PROJECT OF DEVELOPMENT COOPERATION OF THE CZECH REPUBLIC AND MACEDONIA

„OLD ENVIRONMENTAL BURDENS IN CHEMICAL PLANT OHIS, SKOPJE“

Feasibility Study

for Treatment/Disposal of Construction Materials

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Acronyms and Abbreviations Used

a.s.l. - above sea level

BTEX - benzene, toluene, ethyl benzene, xylenes

CHC - chlorinated hydrocarbons

CR - Czech Republic

d.m. - dry matter

DIV - Dutch intervention value

DOC - dissolved organic carbon

DM - dissolved matter

HCH - hexachlorocyclohexane

HM - heavy metals

m b.g.l. - meters below ground level

MK - Republic of Macedonia

PAH - polyaromatic hydrocarbons

PCB - polychlorinated biphenyles

TCB - trichlorobenzene

TDS - total dissolved solids

VOC - volatile organic compounds

1. Introduction

The project „Old Environmental Burdens in Chemical Plant OHIS, Skopje“ is financed from the Official Development Assistance Programme of the Czech Republic. The project is being implemented by Czech company ENACON s.r.o. that has been contracted by Ministry of Environment of the Czech Republic.

This report presents the outputs of Feasibility Study carried out within the frame of the above project. The feasibility study arises out of the Risk Assessment performed in previous project phase.

In total, four separate Feasibility Studies were elaborated for the OHIS plant. The reason for this procedure is that for large remediation projects, funding may not be available all at one time but in increments, it may therefore be appropriate to plan the implementation of remediation in increments - the challenge is to divide the project into increments that can stand alone from environmental and engineering feasibility perspectives should the next funding increment be delayed or unavailable.

This feasibility study proposes and assesses alternative actions aiming at reducing and/or eliminating risks related to the wastes resulting from prospective pull down of former production buildings, warehouses and other structures except for the wastes resulting from pull down of former electrolysis plant that have specific character and are assessed in separate FS for Hg laden soil and waste

This report has been prepared by DEKONTA a.s. (Jan Vana) – the main subcontractor of Enacon. Description of buildings, calculation of construction's volume and cost estimate were completed by subcontracting Czech company CHEMIA SYSTEM GEO s.r.o..

Data processing and graphic outputs were executed by Petr Pokorny and Hana Cudova (Enacon).

Report has been reviewed by Jan Nemecek, project manager (Enacon).

2. Site Settings

2.1 General Information

2.1.1 Geographical Site Definition

The chemical plant OHIS is located at the southeastern edge of the city of Skopje, about 5.5 km apart the city centre in an industrial area that is spread along the road connecting Skopje and the city of Dracevo (see Annex 1). The site was developed in the first half of the 60´s, the lindane was produced in the period from 1965 to 1972; the electrolysis plant was in operation in the period from 1965 to 1995.

The project deals with old environmental burdens originated from historical production of lindane, monochloracetic acid and chlorine. Facilities, storage buildings related to the above stated production, and HCH dumps are located in the western part of the OHIS plant further referred as the "site". The whole OHIS plant covers the area of approximately 0.9 km², the "site" covers the area of approximately 0.1 km² (10 ha). Ruins of the electrolysis plant are situated the northern part of the site (see fig.1).

Figure 1: Site layout

1= ruins of electrolysis plant, 2 = ruins of monochloracetic acid production facility, 3 = dump of lindane isomers

2.1.2 Existing and Planned Land Use

At present, the site is mostly abandoned. Some production activities are performed with regards to repackaging of pesticides (produced off-site) from large containers to small retail packaging, and in the area of former electrolysis plant there is a chlorine distribution facility operating still, the chlorine is transported to this facility in pressurized vessels and it is used for production of hydrochloric acid.

The present surrounding land use is as follows:

To the north: railway with a railway station and beyond it a private agricultural land and further to the north within a distance of 150 m from the site residential houses of the village of Gorno Lisiče (part of Skopje).

To the southeast: the part of the OHIS plant dealing with production of detergents.

To the southwest: the road connecting Skopje and Dracevo and beyond it a mixed industrial/commercial area with an abandoned glass mill and further to the southwest rural area with dwellings of Kisela Voda.

To the northwest: undeveloped part of OHIS plant and beyond it a small residential area.

2.1.3 Basic Demographic Settings

The nearest residential area is Gorno Lisiče located approximately 200 m to the northeast of the site. Dwellings belonging to Kisela Voda are located about 300 m to the southwest of the site. Based on the rough estimate, up to 1,000 residents live within a distance of 500 m from the site mainly in Gorno Lisiče. The site itself is almost abandoned. During filed work performed in March 2008 it was observed that first tens of people are involved in some minor production activities, maintenance and guarding at the site.

2.2 Natural Conditions

2.2.1 Geomorphologic Settings

The site is located at the southwestern edge of the flood plain of the Vardar River at an average elevation of 239 m a.s.l. The site area is almost flat, just very gently sloping to the northeast. Further to the southwest of the site there are the steep side hills of the Vodno Mountain range.

2.2.2 Climatic Settings

The average annual air temperature is 12.5 ^{o}C, and the maximum temperature is 41.2 ^{o}C. Usually the climate during the summer period is very dry and warm, in winter the climate is moderate cold. The average annual precipitation is 502.3 mm (Eptisa 2007).

2.2.3 Geological Settings

The bedrock beneath the site area is composed of Pliocene sediments comprising sandstone, marlstone, and conglomerate. The depth to bedrock rapidly increases in north-east direction from first tens of meters to more than 200 m along the Vardar River. The bedrock is overlain by Quaternary proluvial sediments comprising sandy, gravely and silty loams. Quaternary proluvial sediments fill the depression eroded in Pliocene sediments. The thickness of Quaternary proluvial sediments is about 70 m at the site and increases in northern direction to approximately 90 m. The Quaternary proluvial sediments are overlain by alluvial sediments of the Vardar river comprising mainly gravels, sandy, silty and loamy gravels intercalated with thin layers (first tens of centimeters) of sandy gravelly clay and silt. The uppermost layers of alluvial sediments comprise clayey silt to silty clay. The thickness of these fine grained sediments varies at the site from 1.5 m to 5.2 m. The alluvial sediments are locally overlain by fill comprising mostly crushed aggregate, gravelly clay and gravel. The thickness of the fill averages at about 0.5 m. Allegedly, it was man-deposed during the various historic construction/revamping stages of the site.

2.2.4 Hydrogeological Settings

Phreatic aquifer is developed in the alluvial sediments of the Vardar River. The permeability of the aquifer is 10^{-3} m/s up to 10^{-2} m/s in formations of pure gravel. Underlying proluvial sediments can be also considered as water bearing strata, however of lower permeability. The depth to groundwater is about 8 to 8.5 m below the ground level (bgl). The saturated thickness of the aquifer is about 60 m at the site and increases in northern direction. Groundwater flows generally toward the east and finally discharges into the Vardar River and into the lowermost section of the Markova reka River.

Groundwater is abstracted in down-gradient and cross-gradient direction in number of domestic wells in the village of Gorno Lisiče. The nearest well is located within the distance of about 150 m to the northeast from the site border. Based on the interviews with the local residents, wells are rather shallow (about 10 to 12 m) and abstracted groundwater is used for irrigation only. Drinking water is supplied by municipal mains there. Two abstraction well fields of OHIS plant are located in the alluvial plain of the Vardar River. Well field "Lisiče 1" consists of 8 wells of the depth of approximately 30 m situated perpendicular to groundwater flow at the distance of 1.2 km to the northeast of the site border (thus cross-gradient with respect to groundwater flow). Well field Lisiče 1 is reportedly more than 6 years out of operation. At the distance of approximately 2.3 km to the northeast of the site (about 200 m to the south of the Vardar River) there is abstraction well Lisiče 2. It is a 23 m deep well 5.5 m in diameter with radial drains 17 to 33 m long. The annual amount of groundwater abstracted from this well was approximately 2 mil. m^3 in 2007 (average pumping rate of 63 l/s). According to information provided by OHIS representatives abstracted groundwater is used for sanitary purposes and as a source of process water. Groundwater is not used for drinking. Based on the location of well Lisiče 2 with respect to Vardar River and general direction of groundwater flow, the well abstracts mainly surface water of the Vardar River that recharge the alluvial aquifer rather than intercepts groundwater flowing from the site.

2.2.5 Hydrological Settings

The nearest surface water is the Colemni Kamenj creek flowing in direction SW - NE at the distance of 400 m to the northwest of the site. The Colemni Kamenj creek discharges into the Vardar River – a regional watercourse flowing in northwest – southeast direction at the distance of 2.3 km to the northeast of the site. Another watercourse in the site vicinity is the Markova reka river flowing in south - north direction within a distance of 1.6 to the east of the site. The Markova reka River discharges into the Vardar River some 1 km downgradient of the estuary of Colemni Kamenj to the Vardar.

The Vardar river covers a catchments area of 4,650 km^2, the mean flow rate (calculated for the profile in Skopje) is 63 m^3/s, the 90% flow rate ($Q_{min90\%}$) is 6,34 m^3/s.

Reportedly, the OHIS property has never been flooded by the Vardar River or by the Markova reka River. In 1962, the OHIS area was flooded by the storm water run-off from the Vodno Mountains. The capacity of the Colemni Kamnej creek was not sufficient to collect stormwater and did overflow.

2.2.6 Geochemical and Hydrochemical Settings

Hydrochemical properties of groundwater were investigated with the aim to assess potential groundwater contamination and the fate of contaminants in the aquifer.

In summary, groundwater of the aquifer is of neutral to alkaline pH (6.95 – 9.97), slightly negative redox potential (–14 to -111 mV by Ag/AgCl electrode) and of elevated conductivity within the OHIS site (1086 – 1576 µS/cm). Concentration of dissolved oxygen (measured in September 2007 only) was 0.96 and 3.61 mg/l, respectively). The groundwater has content of nitrates in order of magnitude of tens of mg/l, content of sulphates from 83 to 163 mg/l and low content of iron and manganese (both below 1 mg/l). Based on the above given concentrations of the anions in groundwater and measured physical-chemical parameters the redox conditions of the aquifer can be considered as indifferent (between aerobic and nitrate reducing conditions).

2.3 Previous Investigations

2.3.1 Results of Previous Investigations

No systematic soil and groundwater investigation has been performed at the site in the past.

In 2001, screening of soil and groundwater contamination was performed by company BENA, Thessalonica within the project CARDS in 2002. Within the frame of this project two monitoring wells HS-1 and HS-2 were installed next to the former electrolysis plant and next to the δ-HCH dump, respectively. Soil samples were taken from the core of both borings and samples of groundwater were taken. In addition, samples of sediment of an old wastewater canal and wastewater sample were taken and two soil samples of superficial soil were taken within near the monitoring wells HS-1 and HS-2. All the collected samples were analyzed for wide spectrum of inorganic as well as organic parameters.

In the first superficial soil sample elevated concentration of mercury was determined – 7 mg/kg d.m.; in the second sample laboratory analyses did not found elevated concentration of any analyzed metal. Soil analyses encountered elevated concentrations of total chlorinated hydrocarbons (127 µg/kg calculated as TCE) in the depth interval 4 to 5 m bgl. of boring HS-1 and also in boring HS-2 in the depth interval 3 to 4 m bgl. (42.72 µg/kg).

Groundwater sample taken from well HS-1 contained elevated concentrations of TCE – 104.95 µg/l, PCE – 132.45 µg/l, α-HCH – 0.239, β-HCH µg/l – 0.282 µg/l, aldrin – 0.3 µg/l and of mercury – 1.1 µg/l. Groundwater sample taken from well HS-2 contained elevated concentrations of α-HCH – 2.4, β-HCH – 3.20 µg/l, γ-HCH – 0.38 µg/l and of tribromomethane – 18.39 µg/l. No elevated concentrations of polycyclic aromatic hydrocarbons (PAH) or of analyzed metals (Pb, Cr) were encountered in any of the groundwater samples.

Laboratory analyses of sediments of the old wastewater canal found elevated concentrations of γ-HCH in order of tens of µg/kg in the depth interval from 0 to 2.5 m below the canal bottom. Maximal concentration was 53.9 µg/kg in the depth interval 0 to 0.5 m below the canal bottom. The sample of OHIS wastewater discharged into the Vardar River contained elevated concentrations of TCE – 23.4 µg/l and of Hg – 0.11 µg/l.

In 2007, company EPTISA performed limited site investigation within a project managed by the European Agency for Reconstruction. The site investigation consisted of geoelectrical (resistivity) mapping with the goal to evaluate possible anomaly zones indicating contamination of soil and groundwater by HCH and mercury and to propose strategy for site remediation. Four anomalies were detected by geoelectric mapping – to the east of the former electrolysis plant (Hg contamination), to the southeast of the former monochloracetic acid plant, along the north-eastern side of the α-HCH and β-HCH dump and to the east of this dump (contamination by HCH).

In 2007, the Institute of Public Health in Skopje collected four superficial soil samples (0.05 to 0.35 m b.g.l.) in the surroundings of the former electrolysis plant and analyzed them for the content of mercury. Apparently, content of mercury exceeded respective DIV only in just one sample collected next to the electrolysis plant (110 mg/kg d.m.).

3. Site Characterization

3.1 Method and Scope of the Site Investigation

The goal of the site characterization was to:

1) investigate contamination of soil, groundwater and construction materials;
2) investigate two dumpsites of HCH waste isomers;
3) screen the impact of contaminants on the home-grown vegetables in the OHIS vicinity.

The scope of work included:

- Site visit, preparation of sampling plan;
- Execution of 49 soil borings and 8 direct push probes (performed in the period July – September 2007),
- Installation of 8 monitoring wells (performed in March 2008),
- Collection of 155 soil samples (from soil borings in 2007, from drilling core during installation of monitoring wells in 2008, five samples of topsoil in agricultural land in Gorno Lisiče),

- Collection of three samples of street dust taken from paved road next to the former electrolysis plant and the dumps,
- Collection of one sample of sediment of a sewer at the site,
- Collection of 34 groundwater samples from existing, newly installed monitoring wells as well as domestic and abstraction wells,
- Collection of 11 soil gas samples,
- Collection of 75 samples of construction materials,
- Laboratory analyses of samples for parameters of potential concern,
- Surveying of existing and newly installed monitoring wells and of both dumps of HCH waste isomers,
- Inspection of the abandoned buildings in the area of interest;
- Study of available construction plans,
- Calculation of volume of debris resulting from pull down of abandoned buildings,
- Quantification of various wastes generated by prospective buildings pull down,
- Field and laboratory data processing and evaluation.

3.2 Risk Assessment and Proposed Corrective Measures

3.2.1 Risk Assessment

Detail Risk Assessment has been produced in separate document in June 2008 (Enacon). This chapter provides a concise summary of the RA findings and recommendations regarding the contaminated construction materials.

In sector A the risk assessment resulted to unacceptable risk for on-site worker working in buildings A1 (former storage of HCH and TCB production building) and A3 (former lindane production building) due to inhalation of dust and fine particles contaminated by a-HCH. Nevertheless, both buildings are not used at present (i.e. no receptor of the exposure) similarly to most of the buildings at the site.

These risks identified in sector C are posed by the contaminated soil (below the former production of monochloracetic acid and in its close vicinity) not by the construction materials. Since some excavation activities are assumed in the sector C these risks are mentioned here from the point of view of the occupational health and safety.

3.2.2 Proposed Corrective Measures

As the buildings in sectors A, C and E were designed and constructed with the specific purpose (especially former production buildings) their future use is very problematic (also due to their poor technical state) and thus their pull down and proper disposal of the originated construction waste is recommended. In general, construction materials of the investigated buildings do not meet the EU limits defined for inert waste based on the results of water leachate tests (see further text – chapter 3.2.2). Some construction materials even do not meet limits for hazardous waste due to high content of DOC and thus their treatment is necessary.

Target limit for α-HCH in construction material was set only with respect to the risk identified (see Table 3.1). This limit is applicable for buildings in sector A that will not be pulled down (if any).

Table 3.1: *Target limits for waste in sectors A, C, and E, OHIS*

Waste	Contaminant	Unit	Target limit	Note
Construction material of various structures	α-HCH	mg/kg	570	Derived from acceptable risk for a on-site worker (inhalation)

The limits applicable for construction waste classification are those defined by EU directive 2003/33/EC.

3.3 Waste Characterization

This section is focused on quantification of the volume of waste generated by prospective pull down of the buildings in sectors A, C, and E. Further chapters provide the overview of waste volume as well as specifications of various kinds of wastes expected.

3.3.1 Description of the Buildings to Be Pulled Down

Based on the site inspection of the buildings and structures to be pulled down in the course of the entire site restoration and study of the available construction plans a concise description/characteristic of the buildings intended to be pulled down has been elaborated for the particular sectors considered in this FS – i.e. A, C, and E. Positions of particular buildings are depicted in Figure 2. In the wastes summary presented further the steel scrap is not considered because valuable metal scrap and remnants of technology are being removed by OHIS currently and thus it is expected that the valuable metals will be drawn of the site prior the remedial/restoration commencement.

3.2.1.1 Structures in Sector A

Sector A comprises the buildings that were in the past related with the production, distribution and/or storage of chlorinated pesticides (lindane).

Building A1 – Former storage oh HCH and TCB production

It is a cellarless, one-storey building of a rectangular ground-plan of the size of 30.6 x 7.5 m, height of 3.5 – 5.2 m, with an outbuilding of the ground-plan parameters of 3.7 x 8.2 m and height of 3.5 m – the total built-up area corresponds to 260 m^2. The building is divided into the following parts: a bricked-up part and a sheeted store. The building is founded on the reinforced concrete foundation straps into the depth of 1.0m; the floor is made of concrete. The roof is aisle, covered with corrugated asbestos-cement sheets.

Figure 2: Site plan – sector A

The bricked-up part with the outbuilding is of the total built-up area corresponding to 162.3 m^2. Walls are of the thickness of 30 cm. The ceiling is formed by reinforced concrete slabs. Windows are plate-glass and the barn-doors are steel.

A sheeted part of the store is of the total built-up area corresponding to 162.3 m^2. Circumference of the part of the store is made from reinforced concrete dwarf wall of the height of 1.0 m. Supporting structure for sheeting is represented by the steel columns of the profile I (anchored in reinforced concrete dwarf wall). The sheeting has already been partially removed; the front part is without sheeting. The roof construction is formed by the steel girders of the shape of letter “I”.

Volumes of particular construction materials of the building A 1 are summarized in Table 3.2.

Table 3.2: *Building A 1-volume of construction material*

Material	Volume (m^3)
concrete	93.0
reinforced concrete	62.2
masonry	149.8
asbestos cement	1.4
A 1 total	**306.3**

Building A 2 – Former lindane production building

It is a cellarless, four-storey building of the rectangular ground-plan of the size of 14.25 x 12.25 m, height of 14.2 m and built-up area of 175 m^2; the outbuildings concur from both sides on the four-storey building. One outbuilding is two-storey, but there is not a ceiling between the floors; it is of the ground-plan parameters corresponding to 15.25 x 12.25 m and height of 5.45 m, on which concurs a small one-storey outbuilding of the size of 3.05 x 6.35 m, height of 3.1 m. The second outbuilding is one-storey of the size 4.4 x15.3 m, height of 3.3 m. The total built-up area is approx. 337 m^2.

The main building is made from reinforced concrete supporting poles 0.35 x 0.35m, between which there are the reinforced concrete walls of the thickness of 25 cm. Foundation is carried out on the reinforced concrete foundation straps; there are also the reinforced concrete single footings below the columns. The floor is made from concrete; there are two channels, which used to be provided with a grid, but the grid is not there any more.

Internal ceilings of the building are made from the concrete slabs of the thickness of 5 cm, which are supported by the I-profiles (150mm).

The roof is plane with the minimal inclination above all parts of the building. The roof construction is formed by reinforced concrete slabs; roof covering is made from asphaltic bands.

The particular floors of the main building are connected by two two-ply steel stairs and by one one-ply stairs up the mezzanine.

Windows in the main building are narrow and plate-glass; an access is possible through two steel barn-doors, which are not here any more and through the steel door directly below the stairs. The access into the bigger outbuilding is also through the steel barn-door or through a small outbuilding with the steel door. There are four big windows in wooden frames on one side. The smaller outbuilding is divided into five parts – rooms; the steel barn-door leads into three of them – there are probably stores; the steel door leads into the other two parts – there are also the windows; the offices are situated there.

Volumes of particular construction materials of the building A 2 are summarized in Table 3.3.

Table 3.3: *Building A 2-volume of construction material*

Material	Volume (m^3)
Concrete	99.5
Reinforced concrete	414.75
A 2 total	**514.3**

Building A 3 – Former raw material and packaging store

It is a cellarless, one-storey building, open from one side, of the rectangular ground-plan of the size of approx. 12.5 x 15.5 m, the total built-up area 192 m^2, height of 4-5 m. The building is founded on the reinforced concrete straps into the depth of 1.0 m. The floor is made from concrete.

The external construction is formed from reinforced concrete dwarf wall of the ground-plan in the shape of the letter "U", thickness of 30 cm, height of 85 cm, sheeting carried out from the upper edge of the dwarf wall to the roof construction. The steel little columns, which are principle for the supporting structure of the building sheeting, are anchored in the dwarf wall.

The roof is aisle. Roof construction is formed from the steel girders of the I profile and the steel truss girders. Roof covering is from the corrugated plate.

Volumes of particular construction materials of the building A 3 are summarized in Table 3.4.

Table 3.4: *Building A 3-volume of construction material*

Material	Volume (m^3)
concrete	46.1
reinforced concrete	37.5
A 3 total	**37.5**

Building A 4 - Former lindane production building

It is a cellarless, four-storey building of the rectangular ground-plan of the size of 25.3 x15.3 m, built-up area of 388 m^2, height of 15.6 m, on which concurs a two-storey outbuilding of the ground-plan size of 25.3 x 5.0 m and the height of 7.3 m and a one-storey outbuilding of the size of 20.3 x 5.5 m, height of 3.5 m. The total built-up area is 617.4 m^2.

The building including the outbuildings is made from the reinforced concrete columns, between which there are the bricked-up walls of the thickness of 30 cm. Foundation is carried out on the reinforced concrete foundation straps and on the single footings into the depth of 1.0 m. The floor is made of concrete.

Ceilings of the building are formed by the reinforced concrete slabs of the thickness of 30 cm. The supporting construction of the ceiling, eventually of the technologies, chambers and reservoirs inbuilt in the building, are the reinforced concrete girders and the steel girders of the I profile.

The roof is plane, roof construction is made from the reinforced concrete slabs, and roof covering is made from the asphaltic bands.

The particular floors are connected by two two-ply reinforced concrete stairs and by one one-ply stairs.

Windows are plate-glass, barn-doors are steel.

Volumes of particular construction materials of the building A 4 are summarized in Table 3.5.

Table 3.5: *Building A 4-volume of construction material*

Material	**Volume** (m^3)
concrete	148.2
reinforced concrete	871.8
masonry	477.0
asphalted covering	3.7
A 4 total	**1500.7**

Building A 5 – Locker rooms, workshop

It is a cellarless building of approximately rectangular ground-plan and of the total built-up area corresponding to 846 m^2. The building A6 concurs on the building in question in its north-eastern part. The building is divided into eight parts. Each of these parts has a different height from 2.7 to 7.9 m. Each of those parts has its own roof. In its north-western part the building is two-storey of the height of 7.9m; other parts are one-storey of the height from 2.7 m to 5.1 m.

The building is bricked-up with the thickness of the walls 30-40 cm. Internal bricked-up traverses are of 20-30 cm. The reinforced concrete columns form the supporting structure in a part of the building. Foundation of the building is carried out on the reinforced concrete foundation straps into the depth of 1,0 m. The floor is made of concrete.

The roof of all eight parts is plane, construction is formed by the reinforced concrete slab, and covering is from the asphaltic bands.

An open penthouse with the aisle roof – of the height of 4-4.5m, is built up above the south-eastern part of the building. The penthouse is formed by the reinforced concrete columns, girders of the covering are made of reinforced concrete; covering is formed by the corrugated asbestos-cement.

Windows of the building are plate-glass; most of entrances are represented by the steel barn-doors. Wooden door is only in the two-storey part, where the offices are situated.

Volumes of particular construction materials of the building A 5 are summarized in Table 3.6.

Table 3.6: *Building A 5-volume of construction material*

Material	Volume (m^3)
concrete	253.6
reinforced concrete	474.8
masonry	505.8
asphalted covering	5.07
A5 total	**1,239.3**

Building A 6 – Organophosphates production building

The building A6 is a cellarless, three-storey building of the rectangular ground-plan of the size of 20.4 x 10.6 m, total built-up area of 216.3 m^2 and the height of 14,5 m. The building concurs in its south-western part on the building A5 and in its north-eastern part on the hall A7. The fourth floor spreading above one rectangular of the columns field (5.5 x 4.4m) forms the machine-room of the elevator. The total height of the building is approx. 17.2 m.

The construction is formed by the reinforced concrete columns with the bricked-up walls of the thickness of 30 cm. The ceilings are made of the reinforced concrete of the thickness of 30 cm, with the reinforced concrete girders. The ceiling of the first above ground floor is formed partially by the steel girders. The building is founded on the reinforced concrete foundation straps of the height of 1 m. The floor is made of concrete. Roof is plane, formed by the reinforced concrete slab; roof covering is formed by the asphaltic bands.

Floors of the building are connected by the reinforced concrete two-ply stairs with a half-standing. There is an elevator as well in the steel elevator shaft, which leads up to the fourth above ground floor, where the machine room is situated. There are still the technologies and the steel tanks and dosing machines from production, steel decks and steel stairs in the building.

Windows of the building are plate-glass; most of the entrances are represented by steel barn-doors and wooden doors.

Volumes of particular construction materials of the building A 6 are summarized in Table 3.7.

Table 3.7: *Building A 6-volume of construction material*

Material	Volume (m^3)
concrete	51.91
reinforced concrete	309.0
masonry	346.3
asphalted covering	1.30
A 6 total	**708.5**

Building A 7 – Granular phosphates production building

It is a hall, cellarless, one-storey building of the rectangular ground-plan of the size of 60.2 x 21.2 m, built up area of 1276 m^2 and height 6.9 m. The building concurs on the building A6 with which it is connected by the steel barn-doors. A bricked-up outbuilding in the south-eastern part of the building, which used to be a boiler-room, is a part of the building as well. Its ground-plan size is 6.4 x 3.1m. Total built-up area including the outbuildings is 1296 m^2. Roofing of the stillage at the railroad spur, which is situated above the north-eastern side of the hall, is a part of the building as well.

Construction of the hall is formed by the reinforced concrete columns (4 rows x11), with the bricked-up external walls of the thickness of 30cm. The building is founded on the reinforced concrete foundation straps (external walls) and on the single footings (internal columns). Height of the foundation is 1.0m. The reinforced concrete panels form the floor.

Roof is aisle. Supporting structure of the roof is formed by the reinforced concrete girders. Roof covering is made of asbestos-cement.

Bricked-up offices and other spaces are inside the hall in one corner part. Height of this internal masonry is 2.6m.

Windows of the building are plate-glass. Entrances into the hall are through several steel barn-doors.

Roofing of the stillage at the railroad spur concurs on the roof construction of the hall. It is formed by the reinforced concrete girders and the asbestos-cement covering.

Volumes of particular construction materials of the building A 7 are summarized in Table 3.8.

Table 3.8: *Building A 7-volume of construction material*

Material	Volume (m^3)
reinforced concrete	547.6
masonry	284.2
asbestos cement	9.0
A 7 total	**840.8**

Building A 8 – Production of granulated pesticides

It is a cellarless building of the rugged ground-plan of the total built-up area corresponding to 247 m^2. The main part of the building is two-storey, of the ground-plan in the shape of the letter "L". The second floor is only above the part of the first above ground level floor. The total height is 9.3 m. Two rectangular one-storey outbuildings (6.7 x 5.2 m and 3.8 x 3.3 m) height of 2.4-3.0 m and 3.1-3.9 m are added to this part of the building. The building is connected with the building A10 by the passage way.

Construction of the building is made from the bricked-up columns, with the bricked-up external walls of the thickness of 30 cm. The ceiling is reinforced concrete, thickness of 30 cm, with reinforced concrete girders. Foundation is carried out on the reinforced concrete foundation straps (external walls, outbuildings) and on the single footings (columns). Depth of the foundation is 1.0 m. The floor is made of concrete.

Roof is plane and formed by the reinforced concrete slab, roof covering is made from asphaltic bands. Roof of the outbuildings is aisle, construction is formed by the reinforced concrete slab with the asbestos-cement covering.

There are still the technologies, steel tanks and dosing machines from the production and steel stairs in the building.

Windows of the building are plate-glass and the barn-doors are steel.

Volumes of particular construction materials of the building A 8 are summarized in Table 3.9.

Table 3.9: *Building A 8-volume of construction material*

Material	Volume (m^3)
concrete	71.5
reinforced concrete	91.9
masonry	124.9
asbestos cement	0.3
asphalted covering	1.1
A 8 total	**289.6**

Building A 9 – Storage of final pesticides

It is a hall, cellarless, one-storey building of the rectangular ground-plan of the size of 55.6 x 23.7 m; built-up area corresponds to 1.318 m^2, the height is 7.5 m. The building concurs on the building A10.

Construction of the hall is formed by reinforced concrete and steel columns, with bricked-up external walls of the thickness of 30 cm. A part of the front gable is not bricked-up, but sheeted. A part of the hall is separated by a bricked-up wall of the thickness of 30 cm from the rest of the storage area. This part has a separate entry from outside the building. The building is founded on the reinforced concrete foundations straps (external walls) and on the single footings (internal columns) into the depth of 1.0 m. The floor is formed by the reinforced concrete panels.

The roof is aisle. Supporting construction of the roof is formed by the steel truss girders. The roof covering is from corrugated plate.

Windows of the building are plate-glass. Accesses into the hall are possible through several steel barn-doors.

Volumes of particular construction materials of the building A 9 are summarized in Table 3.10.

Table 3.10: *Building A 9-volume of construction material*

Material	**Volume** (m^3)
reinforced concrete	384.2
masonry	184.7
A 9 total	**568.9**

Building A 10 – Storage of packaging

It is a hall, cellarless, one-storey building of the rectangular ground-plan of the size of 40.5 x 16.6 m; built-up area corresponds to 672.5 m^2. the height is 5.5 m. The building concurs on the building A9 and is connected through a passage way with the building A8. The area of the passage way is 18.7 m^2, the total built-up area including the passage way is 691.2 m^2.

Construction of the hall is made from the reinforced concrete columns, with bricked-up external walls of the thickness of 30cm. A part of the front gable above the windows is not bricked-up, but sheeted. The building is founded on the reinforced concrete foundation straps into the depth of 1.0m. The floors are made from reinforced concrete panels.

The roof is aisle. Supporting construction of the roof is formed by the steel truss girders and reinforced concrete girders. The roof covering is from corrugated plate.

Windows of the building are plate-glass. Accesses into the hall are possible through several steel barn-doors.

Volumes of particular construction materials of the building A 10 are summarized in Table 3.11.

Table 3.11: *Building A 10-volume of construction material*

Material	Volume (m^3)
reinforced concrete	240.1
masonry	130.2
A 10 total	**370.2**

Building A 11 - Storage of packaging

It is a hall, cellarless one-storey building of the rectangular ground-plan of the size of 60.5 x 12.4 m; building volume corresponds to 750 m^2, the height is 7.0 m. The building concurs on the building A9.

Construction of the hall is formed by steel columns, with bricked-up external walls of the thickness of 30 cm. A part of the front gable above the windows is not bricked-up, but sheeted. A part of the hall is separated by a bricked-up wall of the thickness of 30 cm from the rest of the storage area. This part is provided with a separate entry from outside the building. The building is founded on the reinforced concrete foundation straps into the depth o 1.0 m. The floor is formed by reinforced concrete panels.

The roof is aisle. The supporting structure of the roof is formed by the steel truss girders. The roof covering is made from corrugated plate.

Windows of the building are plate-glass. Accesses into the hall are possible through several steel barn-doors.

Volumes of particular construction materials of the building A 11 are summarized in Table 3.12.

Table 3.12: *Building A 11-volume of construction material*

Material	Volume (m^3)
reinforced concrete	265.7
masonry	199.7
A 11 total	**465.4**

3.2.1.2 Summary of Construction Wastes Expected in Sector A

The volume and types of various wastes resulting from pull down of buildings in sector A that were related to production, handling and/or storage of chlorinated pesticides and organophosphates is presented in Table 3.13.

Table 3.13: Summary of construction wastes in sector A, OHIS

Material	Volume (m^3)
concrete	763.7
reinforced concrete	3,699.5
masonry	2,402.6
asphalted covering	11.1
asbestos cement	10.7
Sector A total	**6,888**

3.2.1.3 Structures in Sector C

Sector C comprises the buildings that were in the past related with the production of monochloracetic acid, where CHC were used largely, situation is depicted in Figure 3 and Annex 2.

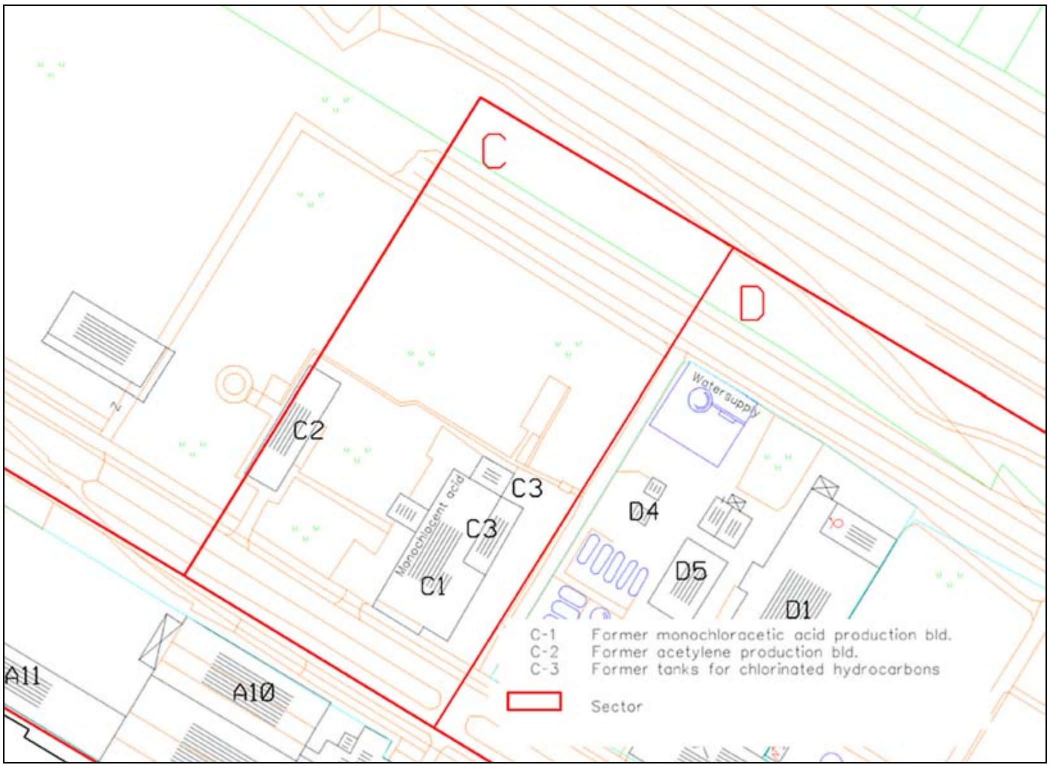


Figure 3: Situation of sector C

Building C 1 – Former monochloracetic acid production building

It is a cellarless, seven-storey building of the rectangular ground-plan of the size of approx. 18.6 x 36.6 m, height of 30.3 m and built-up are of approx. 760 m^2, on which concurs from the northern side an open four-storey reinforced concrete construction with the steel stairs (up to the level of the sixth floor) and a building with tanks for chlorinated hydrocarbons C3.

The main building is formed by ten reinforced concrete supporting poles 0.65 x 1.3 m (circumference). There are the bricked-up walls of the thickness of 30 cm between the supporting poles; in the middle of the hall, there are three more supporting poles 0.6 x 0.6 m. A store building, which is formed also by a complex of eight peripheral reinforced concrete columns 0.6 x 0.3 m and four middle columns 0.3 x 0.3 m, is situated in the front part in front of the hall. Foundation is carried out on the reinforced concrete foundation straps; there are also heavy reinforced concrete single footings below the supporting poles. The floor is in all parts of the building made of concrete.

Internal ceilings of the floors in the main building are made from the reinforced concrete slabs with girders.

The roofs are aisle above all parts of the building with the exception of the main hall, which has a roof in the shape of a semicircle. The roof construction in case of the hall is made from the reinforced concrete girders, in case of the other parts it is made from the reinforced concrete slabs; roof covering is everywhere made from the corrugated plate.

The reinforced concrete consoles, on which a construction of the crane track is fixed, are situated in the upper part of the hall below the roof construction.

Particular floors of the hall are connected through one-ply steel stairs with banisters.

Windows are plate-glass in steel frames; an access into the building was from all sides either through the steel barn-doors, or through the steel doors. Nowadays, some of them are missing.

There are still some left tanks and left technologies in the building.

Volumes of particular construction materials of the building C 1 are summarized in Table 3.14.

Table 3.14: *Building C 1-volume of construction material*

Material	**Volume** (m^3)
concrete	47.3
reinforced concrete	1627.1
masonry	650.4
fibreglass	1.8
tar roofing	0.6
asbestos cement	0.5
C1 total	**2,327.8**

Building C 2 – Former acetylene production building

It is a cellarless building of the rectangular ground-plan of the size of 30.3 x 8.3 m and of the total built-up area corresponding to 251 m^2. The building is founded on the reinforced concrete foundation straps (walls) and on the single footings (columns) into the depth of 1 m. The building is divided into two parts – a one-storey part and a two-storey part.

The two-storey part is of the ground-plan size of 15.3 x 8.3 m, the total height of 8.7 m. The construction is made from the reinforced concrete columns, between which the walls of the thickness of 30 cm are bricked up. The floor is made of concrete.

Ceilings are made from the reinforced concrete slabs of the thickness of 30 cm. The supporting structure of the ceiling, eventually of the technologies, chambers and tanks inbuilt in the building, are made from the reinforced concrete girders.

The roof is plane; roof construction is formed by the reinforced concrete slab; covering is from the asphaltic bands.

Particular floors of the building are connected by two steel stairs. Windows are plate-glass, barn-doors are steel.

To this part concurs a steel covered outbuilding, which is formed by steel columns of I profile and by a steel deck up to the level of the second above ground floor.

The second one-storey part of the building is of the ground-plan size of 15.0 x 8.3 m, the height of 4.5 m. The building is bricked-up with the walls of the thickness of 30 cm. The floor is made from the reinforced concrete panels.

Roof is aisle, construction is formed from wooden truss girders, and covering is from the asbestos-cement.

Neither windows, nor barn-doors occur in this part. An access into the building is possible by an open entry without the stepped barn-doors. The ventilation louvers are inbuilt in the enclosure wall.

Volumes of particular construction materials of the building C 2 are summarized in Table 3.15.

Table 3.15: *Building C2-volume of construction material*

Material	**Volume** (m3)
concrete	30.4
reinforced concrete	198.2
masonry	163.2
tar roofing	0.76
asbestos cement	0.77
fibreglass	0.07
C2 total	**393.4**

Building C 3 – Former tanks for CHC

It is a structure of three vertical tanks for the chlorinated hydrocarbon; the tanks are of the diameter 3.1 m and the height of 7.4 m + 0.2 m of the reinforced concrete support encased with paving. We suppose the steel tanks, which are coated with the gummy casing, for better isolation.

The tanks are situated on the concrete platform (5.65 x 14.2 m); the concrete platform is provided around with an increased curb made from bricks of the length 15 cm and the height 30 cm. The built up area is approx. 80 m^2.

In the nearest vicinity of the tanks, there are several small open reinforced concrete tanks and channels below the ground level, which are encased with paving.

Volumes of particular construction materials of the building C 3 are summarized in Table 3.16.

Table 3.16: Building C3-volume of construction material

Material	**Volume** (m^3)
concrete	132.6
reinforced concrete	96.8
C3 total	**229.4**

3.2.1.4 Summary of Construction Wastes Expected in Sector C

The volume and types of various wastes resulting from pull down of buildings in sector C related to production of monochloracetic acid is presented in Table 3.17.

Table 3.17: Summary of construction wastes in sector C, OHIS

Material	**Volume** (m3)
concrete	210.3
reinforced concrete	1,922.1
masonry	813.58
asphalted covering	1.35
asbestos cement	1.30
fibreglass	1.87
Sector C total	**2,951**

3.2.1.5 Structures in Sector E

Sector E comprises the outdoor cooled storage of flammables. Volatile organic compounds are stored there in corroded drums on the concrete pavement. During higher ambient temperature, drums are sprinkled with water. Situation is depicted in Figure 4.

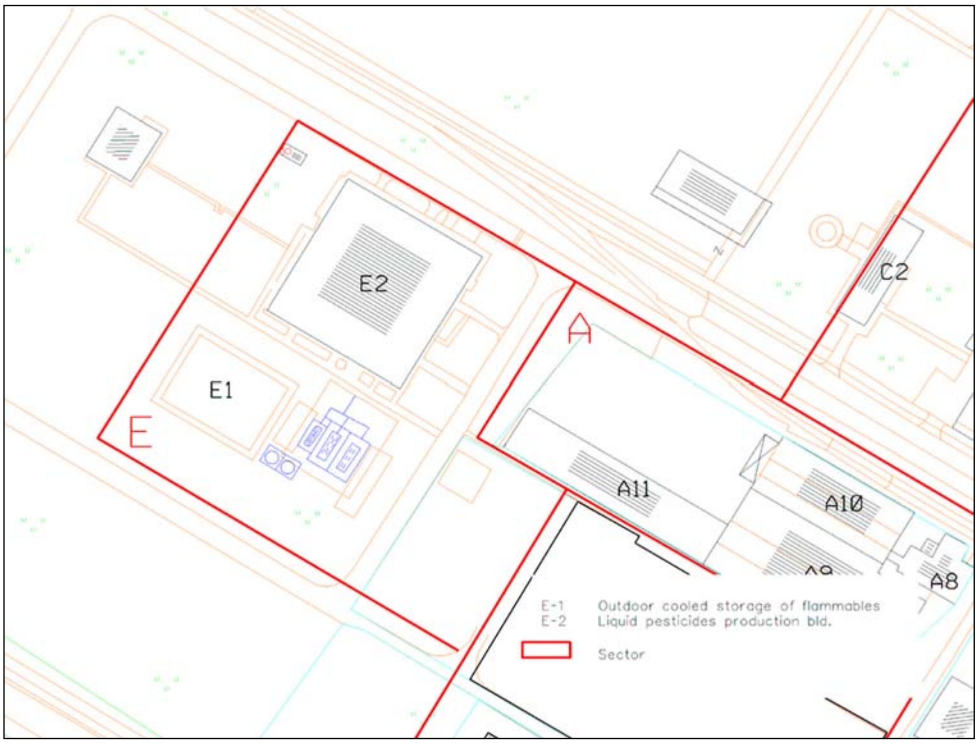


Figure 4: Situation of sector E

Structure E 1 – Outdoor cooled storage of flammables

E1a – Reservoirs with tanks

It is an entity consisting of two separately standing structures - a reinforced concrete reservoir with five tanks and a reinforced concrete reservoir with two tanks. In case of the first structure, there are five reinforced concrete reservoirs put side-by-side. A steel cylindrical tank placed on the concrete supports is situated in every reservoir. The structure is an above ground structure.

Every reinforced concrete reservoir is of the rectangular ground-plan – in total: one reservoir is of the size 18.2 x 6.2 m; three reservoirs are of the ground-plan size of 12.2 x 6.2 m and one reservoir is of 8.3 x 4.3 m. The reservoirs form all together an irregular ground plan the total built-up area of which is 365 m^2.

The reservoir consists of the foundation reinforced concrete slab of the thickness of 20 cm, deposited on the concrete slab of the thickness of 10 cm, and of the reinforced concrete walls of the height 1.0 - 1.3 m according to the type of the reservoir. The reinforced concrete foots for mounting the steel tanks are placed in the reservoirs. There are three types of the steel reservoirs according to the reservoir sizes. It is one piece of the cylindrical tank. diameter 3.0 m and the length 13.5 m; three pieces of diameter 3.0 m and length 7.5 m and one piece of diameter 2.0 m and length 5.4 m.

An access to the tanks is reserved from the steel platform placed in the area above the tanks. The bearing structure of the platform is formed by the steel columns. The access on the steel platform is possible either from the steel stairs on one side or from the steel step ladder.

The second structure is an above-ground reinforced concrete reservoir of the rectangular ground-plan of the size 9.6 x 4.9 m; it means that the total built-up area is 47 m^2. The reservoir is divided by a reinforced concrete wall into two same parts. One steel cylindrical tank of the diameter 2.2 m and the height 6.0 m stands on a reinforced concrete support in every part of the reservoir.

The reservoir consists of the foundation reinforced concrete slab of the thickness of 20 cm, deposited on the concrete slab of the thickness of 10 cm and of the reinforced concrete walls of the thickness of 20 cm and height of 1.3 m.

An access to the tanks placed in the reservoir is possible from the steel platform, which is separately above every tank. An access on the steel platform is up the steel step ladder suspended on the tank.

E1b- Outdoor store of flammable matters with cooling

With respect to the fact, that no documentation from history regarding the building exists, the site visit was carried out. On the basis of the available surface indicators, a possible construction of the building was set up. It is a shallow uncovered reinforced concrete pit of the rectangular ground-plan of the size of 27 x 20 m with a walking platform of the length of 2 m (circumference); the total built-up area is 744 m^2.

The bottom of the pit is formed by the reinforced concrete slab of the thickness of 30 cm. The pit is 20 cm deep; the total height is approx. 50 cm. The structure is inleted into the ground. There are the reinforced concrete supports for deposition of the barrels with flammable materials inside. The structure is fenced with wire netting, which is suspended on the concrete columns. An access into the entity is by a steel barn-door.

A pipeline provided with a sprayer serving to sprinkling the barrels with water is placed above the pit in the height of approx. 2.5 m.

Volumes of particular construction materials of the structure E 1 are summarized in Table 3.18.

Table 3.18: Structure E 1-volume of construction material

Material	**Volume** (m^3)
concrete	4.2
reinforced concrete	566.7
E 1 total	**570.8**

Since the building E 2 is operating it is not considered in this FS and thus the volume of construction material in the above Table 3.18 presents volume of construction waste expected in sector E.

3.3.2 Contaminated Constructions

In total, 34 samples of construction materials were collected from the buildings in within sectors A, C, and E. Sampling locations were selected with respect to historical and present use of buildings and to the expected level and character of contamination. Higher number of samples was preferably taken from already abandoned buildings. Samples were taken by electric hammer from floors, walls and reinforced cladding. In case of masonry, selected samples were taken from the plaster and from the masonry itself.

Laboratory analyses of samples of construction materials are presented in Annex 3. Selected samples of construction material passed standard 10 : 1 EU WAC 12457 batch leach test. Results of these tests of construction material were compared with the EU limits defined for inert waste, non-hazardous waste and hazardous waste landfills (see table 3.19).

None of the nineteen construction material samples tested for leachability complied with limits for inert waste landfill.

Waste classification based on performed analyzes is presented in Table 3.20. This table presents the waste classification for construction materials of particular buildings in sectors A, C, and E; the table also indicates hazardous compounds identified in the construction material that exceeds the limits given.

Obviously, construction material of several buildings (A 4, A 7, A 11, C 1, and C 2) are so heavily contaminated (mainly DOC, and HM) that the limits given for hazardous waste are exceeded and this material **has to be treated** prior its disposal of to reduce its hazardous properties to an acceptable level.

Table 3.19: Results of leaching tests of construction materials (mg/l)

Sampling Location	Material sampled	DOC	Phenol index	Cl-	F-	SO42-	As	Ba	Cd	Cr total	Cu	Hg	Ni	Mo	Pb	Sb	Se	Zn	dissolved solids (105°C)	pH
A-20	concrete floor	117	**0.11**	19	0.46	**257**	<0,001	0.03	<0,004	<0,05	**0.50**	<0,002	<0,03	<0,03	**0.07**	<0,005	<0,001	**0.67**	3070	9.7
A-27	concrete floor	49	**0.14**	**218**	0.94	**223**	0.006	<0,01	<0,004	<0,05	0.030	<0,002	<0,03	<0,03	<0,05	<0,005	0.008	0.01	1030	7.9
A-31	brick	9.45	0.05	**1310**	26.40	**507**	0.009	**2.35**	<0,004	<0,05	<0,02	**0.003**	<0,03	<0,03	<0,05	<0,005	0.004	<0,01	2790	7.3
A-32	concrete floor	40.0	< 0,10	**409**	0.93	**115**	< 0,005	< 0,01	< 0,004	< 0,05	0.16	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	1400	8.50
A-33	mortar, bricks	10.3	**0.24**	44.2	0.31	**1300**	< 0,005	0.02	< 0,004	< 0,05	0.02	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	2330	9.30
A-34	mortar, bricks	11.2	< 0,10	**336**	< 0,2	**139**	< 0,005	0.02	< 0,004	< 0,05	< 0,01	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	1190	8.30
A-36	concrete floor	23.0	< 0,10	**108**	0.44	**144**	0.019	< 0,01	< 0,004	< 0,005	0.02	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	**0.018**	< 0,01	970	10.6
A-37	mortar, bricks	214	0.1	27.1	**4.58**	2190	1.38	< 0,01	< 0,004	< 0,05	**0.3**	< 0,001	< 0,03	< 0,05	< 0,05	**0.026**	0.155	< 0,01	6900	10.5
A-39	mortar, bricks	97	< 0,10	51.2	0.22	**1220**	0.026	0.06	< 0,004	< 0,05	< 0,05	< 0,001	< 0,02	< 0,05	< 0,05	< 0,005	0.006	0.05	2380	9.2
A-40	mortar	25.2	< 0,1	**179**	0.13	1.760	0.005	0.03	< 0,004	< 0,05	< 0,02	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	3360	8.3
A-41	mortar	40.8	< 0,1	**172**	0.83	1.530	< 0,005	0.03	< 0,004	< 0,05	< 0,02	< 0,001	0.03	< 0,05	< 0,05	< 0,005	0.006	< 0,01	2820	8.4
A-42	concrete	49.9	< 0,1	7.2	0.4	74.7	0.008	< 0,01	< 0,004	< 0,05	0.1	< 0,001	< 0,03	< 0,05	**0.14**	< 0,005	**0.02**	< 0,01	728	9.8
A-43	mortar	40.6	< 0,1	23.4	0.41	6000	< 0,005	0.02	< 0,004	< 0,05	0.01	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	0.005	< 0,01	8580	9.1
C-7	concrete	7.0	**0.16**	**134**	0.63	66	0.008	1.49	<0,004	<0,05	0.03	0.08	<0,03	0.04	<0,05	<0,005	<0,001	<0,01	662	11.5
C-10	concrete	460	0.04	**803**	44.30	**1810**	0.044	0.35	<0,004	**0.300**	28.90	0.470	135	<0,03	**0.09**	<0,005	<0,001	**4.49**	**5090**	3.6
C-13	mortar	8.17	< 0,1	20.1	0.06	**598**	< 0,005	0.02	< 0,004	< 0,05	< 0,02	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	1190	8.3
C-14	concrete	145	< 0,1	278	< 0,01	155	< 0,005	0.04	< 0,004	< 0,05	0.06	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	1820	10.0
C-15	mortar	1.95	< 0,1	11.8	0.31	**572**	< 0,005	0.02	< 0,004	< 0,05	< 0,02	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	< 0,005	< 0,01	554	9.9
E - 1	mortar	29.4	< 0,1	35	0.44	**196**	0.005	< 0,01	< 0,004	< 0,05	**0.3**	< 0,001	< 0,03	< 0,05	< 0,05	< 0,005	0.009	< 0,01	590	8.7
Directive 1999/31/EC criteria for	**inert waste**	**50**	**0.1**	**80**	**1**	**100**	**0.05**	**2**	**0.004**	**0.05**	**0.2**	**0.001**	**0.04**	**0.05**	**0.05**	**0.006**	**0.01**	**0.4**	**4000**	NA
	non-hazardous waste	**80**	**NA**	**1500**	**15**	**2000**	**0.2**	**10**	**0.1**	**1**	**5**	**0.02**	**1**	**1**	**1**	**0.07**	**0.05**	**5**	**6000**	NA
	hazardous waste	**100**	**NA**	**2500**	**50**	**5000**	**2.5**	**30**	**0.5**	**7**	**10**	**0.2**	**4**	**3**	**5**	**0.5**	**0.7**	**20**	**10000**	NA

Table 3.20: Classification of construction waste in sectors A, C, and E in OHIS

Waste location						Waste classification					
Sector	**Building**	**Storey**	**Part of the building**	**Material sampled**	**Relevant sample**	**Non-Hazardous**	**Hazardous**	**Hazardous requiring treatment**	**Hazardous constituents identified**	**Concentrations of hazardous constituents found**	**Notes**
A	A1	ground storey	wall	mortar	A-30		x		HCH izomers	Σ HCH = 102,770 mg/kg d.m.	Leaching test not carried out
			wall	brick	A-31		x		F^-	Σ HCH = 1260.7 mg/kg d.m.	
	A2	ground storey	floor	concrete	A-32		x		HCH izomers, PCB, Cl^-, SO_4^{2-}	Σ HCH = 18,960 mg/kg d.m., Σ PCB = 6.97 mg/kg d.m., Cl = 409 mg/l, SO_4^{2-} = 115 mg/l	
			wall	mortar/bricks	A-33		x		HCH izomers, SO_4^{2-}, PHI	Σ HCH = 123.8 mg/kg d.m., SO_4^{2-} = 1,300 mg/l, PHI = 0.24 mg/l	
		1st storey	wall	mortar/bricks	A-34		x		HCH izomers, Cl^-, SO_4^{2-}	Σ HCH = 202.9 mg/kg d.m., Cl^- = 336 mg/l, SO_4^2 = 139 mg/l	
		2nd storey	ceiling	-	A-35		x		HCH izomers	Σ HCH = 52.08 mg/kg d.m.	Leaching test not carried out
	A4	ground storey	floor	concrete	A-36		x		HCH izomers, Cl^-, SO_4^{2-}, Se	Σ HCH = 676.17 mg/kg d.m., Cl^- = 108 mg/l, SO_4^2 = 144 mg/l, Se = 0.018 mg/l	
			wall	mortar/bricks	A-37			x	HCH izomers, DOC	Σ HCH = 55.76 mg/kg d.m., DOC = 214 mg/l	
		1st storey	floor	concrete	A-38	x			HCH izomers	Σ HCH = 781.6 mg/kg d.m.	Leaching test not carried out
	A6	ground storey	floor	concrete	S-A2	x			HCH izomers	Σ HCH = 4.97 mg/kg d.m.	Leaching test not carried out
	A7	ground storey	floor	concrete	A-20			x	HCH izomers, DOC, DDT, DDD,DDE	Σ HCH = 8.2 mg/kg d.m., DOC = 117 mg/l, Σ DDT, DDD, DDE = 9.64 mg/kg d.m.	
			wall	mortar/bricks	A-39		x		HCH izomers, DOC	Σ HCH = 5.095 mg/kg d.m., DOC = 97 mg/l	
	A8	ground storey	floor	concrete	S-A13	x			HCH izomers	Σ HCH = 4.1 mg/kg d.m.	Leaching test not carried out
			wall	mortar	A-40	x			Cl^-	Cl^- = 179 mg/l	
			wall	mortar	A-41	x			Cl^-	Cl^- = 172 mg/l	
	A9	ground storey	wall	mortar	A-24	x			HCH izomers	Σ HCH = 3.89 mg/kg d.m.	Leaching test not carried out
			wall	brick	A-25	x			HCH izomers	Σ HCH = 2.26 mg/kg d.m.	Leaching test not carried out
			wall	mortar	A-28	x			HCH izomers	Σ HCH = 10.13 mg.kg d.m.	Leaching test not carried out
			wall	brick	A-29	x			HCH izomers	Σ HCH = 15.4 mg/kg d.m.	Leaching test not carried out
	A10	ground storey	floor	concrete	A-27		x		HCH izomers, Cl^-, SO_4^{2-}, organophosphates	Σ HCH = 146.1 mg/kg d.m., Cl^- = 218 mg/l, SO_4^2 = 223 mg/l, fonofos = 1,350 mg/kg d.m.	
			wall	mortar	A-26	x			HCH izomers	Σ HCH = 96.78 mg/kg d.m.	Leaching test not carried out
	A11	ground storey	floor	concrete	A-42	x			HCH izomers, Pb, Se	Σ HCH = 4.8 mg/kg d.m., Pb = 0.14 mg/l, Se = 0.02 mg/l	
		wall	wall	mortar	A-43			x	SO_4^{2-}	SO_4^{2-} = 6,000 mg/l	
C	C1	ground storey	ceiling beam	concrete	C-10			x	DOC, Cu, Hg, Ni, pH	DOC = 460 mg/l, Cu = 28.9 mg/l, Hg = 0.47 mg/l, Ni = 135 mg/l, pH = 3.6	
	C2	ground storey	floor	concrete	C-14			x	DOC	DOC = 145 mg/l	
		wall	wall	mortar	C-13	x			SO_4^{2-}	SO_4^{2-} = 598 mg/l	
		ground storey	supporting column	mortar	C-15	x			SO_4^{2-}	SO_4^{2-} = 572 mg/l	
	C3	ground storey	floor	concrete	C-7		x		Hg	HG = 0.08 mg/l	
E	E2	ground storey	wall	mortar	E-1	x			HCH izomers, Cu, SO_4^{2-}	Σ HCH = 2.1 mg/kg d.m., Cu = 0.3 mg/l, SO_4^{2-} = 196 mg/l	

3.3.3 *Waste Quantification*

3.2.3.1 Quantification of Wastes Identified

With respect of classification of construction waste resulting from pull down of particular buildings in sectors A, C, and E, the volumes of non-hazardous waste, hazardous waste and hazardous waste requiring treatment were calculated – see Table 3.21.

Table 3.21: Volumes of wastes identified in sectors A, C, and E in OHIS

Sector	Material	Volume of waste identified (m^3)			Main hazardous constituents
		Nonhazardous waste	Hazardous waste	Hazardous waste requiring treatment	
A	concrete	423,1	340,7	-	HCH isomers, PCB, Cl^-, SO_4^{2-}, PHI
	reinforced concrete	1 494,2	1 348,7	547,6	
	masonry	1 161,7	280,0	961,0	
	asbestos cement	10,7	-	-	
	asphalted covering	9,8	-	-	
	Subtotal sector A	**3 100**	**1 969**	**1 509**	
C	concrete	30,4	132,6	47,3	DOC, SO_4^{2-}
	reinforced concrete	198,2	96,8	1 627,1	
	masonry	163,2	-	650,4	
	fibreglass	1,9	-	-	
	asbestos cement	1,3	-	-	
	asphalted covering	1,4	-	-	
	Subtotal sector C	**396**	**229**	**2 325**	
E	concrete	4,2	-	-	HCH isomers, Cu, SO_4^{2}-
	reinforced concrete	566,7	-	-	
	Subtotal sector E	**571**	**0**	**0**	
GRAND TOTAL		**4 067**	**2 199**	**3 833**	

In total, **10,099 m³** of construction waste will originate from the structures pull down in sectors A, C, and E, this number does not include metal scrap.

Obviously, significant volume of hazardous waste requiring treatment will be generated by pulling down of some buildings in sectors A and C, namely buildings A 4 Former lindane production building, A 7 Granular phosphates production building, A 11 Storage of packaging, C 1 Former monochloracetic acid production building, and C 2 Former acetylene production building. In total, **3,833 m³** of hazardous waste requiring treatment will be produced during the buildings pull down in sectors A, C, and E; this volume represents **38 %** of construction waste in these sectors.

3.2.3.2 Quantification and Characteristics of Hazardous Waste Requiring Treatment

Due to numerous contaminants identified in the construction materials and in order to facilitate selection of feasible method(s) for this type of waste, hazardous construction waste requiring treatment is further sorted from the point of view of hazardous components properties. The main hazardous components identified in the waste requiring treatment are:

- organic compounds – HCH isomers, PCB, phenols, organic carbon;
- inorganic compounds – chlorides, sulphates, heavy metals (namely Cu).

Allocation of hazardous waste requiring treatment to particular buildings in the assessed sectors A, C, and E is presented in Table 3.22.

Table 3.22: Allocation of hazardous waste requiring treatment to particular buildings

Sector	Building	Material	Hazardous waste requiring treatment (m^3)	Main hazardous constituents exceeding limits for hazardous waste landfill
A	A 4	masonry	477	HCH isomers, DOC
	A 7	reinforced concrete	548	HCH isomers, DOC, DDT, DDD, DDE
		masonry	284	
	A 11	masonry	200	sulphates
	Sub-total sector A		***1 509***	
C	C 1	concrete	47	DOC, Cu, Hg, Ni,
		reinforced concrete	1 597	
		masonry	650	
	C 2	concrete	30	DOC, Cu, Hg, Ni,
	Sub-total sector C		***2 325***	
A + C	Total concrete		77	
	Total reinforced concrete		2 344	
	Total masonry		1 412	
	GRAND TOTAL	all constructions	**3 833**	

4. Remedial Objectives

Risks related to contaminated constructions are specified only for the buildings in sector A – those risks are related to indoor inhalation only. Since it is proposed to pull down the buildings in sectors A, C, and E proper occupational health and safety measures have to be considered during the buildings pull down and during the manipulation with hazardous waste generated.

Remedial action objectives are the goals which have to be achieved by implementation of specific remedial actions. Usually these goals are specified in a Risk Assessment study, which identifies and evaluates various risks resulting from existing site contamination for human health and the environment.

Clear definition of remedial action objectives is necessary for subsequent evaluation of the possibility to achieve the objectives by application of specific pre-selected remedial action alternatives.

The primary criteria which must be considered when developing remedial action objectives are the following:

- The acceptable risk levels have to be achieved at the site by implementation of recommended remedial actions.
- Applied remedial actions should eliminate hot spots of contamination at the site.

Applied remedial actions shall prevent or minimize future releases of hazardous substance and migration of hazardous substances which might result in unacceptable risks or significant adverse effects.

With respect to the site conditions, waste character, and reflecting prospective land use (i.e. industrial) these remedial goals have been defined:

- Protect human health from threats caused by exposure to hazardous substances released from waste resulting from buildings/structures pull down.
- Protect the environment against exposure to hazardous substances released from waste originated from buildings/structures pull down.

5. Assessment of Prospective Technologies

5.1 Identification and Description of Promising Technologies

Due to the complexity of the old environmental burdens within the OHIS site, this FS refers to treatment/liquidation of the wastes resulting from buildings pull down only. Remediation/treatment of other contaminated media has been assessed in separate studies.

Identification of promising technologies was focused on:

1. Identification of applicable method(s) for disposal of/liquidation of full spectrum of construction waste resulting from pull down of buildings in sectors A, C, and E contaminated soil clean-up;

2. Identification of applicable method(s) for treatment/liquidation of hazardous waste requiring contaminated construction materials;

Prior identification of applicable methods, **general response scenario** has to be defined – i.e. general approach to the site remediation/restoration which satisfies the required remedial action objectives. The following general response scenarios are usually considered:

- *"No action" scenario* – this scenario normally serves as a baseline for comparison of other potential response scenarios. No active measures for site remediation are applied under this scenario.
- *Institutional control scenario* – application of various legal or administrative measures or actions which reduce exposure to hazardous substances - such as administrative closure of the site for public, relocation of local inhabitants to another place etc.
- *Engineering control scenario* – application of technical measures preventing or minimizing exposure to hazardous substances or reducing the mobility or migration of hazardous substances - such as "capping" (covering a contaminated area with a suitable isolation system), fencing, installation of underground sealing walls etc.

- *Treatment scenarios* – response scenarios based on application of various (physical, chemical, biological) remediation methods enabling achievement of permanent and substantial elimination or reduction in the toxicity, mobility or volume of hazardous substances. In OHIS, waste treatment technologies can be applied ex-situ only in two variants -on site or off site.

After the general response actions have been identified, **potentially suitable remedial technologies should be identified** and screened. Those remedial technologies that are clearly not feasible (e.g., not effective or implementable or are substantially more costly than other technologies for a given general response action) should be eliminated from further consideration.

Since a detailed evaluation of remedial alternatives will take place in the later phase of a feasibility study, the emphasis at this point is on a cursory evaluation of remedial treatment technologies for the purpose of developing an appropriate range of remedial action alternatives.

The relationship between the general categories of pre-selected applicable/reasonable remedial technologies and the remedial objectives is summarized in Table 5.1.

Table 5.1: Summary of remedial objectives and general remedial technologies

Contaminated Media	Remedial Objectives	General Remedial Response Actions	Types of Remedial Technologies
Construction materials	Protection of human health, protection of the environment	No action	Not applicable
		Monitoring	Not applicable
		Institutional control	Closure of the site for public
		Engineering control	Not applicable
		Removal/treatment	Landfilling - on site, off site
			Physical treatment - contaminants extraction, thermal desorption, solidification/stabilization
			Chemical treatment - chemical oxidation.

Apparently, just a few technologies appears to be applicable for the treatment/disposal of the waste generated by the pull down of structures in OHIS sectors A, C, and E.

5.2 Screening of Remedial Technologies

5.2.1 Screening Method

The screening of available remedial technologies is organized by grouping the remedial technologies into a three-tier hierarchical system for describing the remedial processes. This system uses the following categories, in order of increasing specificity: general response action, remedial technology and process option. For example, removal is general response action; one of the remedial technologies is physical-chemical treatment and one of the several options is pyrolysis.

On the basis of this organizational approach, the descriptions of the remedial technologies considered for construction waste disposal of/treatment are summarized in Table 5.2. These are remedial technologies that were carried forward and screened to assess which technologies merit further consideration for the remedial alternatives.

5.2.2 Screening Criteria

The remedial technologies are screened using three broad criteria to judge the suitability of each for the remediation/treatment of contaminated construction materials. The criteria are:

Effectivity

Consideration of effectivity focuses on the degree of reliability of the process that can be expected for the types of hazardous substances and the physical condition at the site. Other considerations are the likelihood of meeting the remedial goals and the possible risks generated during implementation.

Implementability

Implementability encompasses the technical and administrative aspects for implementing a remedial technology. Factors in considering implementability include the availability of the special facilities, equipment and labor required for some remedial technologies.

Estimated Cost

Estimated cost is considered in a relative way in this evaluation stage. The estimated costs are judged as relatively low, medium, or high on the basis of general assumptions. At this screening stage, estimated cost does not have a substantial effect on the screening process except in cases where technologies are relatively equal and one has a substantially greater cost.

Table 5.2: Overview of methods for treatment/liquidation of contaminated construction material in OHIS

General Response Action	Remedial Technology	Process Option	Description of Remedial Technology
No action	None	None	No remedial action at the site, the site remains as it is.
Institutional control	Restricted access	Site closure	Closure of the site for the public
Removal/treatment	Landfilling	On site landfilling	Contaminated material is removed and transported to a permitted waste landfill either off site or on site. Some pre-treatment of contaminated material may be required in order to meet land disposal restrictions. The disposal facility is equipped with drainage and water-proof lining systems preventing leaking of contaminated liquids from the depositing area. Collected leakages are treated. A variety of lining systems are used for construction of landfill sites - usually installation of 2 mm HDPE foil is required. Only material meeting the criteria specified by the relevant local legislation can be disposed on a hazardous waste landfill. Landfilling of explosive, radioactive, flammable and unstable waste is usually not allowed.
		Off site landfilling	
	Physical treatment	Extraction	Ex situ separation processes (often referred to as "soil washing"), mostly based on mineral processing techniques, are widely used for the treatment of contaminated soil. Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the following two ways: (1) by dissolving or suspending them in the wash solution (which can be sustained by chemical manipulation of pH for a period of time); or (2) by concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing (similar to those techniques used in sand and gravel operations). The target contaminant groups for soil washing are SVOCs, fuels, and heavy metals. The technology can be used on selected VOCs and pesticides. The technology offers the ability for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soils.
		Thermal desorption	Thermal desorption is a physical separation process. Contaminated soil is heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. Based on the operating temperature of the desorber, thermal desorption processes can be categorized into two groups: (i) low temperature thermal desorption (LTTD) - waste is heated to 90 - 320 °C and (ii) high temperature thermal desorption (HTTD) - waste is heated to 320 - 560 °C. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them. The target contaminant groups for LTTD systems are non-halogenated VOCs and fuels. The technology can be used to treat SVOCs at reduced effectiveness. The target contaminants for HTTD are SVOCs, PAHs, PCBs, and pesticides; however, VOCs and fuels also may be treated, but treatment may be less cost-effective. Volatile metals may be removed by HTTD systems. The presence of chlorine can affect the volatilization of some metals, such as lead. The process is applicable for the separation of organics from refinery waste
		Solidification	Solidification refers to processes that encapsulate waste in a monolithic solid of high-structural integrity. Solidification does not necessarily involve a chemical interaction between the waste and the solidifying agents, but involves a physical binding of the waste in the monolith. Contaminant migration is restricted by vastly decreasing the surface area exposed to leaching and/or by isolating the waste within an impervious capsule. Encapsulation may address fine waste particles (i.e. microencapsulation) or large blocks or containers of waste (i.e. macroencapsulation). There is, however, inherent risk that the stabilized solidified waste matrix will break down over the time, potentially releasing harmful constituents into the environment.
	Chemical treatment	Chemical oxidation	Chemical oxidation typically involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert. Redox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons). The oxidizing agents most commonly used for treatment of hazardous contaminants in soil are ozone, hydrogen peroxide, hypochlorites, chlorine, chlorine dioxide, potassium permanganate, and Fentons reagent (hydrogen peroxide and iron).

5.2.3 Screening Summary

On the basis of screening assessments of the available disposal of/treatment technologies, some of the technologies were chosen to be incorporated in the overall remedial alternatives.

The selected technologies are favored because of advantages in efficiency, implementability, cost, or a combination of features. The reasons for using the remedial technologies in the overall alternatives are presented in Table 5.3.

The results of technology screening are not intended to eliminate or preclude consideration of other treatment technologies during future stages of remedial study or design. The screening is intended to show the rationale for technology selection at this point in the FS. As new information will become available, other remedial technologies may become favorable, warranting changes to the remedial alternatives.

Table 5.3: Remedial technologies screening

General Response Action	Remedial Technology	Process Option	Comments		
			Effectivity	Implementability	Relative Estimated Cost
No action	None	None	None	Not implementable	None
Institutional control	Restricted access	Site closure	Limited	Implementable	None
Removal/treatment	Landfilling	On site landfilling	High	Implementable	Moderate
		Off site landfilling	High	Implementable	High
	Physical treatment	Extraction	Acceptable	Not implementable, technology not available - it has to be tailored to the waste character and manufactured.	High
		Thermal desorption	High for organic compunds	Implementable, equipment to be purchased abroad and imported.	High
		Solidification/stabilization	Very good	Implementable, easily implementable with common machinery available in MK.	Moderate
	Chemical treatment	Chemical oxidation	Very good for some organics in soil	Not implementable, technology not available - it has to be tailored to the waste character and manufactured.	Moderate to high

5.2.4 *Screening Results*

With respect to the risk posed by contaminated constructions, properties of the media contaminated, character of contamination and site specific conditions just a few viable methods were brought forward to further detail assessment:

1. selective pull down of buildings and on site landfilling of non-hazardous waste;
2. selective pull down of buildings and on site landfilling of hazardous waste;
3. selective pull down of buildings and treatment of construction material with thermal desorption, subsequent on site landfilling of treated waste;
4. selective pull down of buildings and treatment of construction material by solidification.

These selected methods demonstrate good effectivity, they are implementable quite easy, prevailing part of equipment is available in MK (except desorption unit) and the costs are acceptable.

The results of remedial methods screening are summarized in the Table 5.4.

Table 5.4: Results of methods screening

General Response Action	Remedial Technology	Process Option	Comments
No action	None	None	Not acceptable, does not reduce/eliminate the risk of contaminants spreading. Disables future landuse.
Institutional control	Restricted access	Site closure	Conditionally acceptable, does not reduce/eliminate the risk of contaminants spreading, reduce the risk to humans exposure. Disables future landuse. In fact, this is the current status - contaminated buildings are within the OHIS boundary (fenced and guar
Removal/treatment	Landfilling	On site landfilling	Brought forward to detail assessment.
		Off site landfilling	Unrealistic in a reasonable period, long lasting process of selection of suitable location, EIA, construction, etc.
	Physical treatment	Extraction	Not implementable.
		Thermal desorption	Implementable, equipment has to be purchased abroad, brought forward to detail assessment.
		Solidification	Easily implementable, capable address wide spectrum of contaminants.
	Chemical treatment	Chemical oxidation	Not implementable.

5.3 Proposed Corrective Measures

5.3.1 Assembly of Procedures of Corrective Measures

In this chapter, the remedial technologies that were brought forward through the screening evaluation in previous chapters are combined to create a procedure for the treatment/liquidation of construction waste in the areas of former pesticides production (sector A), area related to former production of monochloracetic acid (sector C) and outdoor cooled storage of flammables (sector E) at the OHIS site.

Demolition of buildings and paved areas should be the first step in the remedy of sectors A, C and E, and it should be coordinated with pull down of buildings in other sectors – i.e. in sector D (former electrolysis plant) and rehabilitation of HCH dumps.

Reflecting the contamination of construction waste in sectors A, C, and E and screening of available methods this general procedure was assembled for detail assessment:

1. selective pull down of buildings and on site landfilling of non-hazardous waste;
2. selective pull down of buildings and on site landfilling of hazardous waste
3. selective pull down of buildings and treatment of construction material with thermal desorption, subsequent on site landfilling of treated waste;
4. selective pull down of buildings and treatment of construction material by solidification, subsequent on site landfilling of treated waste.

In fact, there is no other viable option then on site landfilling of construction waste - there are no adequate facilities in MK allowing its secured disposal of and prospects on development of such facilities within a reasonable period are minimal.

Task 1

This task comprises selective pull down of buildings with low contamination identified – i.e. the debris resulting from their pull down is expected to comply with limits given for non-hazardous waste and thus it can be disposed of in new constructed on site landfill (details see in FS focused on remediation of HCH dumps). These building have to be pulled down within this task – A 3, A 6, A 8, A 9, and E 1. Total volume of non-hazardous construction waste expected is about 4,067 m^3 .

Task 2

Task 2 comprises selective pull down of buildings/structures where hazardous waste will originate – buildings A 1, A 2, A 4, A 7, A 10, and C 3. Total volume of hazardous waste expected is about 2,199 m^3. This waste is also intended to be disposed of in separate sector of newly constructed on site landfill.

Task 3

<u>*Alternative 1*</u>

This task relies on selective pull down of buildings where hazardous waste requiring treatment prior disposal of was identified during the site investigation. This type of waste was identified in buildings A 4, A 7, A 11, and C1. Expected volume of hazardous waste requiring treatment is about 3,833 m^3. As alternative 1, the treatment method proposed is low thermal desorption.

<u>Alternative 2</u>

This alternative differs from alternative 1 only in proposed technique for waste treatment – in this alternative solidification is considered for treatment of the hazardous waste requiring treatment. Common hydraulic binders are expected to be used – Portland cement or lime, and fly ash.

5.3.2 Detailed Analysis of Proposed Tasks

Within the process of screening and selection of applicable clean-up methods for construction waste disposal/treatment were brought forward to further analysis.

The criteria used for evaluation of selected procedure are technical, institutional, and economic considerations that decision-makers will take into account in selecting the remedial actions. The following criteria were used to evaluate each remedial task/alternative:

- Protection of Human Health and the Environment;
- Short-term Efficiency;
- Long-term Efficiency;
- Implementability;
- Compliance with current environmental regulations;
- Cost.

Each of these evaluation criteria is described below.

Protection of the human health and the environment

This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment.

Short term effectivity

This evaluation criterion addresses the effects of the methods involved. Under this criterion, methods are evaluated with respect to their effects on human health and the environment during implementation of the remedial action addressing following factors:

- Protection of community during remedial actions;
- Protection of workers during remedial actions;
- Environmental impacts that may result from the construction and implementation of a remedial alternative;
- Times until remedial action objectives are achieved.

Long term effectivity and permanence

The evaluation of methods under this criterion addresses the reset of a remedial action in terms of this risk remaining at the site after response objectives have been met. Long-term efficiency will be evaluated according to (1) magnitude of residual risk remaining at the site after implementation of the remedial procedure and (2) the adequacy and reliability of remedial controls. The long-term reliability of the remedial actions is judged according to the need for replacing components of the remedy and consequences of the failure of those components.

Implementability

The implementability criterion encompasses the technical and administrative feasibility of implementation and the availability of required services and materials taking into account following factors:

- Ability to construct and operate the technology;
- Reliability of the technology;
- Ease of performing additional remedial work if necessary;
- Ability to monitor efficiency of remedy;
- Ability to obtain approvals from authorities;
- Coordination with authorities;
- Availability of offsite treatment, storage, and disposal services and capacity;
- Availability of necessary equipment and specialists;
- Availability of prospective technologies.

An important aspect of implementability is the availability of equipment and services (i.e. equipment and services available in MK). For the FS assumption is that all workers would be trained in the specific health and safety procedures required by the Macedonian regulatory authorities.

Socioeconomic effects

The socioeconomic effects will be evaluated according to the economic effect of the land use after completion of the correction measures.

Compliance with current environmental regulations

The assessment against this criterion describes how the method/procedure complies with the current Macedonian environmental legislation or if a waiver is required and how it is justified.

Cost

The cost for the corrective measures is made up of capital cost, operating and maintenance cost.

<u>The capital cost</u> consist of direct cost (e.g. construction of prportonal part of the on-site landfill, purchase of the thermal desorption facility, incl. instalation) and indirect cost(non-construction and overhead) costs. Direct costs include expenditures for the equipment, labor and materials necessary to install remedial facility. Indirect costs include expenditures for engineering, financial and other services that are not part of actual installation activities but are required to complete the installation of remedial alternatives.

<u>Operating and maintenance costs</u> are post-construction costs necessary to ensure the continued efficiency of a remedial action. It comprise mainly cost for building demolition, screening and crushing of debris (within task 3 only), solidification (within task 3 alternative 2 only) loading, transportation and landfilling, monitoring, management and reporting cost.

Capital cost and operating and maintenance cost estimates for each of the remedial alternatives were prepared using information from Macedonian construction experience, estimates of remedial contractors and our practical experience with similar projects.

The cost estimates were prepared as the part of the overall evaluation of corrective alternatives. The estimates were based on information available at the time of the FS and on contraction assumptions that are reasonable for the state of the practice in Macedonia. The availability and cost of remedial services is expected to change, so these cost estimates should be refined in further stages of design or as new information becomes available.

Final project costs will strongly depend on actual labor and material costs, the capabilities of local contractors, the amount of imported equipment and labor, actual site conditions, productivity, actual health and safety requirements, competitive market conditions, final project scope, final project schedule, the firm selected for final engineering design and other factors.

Prospective offset from resale of separable reinforcing steel bars is not involved in the cost calculation – it may be considered as contingency. Tonnage of other saleable metallic scrap is not also involved in the cost estimation – the technology is being removed and tonnage of technology remnants in time of site remediation cannot be predicted.

The cost estimates in this FS are considered order of magnitude with an expected accuracy of plus 50% minus 30%. The cost-estimate is an unavoidable consequence of the conceptual stage of this remedial project. The range does not account for changes in the scope of the alternatives. A realistic discount rate of 5 percent before taxes and after inflation is assumed.

The results of assessment of the alternatives proposed are summarized in Table 5.5.

Table 5.5: Results of detail assessment

Criteria	Task 1 On site landfilling (non-hazardous waste)	Task 2 On site landfilling (hazardous waste)	Task 3 Alternative 1 Low thermal desorption	Task 3 Alternative 2 Solidification
Protection of human health and the environment	Protects the human health and the environment by izolation of the non-hazardous waste.	Protects the human health and the environment by izolation of hazardous waste.	Protects the human health and the environment by removal of hazardous contaminant and izolation of residual waste.	Protects the human health and the environment by immobilization of hazardous contaminants and izolation of hazardous waste.
Short term effectivity				
- community protection	Acceptable - the site is abandoned, dust release during the buildings pull down can be effectively and easily controlled; non-hazardous waste will be manipulated and the risk posed to community is negligible as well as environmental impact.	Acceptable - the site is abandoned, dust release during the buildings pull down can be effectively and easily controlled. Correct work practice will minimize the risk posed.	Acceptable - the site is abandoned, dust release during the waste manipulation can be effectively and easily controlled. The off gass from low thermal desorption is well treated and no risk is posed to the community.	Acceptable - the site is abandoned, dust release during the waste manipulation can be effectively and easily controlled. The solidification itself is wet process and dust release is minimized.
- worker protection	Potential occupational health and safety risks are easily manageable by use of proper PPE and correct work procedures.	Potential occupational health and safety risks are easily manageable by use of proper PPE and correct work procedures.	Potential occupational health and safety risks are easily manageable by use of proper PPE and correct work procedures.	Potential occupational health and safety risks are easily manageable by use of proper PPE and correct work procedures.

Table 5.5 – cont.

Criteria	Task 1 **On site landfilling** (non-hazardous waste)	Task 2 **On site landfilling** (hazardous waste)	**Task 3 Alternative 1 Low thermal desorption**	**Task 3 Alternative 2 Solidification**
Short term effectivity				
- environmental protection	Negative impacts are not expected, negigible risk posed to the environment	Negative impacts are not expected if good operation practise adopted.	Negative impacts are not expected if good installation and opearation practise adopted.	Negative impacts are not expected if good installation and opearation practise adopted.
- time requested for measures completion	Construction of on site landfill at HCH dumps would require approx. 2 months, pull down and transport of non-hazardous waste would require 3 months.	Approximately 2 months	Approximately 14 months.	Approximately 3 months.
	Another 12 months of designing and permitting (EIA is necessary). In total about 17 months.	Another 12 months of designing and approval phase. In total about 14 months.	Another 6 months of designing and approval phase. In total about 20 months.	Another 6 months of designing and approval phase. In total about 9 months.
Long term effectivity				
- soil and waste contamination	High - potential contaminants captured and isolated from the environment.	High - potential contaminants captured and isolated from the environment.	High - potential contaminants destroyed and isolated from the environment.	High - contaminants immobilized and isolated from the environment.
- adequacy and reliability of controls	Adequate and reliable method, proven.	Adequate and reliable method, proven.	Adequate and reliable method, proven.	Adequate and reliable method, proven.
Socioeconomics effects				
- socioeconomics effects	Negligible negative effects - a very limited area of land will be disabled for future industrial use.	Negligible negative effects - a very limited area of land will be disabled for future industrial use.	Negligible negative effects - a very limited area of land will be disabled for future industrial use.	Negligible negative effects - a very limited area of land will be disabled for future industrial use.

Table 5.5 – cont.

Criteria	Task 1 On site landfilling (non-hazardous waste)	Task 2 On site landfilling (hazardous waste)	Task 3 Alternative 1 Low thermal desorption	Task 3 Alternative 2 Solidification
Implementability				
- ability to construct and operate	Simple for construction and for operation,	Simple for construction and for operation,	Simple for construction, key equipment can be purchased abroad, proper training of staff is needed.	Simple for construction, common construction machinery needed - available in MK.
- ease and performing more actions if needed	Simple to extend.	Simple to extend.	Simple to extend.	Simple to extend.
- ability to monitor the effectivity	Easy	Easy	Easy	Easy
- ability to obtain approvals and coordinate from/with authorities	Might be complicated due to the necessity of EIA.	Might be complicated due to the necessity of EIA.	Might be complicated due to the necessity of EIA.	Might be complicated due to the necessity of EIA.
- availabilty of equipment and materials	Equipment and material available.	Equipment and material available.	Equipment and material available.	Equipment and material available.
- availabilty of technology	Available.	Available.	Available.	Available.
Compliance with current regulations				
- legal compliance	Most likely would meet current regulations.	Most likely would meet current regulations.	Most likely would meet current regulations.	Most likely would meet current regulations.
Cost estimated				
- construction cost (€)	250 000	175 000	3 950 000	475 000
- operational cost (€)	990 000	650 000	2 410 000	2 110 000

Analysis of the remedial tasks and task alternatives is intended to characterise individua tasks and identify differences among task alternatives and highlight the discriminating features listed in Tables 5.4 and 5.5. The comparative analysis discusses tradeoffs among task alternatives.

Protection of the human health and the environment

All of the remedial tasks/task alternatives are considered protective of human health and the environment. The differences are in the techniques used. All the task (alternatives) can adequately isolate the contaminated construction materials from the environment with regards to degrese of their contamination.

Short term effectivity

The effects on the community during the installations are related to the risks caused by pull down of constructions, to the amount of truck traffic required to haul the generated waste and contaminated soil for disposal of. These effects can be effectively reduced by preventive measures.

With regards to workers protection, all task (alternatives) consider protection of workers performing remedial activities.

The differences in the environmental effects are similar to the issues raised regarding community protection. That is, environmental effects would be related to releases generated during pull down of buildings and to transport of contaminated soil. These effects are negligible – the work will be carried out in an abandoned part of OHIS.

The technologies selected are considered environmentally friendly. Products of treatment will be either securely disposed of or immobilized and will remain captured in the on site landfill (treated hazardous waste).

Completion of each task takes from 9 to 20 months. Total time required for completion of the whole corrective action (Task 1 + Task 2 + Task 3) would take 2 years (applying alternative 2 in Task 3) up to 3 years (applying alternative 1 in Task 3).

Long term effectivity and permanence

For all tasks (alternatives) residual risks at the site were judged according to whether hazardous substances would remain or would be removed from the site, with or without treatment.

In cases of task 1 and task 2 the contamination will not be removed, contaminated material will be isolated from the environment in newly constructed on site landfill.

In case of task 3, alternative 1 the contaminants will be removed from the media contaminated and properly liquidated and the remaining debris will be isolated from the environment – disposed of at the newly constructed on site landfill. However, a portion of construction materials contains elevated concentrations of heavy metals in water leachate. HM cannot be destroyed or immobilized by thermal desorption.

In case of the task 3, alternative 2, the contaminants will be immobilized and the treated waste will be also isolated from the environment – disposed of at the newly constructed on site landfill.

All the task (alternatives) assessed for disposal of/treatment of construction waste can reduce the contamination (or potential risk related to contamination) to acceptable level. All the technologies are effective and proven.

Socioeconomic effects

Socioeconomic effects are considered as negligible – just a small portion of the land will not be useable for industrial purpose – the land occupied by newly constructed on site landfill – i.e. area about 22,000 m^2.

Implementability

All the task (alternatives) are technically easy to implement and would require mainly conventional construction procedures modified to meet health and safety rules.

Compliance with current environmental regulations

The conceptual remedial approach considered in this FS was developed to comply with the expected requirements of the pending Macedonian environmental regulations and requirements defined in EU regulations. As Macedonian environmental legislation is being developed, the final design of the remedial actions must be tailored to comply with the exact requirements of the regulations that will be in effect when remedial activities are implemented.

Cost

Treatment and disposal cost of hazardous waste according the alternatives 1 and 2 of task 3 differ significantly – the alternative 1 considering thermal desorption requires very high investment cost for purchase of the equipment as well as high operational cost due to high energy consumption. Alternative 2 considering the solidification as treatment method has relatively low installation cost and high operational cost due to consumption of big volume of additives needed and large repetitive manipulation with bid waste volume.

Total estiomated cost required for completion of the whole corrective action (Task 1 + Task 2 + Task 3) is 4,650,000 € (applying alternative 2 in Task 3) up 8,425,000 € (applying alternative 1 in Task 3)..

The only differences in compliance with the above criteria found for the alternatives 1 and 2 of task 3 were the cost and inefficient removal/immobilization of heavy metals by thermal desorption (alternative 1). Thus recommended technique for the liquidation/treatment of the construction waste in sectors A, C, and E comprises gradual selective pull down of building in order to avoid mixing of various kinds of wastes, on site landfill construction, on site landfilling of non-hazardous (task 1) and hazardous waste (task 2), and treatment of hazardous waste requiring treatment by solidification (preferably by common hydraulic binders – cement) with subsequent disposal of at the on site landfill (task 3 alternative 2).

6. Conclusion and Recommendation

Based on the assessment of applicable methods for disposal/treatment of contaminated construction waste, the most feasible option was selected – combining several technologies:

- on site landfilling of non-hazardous waste;
- on site landfilling of hazardous waste;
- solidification of hazardous construction waste requiring treatment and subsequent on site landfilling of treated construction waste;

The main factors influencing the selection of technologies to be incorporated in the construction waste disposal/treatment activities is the cost and the fact that HM contained in a portion of construction waste cannot be destroyed/extracted by thermal desporption but can be effectively immobilized by solidification.

The technology proposed for waste treatment relies on low cost, effective, easily implementable and proven methods.

Anticipated cost for the construction waste liquidation/treatment in sectors A, C, and E in OHIS is estimated in total about **4,650,000 €**. This cost includes site preparation, pull down of buildings, on site landfill construction, cost for material and operational cost.

The liquidation/treatment of construction waste can be completed within the period not exceeding 2 years.

7. Closing Remarks

It has to be noted that the FS was elaborated on the basis of data gathered during only a limited site investigation carried out within the frame of the project „Old Environmental Burdens in Chemical Plant OHIS, Skopje“. Data gaps still exist regarding exact delineation of contaminated soil.

This feasibility focused on selection of feasible corrective measures addressing the liquidation/treatment of contaminated construction waste in the areas of former pesticides production, monochloracetic acid production, and outdoor cooled storage of flammables.

It has to be noted that cost for liquidation of wastes stored in sector E – open cooled storage of flammables are not included in this FS – this sector would require investigation which is out of the scope of this project.

ANNEX 1

Site location map

ANNEX 2

Site layout map

ANNEX 3

Laboratory analyzes

ANNEX 4

Photolog

Building A 1 – former storage of HCH and TCB production

Building A 2 – former lindane production building (southern frontage)

Building A 2 – former lindane production building (inside)

Building A 4 - former lindane production building

Building A 4 - former lindane production building (ground storey)

Building A 4 - former lindane production building inside

Building A 3 (former raw material and packaging storage; A 5 (locker rooms, workshop); A 6 (organophosphates production building), A 7 (granular organophosphates production building)

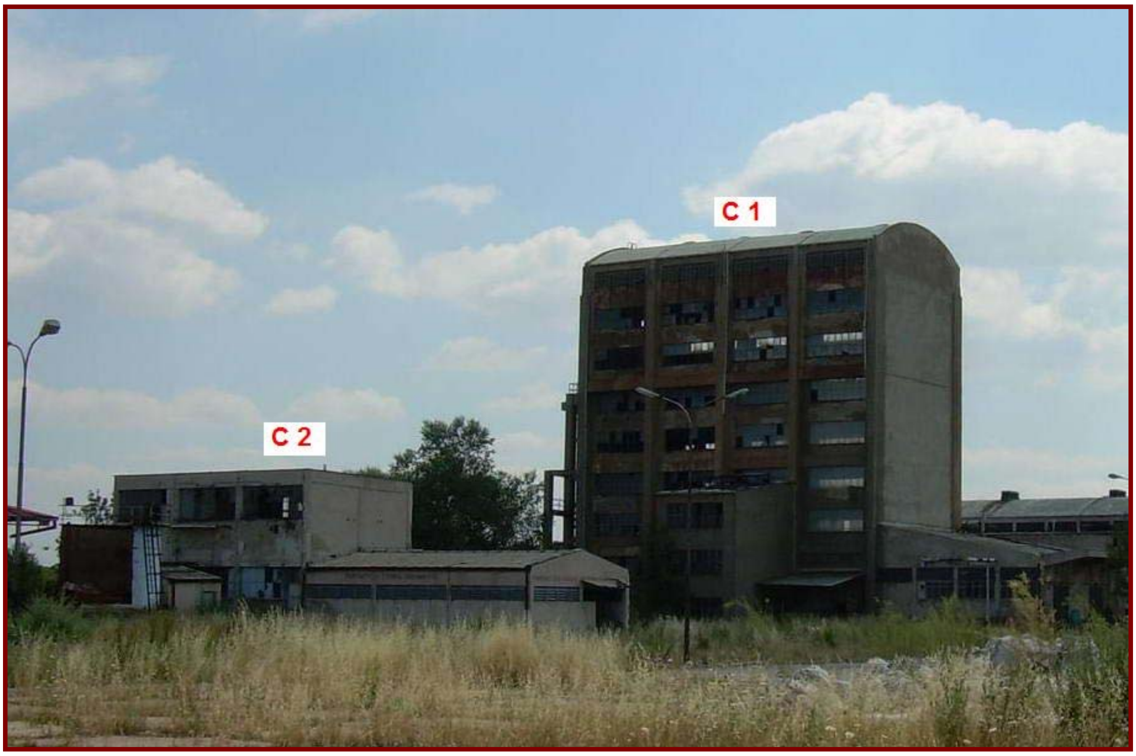
Building A 7 – western frontage

Building A 7 – inside

Building A 9 – storage of final pesticides

Building A 9; A 10 (storage of packaging); A 11 (storage of packaging)

Building A 8 – production of granulated pesticides (inside)



Building C 1 (former monochloracetic acid production); building C 2 (former acetylene production)

Building C 1 – southern frontage

Building C 1 – eastern frontage

Building C 1 – northern frontage

Building C 1 – inside, ground floor

Building C 1 – inside

Building C2

E 1 – outdoor cooled storage of flammables