, five soil samples collected at the Cinkarna Celje site were additionally analyzed. A parallel analysis was performed for five soil samples collected while execution of boreholes at the Cinkarna Celje site. In laboratory, each of selected soil samples was dried, homogenized and two analyses were performed:

- analysis of heavy metals contents in dry weight (extractable with Aqua Regia), and
- analysis of heavy metals in water leachate. In the latter case, a soil sample is subject to 24-hour leaching with distilled water in a proportion of 1:10 (soil to water). The obtained extract is filtered, acidified with 10% nitric acid and analyzed with ICP-OES.

Leaching tests are performed in order to simulate natural environmental events and they are indicative of an associated environmental risk. Results of leaching of metals with water indicate a potential of heavy metals reaching the natural groundwater body.

Results of analysis of metal contents in dry weight and in water leachate are given in a table below.

Sample ID	2-3 at 2.0 m-bgl		3-1 at 2.5 m-bgl		7-2 at 2.0 m-bgl		8-3 at 1.4 m-bgl		13-2 at 2.0 m-bgl	
Sample Description	Man-made fill (brown to black, gravel and sand sized material with coal grains)		Man-made fill (black/reddish-black with sand and gravel)		Clayey, sandy silt (yellowish brown silty and sand on the top)		Clayey silt/silty clay (grey, compact medium plastic, with fine sand to the bottom)		Man-made fill (red, silty, industrial waste material)	
	Metal contents in soil (mg/kg dry weight)	Metal contents in leachate (µg/l)	Metal contents in soil (mg/kg dry weight)	Metal contents in leachate (µg/l)	Metal contents in soil (mg/kg dry weight)	Metal contents in leachate (µg/l)	Metal contents in soil (mg/kg dry weight)	Metal contents in leachate (µg/l)	Metal contents in soil (mg/kg dry weight)	Metal contents in leachate (µg/l)
Arsenic	53	5.4	24	2.3	11	4.5	35	2.5	1100*	8300*
Barium	850	210	64	170	95	< 0.05	92	110	660	160
Cadmium	180*	8.7*	8.2	0.37	1.1	< 0.08	0.8	8.7*	7.5	3.4
Chromium	110	1.8	63	2.3	25	1.5	24	1.6	<1.0	0.7
Cobalt	99	2.3	95	390*	11	0.6	11	84	15	11
Copper	2200*	58	70	3.0	27	13	38	2.4	610*	5.2
Lead	440	20	200	14	50	2.3	71	8.9	1400*	320*
Mercury	<0.3	< 0.5	<0.3	< 0.5	<0.3	< 0.5	<0.3	< 0.5	6.6	< 0.5
Molybdenum	17	21	6.3	26	1.1	3.2	0.7	< 0.4	1.9	< 0.4
Nickel	190*	3.5	160	170*	34	1.4	33	83	18	12
Tin	190	9.1	37	11	2.5	< 1.0	2.3	< 1.0	4.9	< 1.0
Zinc	3500*	44	70000*	23000*	200	10	560	7800*	1000*	1100*

*Bolded figures indicate concentrations above Dutch List Intervention Values.

Obtained results indicate that metals contained in analyzed soil samples may be easily leaching and vertically migrating into groundwater. This phenomenon is particularly visible for Arsenic, Cadmium, Cobalt, Lead, Nickel and Zinc. In the leachate, metals concentrations reached values significantly exceeding Dutch List Intervention Values for groundwater.

7 Assessment of Results

Cinkarna Celje production facility in Celje

Laboratory analysis of collected soil samples indicated significant contamination of soil at the site with heavy metals. In numerous samples, both the Slovenian Critical Values and Dutch List Intervention Values were exceeded.

The highest concentrations were observed for:

- Zinc (concentrations up to 180,000 mg/kg, which is 250 times higher than Dutch List Intervention Value of 720 mg/kg),
- Antimony (concentrations up to 530 mg/kg, which is 24 times higher than Dutch List Intervention Value of 22 mg/kg),
- Arsenic (concentrations up to 10,000 mg/kg, which is 131 times higher than Dutch List Intervention Value of 76 mg/kg),
- Barium (concentrations up to 3,200 mg/kg, which is 3.5 times higher than Dutch List Intervention Value of 920 mg/kg),
- Cadmium (concentrations up to 660 mg/kg, which is 50 times higher than Dutch List Intervention Value of 13 mg/kg),
- Copper (concentrations up to 160,000 mg/kg, which is 842 times higher than Dutch List Intervention Value of 190 mg/kg),
- Cobalt (concentrations up to 770 mg/kg, which is 4 times higher than Dutch List Intervention Value of 190 mg/kg),
- Lead (concentrations up to 45,000 mg/kg, which is 84 times higher than Dutch List Intervention Value of 530 mg/kg) and
- Nickel (concentrations up to 670 mg/kg, which is 6.7 times higher than Dutch List Intervention Value of 100 mg/kg).

The highest concentrations of heavy metals are associated with presence of man-made fills, mainly in the layers of gravel-size metallurgical waste and fine, red-colored industrial waste ("pyrite waste"). Man-made fills, in which the highest concentrations of heavy metals were detected, were observed in all executed boreholes. The layer of man-made fills reaches a thickness of 1.4-3.6 m-bgl in Area 1, 1.2-4.7 m-bgl in Area 2, 2.1-3.7 m-bgl in Area 3, 3.5 m-bgl in Area 4, 2.2 m-bgl in Area 5, 0.5-1.4 m-bgl in Area 6, 1.2-1.6 m-bgl in Area 7, 0.6-3.8 in Area 8, 1.1-2.0 m-bgl in Area 9, 0.9-1.4 m-bgl in Area 10, 1.7 m-bgl in Area 11, 0.5-4.4 m-bgl in Area 12, 0.5-3.5 m-bgl in Area 13, 0.9 m-bgl in Area 14, 3.0-4.5 m-bgl in Area 15 and 1.2 m-bgl in Area 16.

In the eastern part of the site (boreholes 12-10, 12-13, 13-2), presence of silty, red-colored industrial waste material ("pyrite waste") was observed, with a total depth exceeding 4.5 meters bgl. Concentrations of heavy metals in this layer were also significant (Antimony: 59-150 mg/kg, Arsenic: 800-10,000 mg/kg, Cadmium: 8-37 mg/kg, Copper: 510-4,000 mg/kg, Lead: 970-2000 mg/kg, Nickel: 15-400 mg/kg and Zinc: 1,700-9,600 mg/kg). As reported by site representatives, most likely, the red-colored industrial waste originates from historical production of sulfuric acid using a pyrite as raw material. Similar material was also observed at the solid waste landfill Bukovžlak and the air side of the red gypsum dam Bukovžlak and Za Travnikom.

In soil samples collected from natural soil strata, located beneath the layers of man-made fill, concentrations of heavy metals were significantly lower than in soil samples collected from man-made fills. However, elevated concentrations of heavy metals were also observed in soil samples collected from natural strata, for example in soil samples:

- 1-2 at 3.5 m-bgl in a layer of gravel (concentration of Antimony of 290 mg/kg, concentration of Copper of 230 mg/kg, concentration of Lead of 2,400 mg/kg and concentration of Zinc of 3,500 mg/kg),
- 1-4 at 3.5 m-bgl in a layer of fine/medium sand (concentration of Barium of 3,200 mg/kg and concentration of Zinc of 1,100 mg/kg),
- 2-2 at 3.5 m-bgl in a layer of medium sand (concentration of Zinc of 2,100 mg/kg),
- 2-3 at 3.0 m-bgl in a layer of fine sand (concentration of Zinc of 1,100 mg/kg),
- 5-1 at 3.4 m-bgl in a layer of coarse sand (concentration of Zinc of 730 mg/kg),
- 7-2 at 3.0 m-bgl in a layer of clay (concentration of Copper of 220 mg/kg and a concentration of Zinc of 3,700 mg/kg) and at 3.6 m-bgl in a layer of clay (concentration of Copper of 470 mg/kg),
- 8-1 at 1.0 m-bgl in a layer of clay (concentration of Copper of 440 mg/kg and a concentration of Zinc of 1,300 mg/kg),
- 8-2 at 3.0 m-bgl in a layer of fine/medium sand (concentration of Zinc of 1,100 mg/kg),
- 8-3 at 3.5 m-bgl in a layer of clayey sand (concentration of Zinc of 4,000 mg/kg),
- 8-6 at 1.0 m-bgl in a layer of silty clay (concentration of Zinc of 730 mg/kg),
- 9-1 at 2.3 m-bgl in a layer of silty sand (concentration of Cadmium of 16 mg/kg and a concentration of zinc of 1,500 mg/kg),
- 10-3 at 1.0 m-bgl in a layer of clayey silt (concentration of Cadmium of 39 mg/kg and a concentration of Zinc of 3,900 mg/kg),
- 11-1 at 1.0 m-bgl in a layer of silty clay (concentration of Zinc of 2,000 mg/kg) and at a depth of 2.5 m-bgl in a layer of medium sand (concentration of Zinc of 1,900 mg/kg).

These results indicate that heavy metals may be leached (with precipitation water infiltrating into the soil) from the layer of man-made fills into deeper, natural soil strata.

This observation is also supported with the results of leaching tests (presented in Chapter 6.3 above), where significant concentrations of heavy metals were observed in eluate obtained by mixing of selected soil samples and water. Results of soil leaching tests and principles of environmental impacts indicate that an impact on the environment of analysed soil is negative. This opinion is also confirmed by laboratory analysis results for the presence of heavy metals in groundwater samples collected from monitoring wells.

The results of analysis of groundwater samples collected from 25 temporary monitoring wells installed at Cinkarna Celje site indicate that groundwater is impacted with heavy metals, in particular Zinc, which was observed in all collected groundwater samples. Elevated concentrations of Zinc (over the Dutch List Intervention Value of 800 µg/l) were observed in 13 out of 25 collected groundwater samples. In some groundwater samples, concentrations of Zinc were significantly high, exceeding Dutch List Intervention Value

of 800 µg/l in groundwater samples collected from temporary monitoring wells No. 2-1 (25,000 µg/l), 2-5 (34,000 µg/l), 3-1 (120,000 µg/l), 4-1 (1,700 µg/l), 5-1 (7,700 µg/l), 7-1 (1,600 µg/l), 8-5 (18,000 µg/l), 8-6 (2,000 µg/l), 8-7 (1,700 µg/l), 11-1 (1,000 µg/l), 12-3 (8,400 µg/l), 12-11 (1,600 µg/l) and 12-13 (2,400 µg/l). Elevated concentrations of Arsenic, Cadmium, Cobalt, Copper, Lead, Mercury and Nickel, exceeding the Dutch List Intervention Values, were also observed.

With regards to organic compounds, elevated concentrations of these parameters were observed in soil samples collected only in two boreholes: borehole No. 3-1 and 9-2. In borehole No. 3-1, a concentration of sum of Polycyclic Aromatic Hydrocarbons in a soil sample collected at 1.0 m-bgl was 52.8 mg/kg and exceeded the Dutch List Intervention Value of 40 mg/kg and a concentration of mineral oil (TPH fraction C12-C35) in a soil sample collected at 3.0 m-bgl was 6,700 mg/kg and exceeded the Dutch List Intervention Value of 5,000 mg/kg. In borehole 9-2 in a sample collected from a depth of 1.0 m-bgl a concentration of TPH (C12-C35) was 77,000 mg/kg and exceeded the Dutch List Intervention Value of 5,000 mg/kg. In the case of borehole No. 3-1, no obvious existing source of impact was observed in the vicinity of the borehole (borehole 3-1 was drilled through an asphalt cover on a yard located at the area of Titanium Dioxide production). In the case of borehole No. 9-2, soil contamination with TPH was observed in a thin layer of soil stained with heavy oil (mazoute) in the vicinity of historical Aboveground Storage Tanks for heavy fuel.

Cinkarna Mozirje production facility in Mozirje

Laboratory analysis of soil samples collected from three boreholes at the site of the Cinkarna Mozirje did not reveal significant soil contamination, both in the soil samples collected from natural strata (MO-2 at 3.0 m-bgl, MO-3 at 1.0 m-bgl and MO-3 at 3.0 m-bgl) and in the soil samples collected from a layer of man-made fills (MO-1 at 0.7 m-bgl, MO-1 at 2.2 m-bgl and MO-2 at 0.5 m-bgl).

With regards to presence of heavy metals in soil, the observed concentrations indicated natural, background concentrations, except for concentration of Zinc in one soil sample (concentration of Zinc of 850 mg/kg in a soil sample MO-1 at 2.2 m-bgl, exceeding the Dutch List Intervention Value of 720 mg/kg). Presence of organic compounds was detected in two soil samples (MO-1 at 2.2 m-bgl and MO-2 at 0.5 m-bgl). Both soil samples were collected from a level of man-made fill. In both samples, compounds from the group of Polycyclic Aromatic Hydrocarbons (the sum of PAHs in the first sample was 4.46 mg/kg and was 18.8 mg/kg in the second one), as well as mineral oil (TPH fraction C12-C35 in the first sample was 19 mg/kg and was 100 mg/kg in the second one) were detected. Concentrations of PAHs were below Dutch List Intervention Values.

Analysis of groundwater samples collected from three temporary monitoring wells installed at the Cinkarna Mozirje site, did not reveal significant impacts both of heavy metals and organic compounds. In particular, no presence of Polycyclic Aromatic Hydrocarbons or Volatile Organic Compounds was observed.

Bukovžlak red gypsum landfill

Laboratory analysis of soil samples collected from three boreholes at the Bukovžlak landfill for red gypsum, did not reveal significant soil contamination, except for one soil sample, collected from borehole BG-2 at a depth of 4.2 m-bgl. Laboratory analysis of this sample revealed high concentrations of Antimony (54 mg/kg), Arsenic (2,000 mg/kg), Copper (1,800 mg/kg), Lead (910 mg/kg) and Zinc (2,400 mg/kg), all of them exceeding Dutch List

Intervention Values. This sample was collected from a borehole located down-gradient of the Bukovžlak landfill for red gypsum, approx. 3 meters north of the landfill's dam, within the area of the solid waste landfill Bukovžlak. The sample was collected from a layer of silty, red-colored fine industrial waste material ("pyrite waste").

Analysis of groundwater samples collected from four permanent monitoring wells installed in the vicinity of Bukovžlak landfill for red gypsum indicated:

- Concentrations of heavy metals typical for natural, not impacted groundwater, in a groundwater sample BUK-1, collected from a monitoring well located up-gradient of the landfill.
- Elevated concentrations of heavy metals in two groundwater samples collected from monitoring wells located down-gradient of the landfill: in groundwater sample K-10 (Arsenic concentration of 1,550 µg/l and Zinc concentration of 990 µg/l, both exceeding Dutch List Intervention Values) and in groundwater sample K-11 (Cadmium concentration of 43 µg/l, Cobalt concentration of 210 µg/l, Nickel concentration of 140 µg/l and Zinc concentration of 8,400 µg/l, all exceeding Dutch List Intervention Values). Both permanent wells (K-10 and K-11) are located in the area built of "pyrite waste" (silty, red-colored fine industrial waste material), which was incorporated in the air side of the dam Bukovžlak. Increased concentrations of heavy metals in groundwater sample collected from a monitoring wells K-10 and K-11 result from leaching of heavy metals from the "pyrite waste". The "pyrite waste" is known to contain elevated concentrations of leachable heavy metals (which was confirmed with leaching test of one "pyrite waste" sample, discussed in Chapter 6.3).

No organic compounds were detected in any of the groundwater samples collected at the Bukovžlak landfill for red gypsum. Groundwater quality at the landfill is monitored on a regular basis.

Bukovžlak non-hazardous solid wastes landfill

Laboratory analysis of soil samples collected from three boreholes at the Bukovžlak landfill for solid wastes, did not reveal significant soil contamination, except for one soil sample, collected from borehole BS-2 at a depth 1.0 m-bgl. Laboratory analysis of this sample revealed high concentrations, exceeding Dutch List Intervention Values, of Antimony (48 mg/kg), Arsenic (1,200 mg/kg), Cadmium (15 mg/kg), Copper (3,200 mg/kg), and Zinc (4,100 mg/kg). This sample was collected from a borehole located down-gradient of the Bukovžlak landfill for solid wastes, approx. 50 meters north-west of the landfill's embankment. The sample was collected from a layer of silty, red-coloured fine industrial waste material ("pyrite waste").

Analysis of groundwater samples collected from six permanent monitoring wells installed in the vicinity of Bukovžlak landfill for solid wastes, indicated:

- Elevated concentrations of heavy metals in one groundwater sample collected from monitoring wells located down-gradient of the landfill: in groundwater sample A-3 (Cobalt concentration of 220 µg/l, Nickel concentration of 140 µg/l and Zinc concentration of 9,200 µg/l), all of them exceeding Dutch List Intervention Values.
- Elevated concentrations of heavy metals in one groundwater sample located up-gradient of the landfill: in groundwater sample P-4 (Cadmium concentration of 9.9 µg/l, Copper concentration of 110 µg/l, and Zinc concentration of 4,700 µg/l - all of them exceeding Dutch List Intervention Values). This monitoring well (P-4)

is located up-gradient of Bukovžlak landfill for solid wastes but down-gradient of the Bukovžlak landfill for red gypsum (10 meters north of the landfill's embankment). P-4 monitoring well is located in the area built of "pyrite waste" (silty, red-colored fine industrial waste material), which was incorporated in the air side of the dam Bukovžlak and disposed of in the location of solid waste landfill Bukovžlak. Increased concentrations of heavy metals in groundwater sample collected from a monitoring well P-4 result from leaching of heavy metals from the "pyrite waste". The "pyrite waste" is known to contain elevated concentrations of leachable heavy metals (which was confirmed with leaching test of one "pyrite waste" sample discussed in Chapter 6.3).

No organic compounds were detected in any of the groundwater samples collected at the Bukovžlak landfill for solid wastes. Groundwater quality at the landfill is monitored on a regular basis.

Za Travnikom red gypsum landfill

Laboratory analysis of soil samples collected from three boreholes at the Za Travnikom landfill for red gypsum, did not reveal significant soil contamination with respect to both heavy metals and organic compounds. The observed concentrations of heavy metals and organic compounds indicated natural, background concentrations.

Analysis of groundwater samples collected from four permanent monitoring wells installed in the vicinity of the Za Travnikom landfill for red gypsum, indicated:

- Concentrations of heavy metals typical for natural, not impacted groundwater, in a groundwater sample Z-1A, collected from a monitoring well located up-gradient of the landfill.
- Elevated concentrations of heavy metals in one groundwater sample collected from a monitoring well located down-gradient of the landfill: in groundwater sample TV-1A (Cobalt concentration of 1,700 µg/l, Nickel concentration of 430 µg/l and Zinc concentration of 9,000 µg/l), all of them exceeding Dutch List Intervention Values. According to the information of Cinkarna's representatives, on this location pyrite burdens ("pyrite waste") were incorporated in the air side of the dam Za Travnikom. Increased concentrations of heavy metals in groundwater sample collected from a monitoring well TV-1A result from leaching of heavy metals from the "pyrite waste". The "pyrite waste" is known to contain elevated concentrations of leachable heavy metals (which was confirmed with leaching test of one "pyrite waste" sample discussed in Chapter 6.3).

No organic compounds were detected in any of the groundwater samples collected at the Za Travnikom landfill for red gypsum. Groundwater quality at the landfill is monitored on a regular basis. According to the information of Cinkarna's representatives, on this location pyrite burdens were incorporated in the air side of the dam Za Travnikom.

Farming land located north of Bukovžlak landfill

Laboratory analysis of three soil samples collected at the farming land located north of the Bukovžlak landfill, did not reveal significant soil contamination with respect to both heavy metals and organic compounds. The observed concentrations of heavy metals and organic compounds indicated natural, background concentrations.

8 General Conclusion and Recommended Improvement Action Plan

General

Recommended Improvement Action Plan presented below is applicable to the site of Cinkarna Celje. Despite observed environmental impacts (i.e. elevated concentrations of heavy metals in some of soil and groundwater samples collected at Bukovžlak and Za Travnikom landfills, which are clearly the result of impact of pyrite waste and not of deferred red gypsum), it is understood that the already implemented mitigation measures and control at the landfills, including a yearly monitoring of groundwater, collection of leachates from Bukovžlak landfill for solid wastes, capping of the landfills' surface with waters (landfills for red gypsum) and vegetation (Bukovžlak landfill for solid wastes) are oriented on minimization of environmental impacts. Additionally the company has prepared a project of installation of a capping system equipped with a system of drainage and collection of rain water in the frame of closing Bukovžlak solid waste landfill. At the landfill Za Travnik a project of dewatering of the landfill's surface is already under completion and the same solution could be carried out on the landfill of red gypsum Bukovžlak.

Concentrations of heavy metals in soil and groundwater samples collected at Cinkarna Mozirje site do not indicate a need to undertake improvement (remediation type) measures. Therefore, the following conclusions and proposed improvement activities applicable to the Cinkarna Celje site.

Cinkarna Celje Site

The results of analysis of soil and groundwater samples collected at the area of Cinkarna Celje indicate that both the soil and groundwater contain significant concentrations of heavy metals (Antimony, Arsenic, Barium, Cadmium, Copper, Lead, Nickel and Zinc). Concentrations of heavy metals, both in soil and groundwater, significantly exceed Dutch List Intervention Values, which indicate that the functional properties of the soil for humans, plant and animal life are seriously impaired or threatened. They are representative of the level of contamination above which there is a serious case of soil contamination is deemed to exist.

Soil and groundwater contamination at the site of Cinkarna Celje can be attributed to presence of man-made fills, mainly in the layers of gravel-size metallurgical waste and fine, red-colored industrial waste ("pyrite waste"). Man-made fills, in which the highest concentrations of heavy metals were detected, were observed in all executed boreholes and are assessed to comprise the source of secondary contamination (i.e. to groundwater).

It was also observed that in the eastern part of Cinkarna Celje site (location of sulphuric acid facility and solid sulphur storage), fruit trees (apple trees) and vegetables (tomatoes) are being cultivated and, probably, fruits and vegetables are eaten by site employees. Because the area where the trees and vegetables are cultivated was observed to contain soils and groundwater with elevated heavy metals concentrations (in particular, soil samples from boreholes 12-8, 12-9 and 12-13 and groundwater from monitoring wells 12-11 and 12-13), as an immediate measure, consumption of vegetables and fruits should be eliminated, because heavy metals can be accumulated in the biomass of fruits and vegetables,

potentially causing adverse effects on the health of individuals consuming these fruits and vegetables.

Recommended Remediation Action Plan

The goal of the recommended Remediation Action Plan is:

- to minimize environmental impact of historical contamination present at the site ("**technical part**"),
- to obtain formal confirmation (decision/certificate) from an appropriate authorities that the proposed (and completed) technical improvements are accepted and the current/future owner of the site is not liable for additional remediation activities connected with historical contamination ("**formal part**").

Technical Part

While considering potential remediation scenarios, the following factors were taken into account:

1. Elevated concentrations of heavy metals were detected in soil and groundwater samples collected at the Cinkarna Celje site;
2. Soil and groundwater contamination was observed on a majority of the site area (heavy metals concentrations exceeding Slovenian Critical Values and Dutch List Intervention Values for soil were observed in 39 boreholes out of 55 executed boreholes and heavy metals concentrations exceeding Dutch List Intervention Values for groundwater were observed in 16 groundwater samples out of 25 collected samples);
3. Aboveground infrastructure as well as a dense network of underground utilities is present at Cinkarna Celje site;
4. While performing any type of remediation actions at Cinkarna Celje site, it is necessary to ensure continuous, undisturbed and safe operation of the production plant;
5. In cases where due to construction needs it will be necessary to excavate soil at Cinkarna Celje site, the excavated soil should be remediated and all dusting preventive measures during the work should be undertaken. It is also recommended to implement appropriate Health and Safety measures for workers that may come into contact with impacted soils.

In ENVIRON's opinion, the most reasonable (from technical, environmental and economical points of view) would be the following direction of action:

- In order to ensure that heavy metals are not migrating out of the areas of their current presence, the areas which are not hardened or covered by buildings should be covered by permanent vegetal cover.
- Quality of groundwater at Cinkarna Celje site should be monitored on permanent basis; it is recommended to install a network of permanent monitoring wells. According to land surveying measurements performed in August 2014 (within investigations conducted by ENVIRON), the groundwater flow direction is towards

the north-west. It is recommended to install permanent groundwater monitoring wells downgradient and upgradient of the potential groundwater flow. The potential cost of permanent monitoring system installation at the site is approximately 50,000-80,000€. The hydrogeological monitoring should be based on measurements of groundwater table depth at least one time per month. Groundwater sampling and testing should be conducted every three months; in the future, based on obtained monitoring results, the frequency of sampling and testing can be modified accordingly.

- In order to observe the quality of groundwater, it is recommended to install a network of permanent monitoring wells. According to land surveying measurements performed in August 2014 (within investigations conducted by ENVIRON), the groundwater flow direction is towards the north-west. It is recommended to install permanent groundwater monitoring wells in the following areas:
 - inflow of groundwater (south-eastern part of the site): in location of temporary monitoring wells 10-3, 16-1 and on a lawn in the vicinity of the fire-station),
 - Area 12 (with observed groundwater contamination with Arsenic, Chromium, Nickel, Cadmium and Zinc): in location of temporary monitoring wells 12-3, 12-11 and 12-13,
 - central part of the site: in location of temporary monitoring wells 3-1, 5-1, 7-1, 8-5, 8-6, 8-7,
 - outflow of groundwater: in location of temporary monitoring wells 2-1, 2-5, 6-3 and one additional monitoring well on a lawn in the vicinity of Hudinja river (north-western border of the site).
- The on-site groundwater monitoring system via on-site monitoring wells should be supplemented by monitoring of quality of surface water in both rivers located in the site's vicinity. According to the site management, monitoring of water, sediment and biotope of Hudinja river has been performed by the company since 2005, but the scope of monitoring is limited to parameters which are associated with actual production of TiO₂.
- With the aim to determine the possible impact on the environment and human health (ZVO-1) it is recommended to prepare a comprehensive monitoring program on rivers Hudinja and Vzhodna Ložnica. The scope of the monitoring program should cover all the pollutants that exceed Dutch List Intervention Values and/or Slovenian Critical Values. The frequency and duration of monitoring should be determined by the competent authority.
- If future groundwater monitoring results indicate a significant impact of the contaminated fill material present at the site, in order to avoid further propagation (migration) of contaminants through groundwater into adjacent water bodies (Hudinja and Vzhodna Ložnica rivers), it is proposed to consider implementation of further mitigation measures.

Formal Part

- All improvement works should be discussed, with participation of a legal advisor, with a competent environmental authority. Prior to initiation of improvement works/measures, it is recommended to obtain a confirmation (a formal

document/decision/certificate) from a competent environmental authority that the proposed scope of works will result in: (1) acceptable limitation of impacts on humans and environment, and (2) that the current/future owners/occupants of the site will not be held liable for a historical contamination.

- After completion of works, it is recommended to obtain a formal confirmation from competent authorities that agreed activities have been completed in line with agreed scope and conditions.