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Project: **Kharkiv Metro Expansion Project**

Services: **Feasibility Study**

Environmental and Social Due Diligence
Environmental and Social Analysis Report

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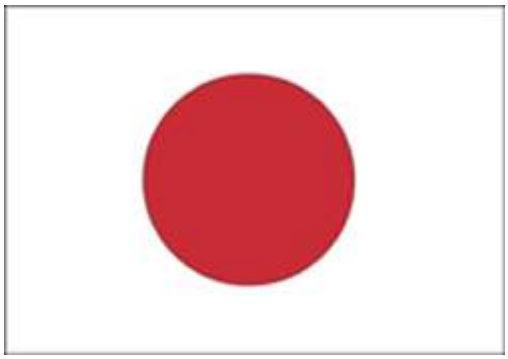

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Register of Submissions

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Rev No.	Date	Description
00	07.07.2016	Submission of Environmental and Social Analysis Report
01	02.10.2016	Revision of report in accordance with EBRD's comments
02	18.08.2017	Update of greenhouse gas calculations and other minor amendments

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Report prepared by Tebodin Ukraine CFI

Executive Summary

A Consultancy Contract dated 9 December 2015 for the Kharkiv Metro Expansion Project – Feasibility Study has been signed by the European Bank for Reconstruction and Development (EBRD) and BERNARD Ingenieure ZT GmbH, who contracted Tebodin Ukraine CFI for the Environmental and Social Due Diligence (ESDD). The ESDD is Task 9 of the Consultant's Terms of Reference and comprises 6 sub-tasks. This Report covers sub-task **9.2 Environmental & Social Analysis** and provides the assessment of the potential environmental and social impacts associated with the project as well as proposes measures to mitigate impacts.

The feasibility Study of the Kharkiv Metro Expansion Project comprises three main components:

1. Extension of the existing Green Line towards the airport by 3.47 km and construction of two new stations: Derzhavinska and Odeska;
2. Construction of a metro wagon depot for the Green Line; and
3. Procurement of rolling stock.

A legal entity has been established for the development of the Kharkiv Metro, namely the Metro Construction Company (MCC). The municipal company Kharkiv Metro (KMC) is the current metro operator, and will also be the future operator.

The main findings of the E&S Analysis and the Consultant's recommendations are presented below.

Categorisation

According to the EBRD Environmental and Social Policy (ESP), the Bank categorises each project to determine the nature and level of environmental and social investigations, information disclosure and stakeholder engagement required. A project is categorised "A" when it could result in potentially significant adverse future environmental and/or social impacts which, at the time of categorisation, cannot readily be identified or assessed.

A list of indicative Category A projects (Appendix 2 to the ESP) includes projects which may involve significant involuntary resettlement or economic displacement. Although the Kharkiv Metro Expansion Project is expected to cause physical and economic displacement, its parameters can be well defined at the moment of categorisation.

As of August 2017, the City has identified 249 tenants registered in 45 houses that will be directly affected by the construction and operations of the Extension. Potential adverse social impacts will be addressed through mitigation measures envisaged in the Resettlement Action Plan (the RAP). Furthermore, the resettlement can be considered as an opportunity to improve poor living conditions observed.

Key environmental considerations are assessed in the statutory EIA and the ESDD. Potential adverse impacts will be addressed through mitigation measures prescribed in the Environmental and Social Action Plan (the ESAP), and balanced by positive impacts such as improved air quality and reduction of the GHG emissions that are expected due to decrease of the road traffic.

Based on the foregoing, the Project's potential adverse future environmental and social impacts are seen as site specific, readily identified and addressed through mitigation measures. Therefore, the application of Category B to the Project is proposed.

Baseline Conditions

Legal situation

The Consultant considers the spatial planning to be compliant with the national and local regulations, whereas the current operation permits will need to be revised.

- Spatial planning:

The City Master Plan till 2026 (approved by the decision № 24-22 of Kharkiv City Council as of 23.06.2004) outlines the development of the City Metro system. That includes of extension of the lines up to 52.6 km and construction of a depot at a Green line.

The Program of Construction and Development of Kharkiv Metro for 2010-2015 (approved by the decision № 37/10 of Kharkiv City Council as of 24.02.2010) reasserted for 2010-2020 (by the decision № 643/17 of Kharkiv City Council as of 19.04.2017) confirms plans for a prospective construction of the section between Metrobudivnykiv and Odeska stations as well as the construction of the Oleksiivske depot with the connecting thread.

- Construction and operation permits for the Extension and the Depot:

The Construction Permit will be issued by the State Architectural and Construction Inspection of Ukraine on the basis of positive Expert Report of the State Construction Expertise that examines basic design documents for compliance with national standards on architecture, construction, environmental, sanitary and fire safety.

The Environmental Impact Assessment (EIA) of both the extension and the Depot has been prepared by the Project designer, i.e., Kharkivmetroproekt (as an integral part of basic design documents) and examined by the State Expertise. In 2015 and 2016 the Basic Design Documents (including the EIA) have been updated and provided with Expert Report of the State Construction Expertise that certify compliance of the design(the Extension: ref. No. 00-1599-16/ПБ (00-0548-16/ПБ) dated 20.01.2017; the Depot: ref. No. 00-1598-16/ПБ (00-0474-16/ПБ) dated 28.12.2016).

Since the Project is associated with adverse environmental impacts (as well as positive impacts), KMC should update its current environmental permits for Air Emissions, Special Water Use and Waste Operations at the time of Project commissioning.

Management system

The decision № 193/11 “On establishment of municipal Company "Kharkiv subway construction management” (Metro Construction Company - MCC) was taken by Kharkiv City Council on 23.02.2011. According to this decision an autonomous department of KMC was separated into a new legal entity. Thus, MCC is the Project owner who is responsible for design and construction phases of the Project.

The Consultant considers the management system of MCC to be not fully adequate, to secure compliance with applicable E&S requirements of the EBRD and the EIB during the Project construction stage. Currently environmental and social performance of contractors is not controlled by MCC.

Labour and Working Conditions during the operational phase will be covered by KMC management system which is considered appropriate.

The environmental and social goals of both MCC and KMC are not formalized in an overarching policy document.

Environmental baseline and impact

The Consultant considers the environmental baseline study to be not fully adequate.

The presented EIA reports:

- Do not cover potential social impacts of the project e.g. resettlement or economic displacement;
- lack information on ambient quality of the water in Lozovenka River where the Depot’s storm water will be discharged.

All the Project components will be developed at brownfield sites. A number of concerns have been identified related to environmental quality:

- Oil from the oil depot (adjacent to the Extension route) has been identified in the samples of groundwater that will tentatively fall into the Extension’s drainage system at section between chainage 130+00 and chainage 135+00. The risk of pollution of metro drainage waters with oil from the oil depot adjacent to the route of the extension has not been considered in the Basic Design Documents.
- The drainage system design at the Extension will unlikely prevent potential waterlogging because of rising of the groundwater between chainage 128+00 and chainage 138+00.

Social baseline and impact

The Consultant considers the social baseline study to be adequate but the impact is not covered in the EIA.

The Extension route passes through residential and industrial areas of the City. Some land plots currently occupied by living and business premises are planned for the Project-related acquisition with subsequent resettlement and economic displacement.

As of August 2017, the City has identified 45 houses (42 private households and 3 blockhouses) with 249 registered tenants and several businesses that will be directly affected by the construction and operations of the Extension.

The City undertook an informal social and economic survey of the residents of the affected households determined for acquisition.

To address potential adverse social impacts Resettlement Action Plan has been developed in line with national legislation and the corresponding requirements of the EBRD and the EIB. The City has declared its commitment to follow the RAP.

An area initially dedicated for the extension's construction camp is occupied by private garages, underground food storages, and a children's playground. After careful consideration, an alternative land plot for the construction camp has been selected. The new site, located in 200 metres to the North East from the initial one, is free of third-parties' property and public amenities.

An area dedicated for the Depot construction is currently used for deposition of piles of clay soil, delivered from the pit of Peremoha station. Minor part of the land plot earmarked for the connector line is informally used for private gardening.

The formal requirements for the disclosure of information on the Project are fulfilled: The Statement of Intent and the Statement of Consequences have been published in the local newspaper. Local TV news highlights the process of the Project preparation. Public consultations on environmental and social impacts (an element of EIA) of the Project have been conducted in 2008; however this does not guarantee an appropriate level of stakeholders' engagement.

In early 2017, surveys of residents who will be affected by the Project were organized by the City. The Consultant provided copies of sample questionnaires for the survey.

Significant Environmental and Social Impacts

Phase	Type of impact	Project Facility	
		Extension	**Depot**
Construction	negative	Land acquisition, involuntary resettlement and economic displacement can result in social conflicts unless thoroughly planned and properly conducted. Outdated public consultations cannot guarantee the proper stakeholder engagement that can result in social conflicts	The use of asbestos materials (suggested by basic design documents[1]) imposes the risk of oncological diseases on construction workers, and all the personnel handling these materials through the whole supply chain that precedes the final use. Asbestos fibres released during underground construction works are likely to remain, causing a public health risk.
		The risk of construction subcontractors' incompliance with EHS requirements can lead to poor performance on the Project site	
	positive	Local economic growth: The Project will facilitate the demand for construction materials, engineering services, equipment most of which can be supplied by local, regional or national suppliers and contractors.	
Operation	negative	Potential waterlogging as a result of raising of the groundwater levels because of damming effect made by tunnels[2] The oil spilled from the oil depot can pollute the Extension's drainage waters	Emissions of GHG and pollutants to the atmosphere that can be avoided through the application of renewable energy for heating. There is a risk of adverse impact on Lozovenka River ecosystem through the discharge of the Depot's storm water

[1] According to the Order of the Ministry of Healthcare of Ukraine No. 339 as of March 29, 2017 On Approval of the State Sanitary Norms and Rules "On Safety and Protection of Workers against Harmful Effects of Asbestos and Materials and Articles Containing Asbestos", manufacturing and use of asbestos is prohibited (regardless of asbestos-containing products and materials type) in the technological processes and during construction and installation work. The Project design documentation will be adjusted in accordance with valid requirements.

[2] The design of the tunnels will be revised and deepened by at least 3.0 m. The impact of deepening the design of tunnels on the intensity of the damming effect and the need for additional measures to eliminate the risk of flooding will be determined after additional geological survey is conducted. Under the terms of the tender for the survey, announced by the MCC on August 11, 2017, the survey will be completed by December 20, 2017.

	positive	Improved access to safe and reliable transportation services for inhabitants of Kharkiv's southern residential areas and suburbs Additional 132 workplaces Decrease in road users results in less road accidents, less congestion and less direct emissions to air and less noise. All that will have a positive impact on community health.	The new depot enables reduction of the headway time and thus enhances the comfort of transportation for passengers Additional 453 workplaces

According to the Metro Construction Standard (ДБН В.2.3-7-2010) the design life of tunnels and stations is at least 250 years. For this reason the Consultant did not assess the impacts associated with decommissioning of the extension. Should a decision on decommissioning of the depot be taken, the expected impacts will be similar to those during construction phase supplemented with handling the decommissioning debris.

Recommended Mitigation and Enhancement Measures

Related to the main impacts, it is recommended:

- To develop and implement EHS management based on best industry practices and international standards such as ISO 14001 (or CEEQUAL) and OHSAS 18001;
- to replace asbestos with alternative materials;
- to conduct second round of public consultations on the Project;
- to finalise a census on resettlement (after the City Council approves the Decision on "Purchase of Land and other immovable assets for the Public Needs");
- to follow a Resettlement Action Plan in order to mitigate the negative impacts of displacement, identify potential benefits and establish the entitlements of all categories of affected persons, with particular attention paid to the needs of the vulnerable;
- to develop and implement procedures on securing contractors' EHS compliance;
- to conduct further survey on oil pollution and to develop and implement measures for prevention of metro drainage water oil contamination;
- by changing the Project design to mitigate the risk of waterlogging as a result of rising of the groundwater due to damming effect caused by the tunnels;

The Environmental and Social Action Plan (ESAP) is presented in the ESDD.

To mitigate the identified negative impacts and to manage the issues successfully, a comprehensive stakeholder engagement process is required. MCC already has some elements of a stakeholder communication system and has been engaged in public consultation activities as part of the Project permitting procedures.

The Company communicates their positive achievements to the general public via local media and their website. To make this process more comprehensive and compliant with EBRD expectations, a Stakeholder Engagement Plan (SEP) has been prepared as part of the ESDD.

Monitoring Proposal

The Environmental and Social Action Plan (ESAP) also includes monitoring. In general, KMC has to report to EBRD on the status and progress of the ESAP. EBRD should monitor the compliance with the ESAP.

Glossary

Definitions

The Bank	European Bank for Reconstruction and Development
The Company	Kharkiv Metro Company
The Consultant	BERNARD Ingenieure ZT GmbH, with Tebodin Ukraine CFI as a specialist consultant for preparation of the ESDD
The Depot	The metro wagon depot “Oleksiivske” and connection to the Green Line
The Designer	The Design Institute “Kharkivmetroproekt” that develops Project design documents
The Developer	MCC that acts as a client for construction of the Extension and the Depot
The Extension	The extension of the Green Line by 3.5 km and construction of two new stations “Derzhavynska” and Odeska;
The Green Line	The existing 8-station Oleksiivska (or “III”) Line of Kharkiv Metro System
The Project	Current metro system expansion that includes: i) the Extension of Green Line by 3.5 km and construction of two new stations “Derzhavynska” and Odeska; ii) construction of the Depot iii) acquisition of 85 units of rolling stock.
The Project Site	Land plots where the extension of the line, auxiliary premises and depot will be constructed

Abbreviations

CMS	Construction Method Statement (a volume of Design Documents)
ESA	Environmental and Social Audit
EBRD	European Bank for Reconstruction and Development
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment (a volume of Design Documents)
ESAP	Environmental and Social Action Plan
ESDD	Environmental and Social Due Diligence
ESMS	Environmental and Social Management System
ESP	Environmental and Social Policy of EBRD (2014)
EU	European Union
FS	Feasibility Study
GHG	Greenhouse Gases (restricted to GHG under the Kyoto Protocol: carbon dioxide, methane, nitrous oxide, sulphur hexafluoride and two groups of gases (hydrofluorocarbons and perfluorocarbons))
HR	Human Resources
JSC	Joint Stock Company
LRP	Livelihood Restoration Plan
MAC	One-time Maximum Allowable Concentration of a substance
MCC	Municipal company “Kharkiv Metro Construction Management”
NGO	Non-Governmental Organisation
NTS	Non-Technical Summary
OS	Occupational Safety
OSMS	Occupational Safety Management System
PR	Performance Requirement (of EBRD)
PPE	Personal Protective Equipment
PT	Public Transport
RAP	Resettlement Action Plan
SE	Specific Emission
SEP	Stakeholder Engagement Plan
VTC	Vehicle Technical Condition

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1 OPERATIONAL CONTEXT

1.1 Purpose and Need

The implementation of the Project would allow the City and the State to fully capture the anticipated economic benefits of this investment as a result of ridership increase (by 1 million of passengers per year, according to the Company) and travel time savings. Besides that, reduction in the reliance on private car and road public transport would result in decrease in traffic intensity, less road accidents, better air quality and public health due to lower emissions.

The main objective of the Project is to improve the provision of mass transit in Kharkiv as part of an overall strategy to achieve sustainable urban transport in the city.

1.2 Project description

The feasibility Study of the Kharkiv Metro Expansion Project comprises three main components:

a) Extension of the existing Green Line towards the airport by 3.47 km and construction of two new stations: Derzhavinska and Odeska;
b) Construction of a metro wagon depot for the Green Line; and
c) Procurement of rolling stock.

The metro extension is located in an urban area south of Kharkiv's city centre (Figure 1). The entire alignment runs underground though is generally shallow (~ max. depth 15 m to track level). Geotechnical exploration has already been undertaken and indicated geological / hydrogeological ground conditions of fines with groundwater and potential for confined groundwater levels.

The alignment runs mainly along Gagarina Avenue and partially along Derzhavinska Street. The proposed extension of the Green Line starts at the already existing part of the route south of the station Metrobudivnykiv and leads south to the planned stations Derzhavinska and Odeska. The alignment underpasses the Gagarina Avenue at a very acute angle in a reverse curve. From there, the alignment remains on the western side of Gagarina Avenue, underpasses the railway line and continues in a straight alignment to the Odeska station. South of the Odeska station, a four-rail reverser including necessary switch connections is designed.

The section from the existing tunnels to the station Derzhavinska (959 m long) is planned to be built in open cut technology, i.e. from the ground surface. The construction pits will be made of bored pile walls and metal piles. Dewatering of the construction pits will be required. The construction will either be of prefabricated concrete elements or cast-in-place reinforced concrete. The double-track section will consist of two separated frame-structures, which merge in a ventilation aperture of Derzhavinska station.

The stations Derzhavinska and Odeska will be built in open cut technology, (similar to the section between the Metrobudivnykiv and Derzhavinska stations) on the east side of Gagarin Avenue on a private development area and in the area of Odeska and Heroyiv Stalingradu streets respectively.

For the section between stations Derzhavinska and Odeska (2514 m long) tunnelling by means of a shielded TBM is planned. Two tunnel drives will be required (since the metro tunnels will be twin-tube). The launching shaft is situated south of the station Odeska, the receiving pit is designed to be in the area of the northern end of Derzhavinska station. Shafts will be constructed top-down. The tunnels are lined with precast, watertight, reinforced concrete segments.

The extension of the Green Line requires installation of the temporary structure for household use of 120 construction workers. The structure will be located nearby the planned Odeska Station.

The operation of the extended Green Line requires the construction of the wagon Depot. The area designated for Oleksiivske Depot (7.4 ha) is located on the lands of Malodanylivska village council of Derhachivskyi district of Kharkiv region. The land plot earmarked for the Green line connector thread (4.0 ha) is situated on the territory of the City nearby the City ring road (Lozovenkivskyi avenue). The Depot area is currently used for deposition of piles of clay soil, delivered from the pit of Peremoha station. Some informal gardening takes place on the connector line land plot.

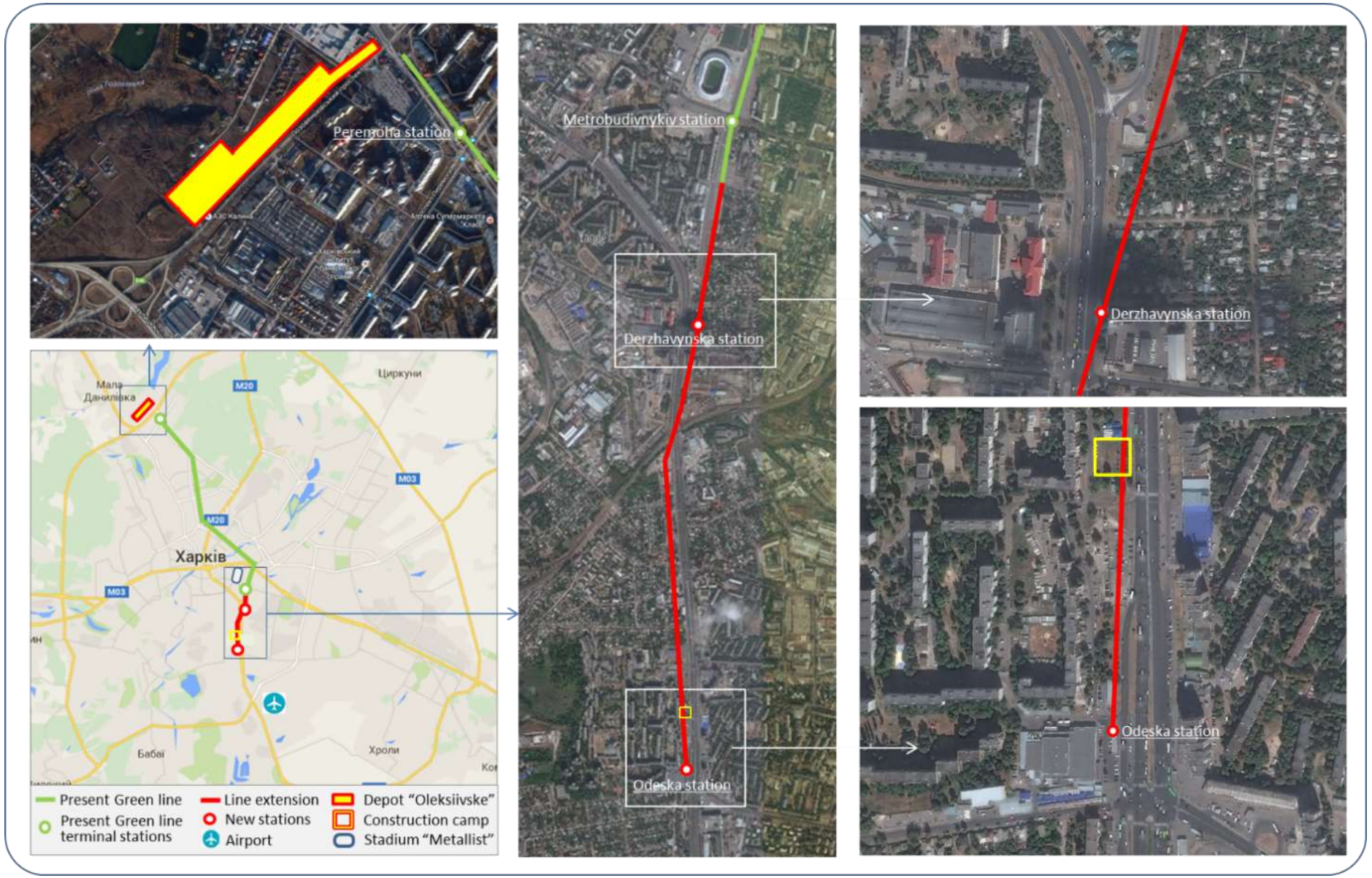


Figure 1: Location of the Project components

1.3 Legal and Institutional framework

1.3.1 Legal Status

Pre-design

The City Master Plan till 2026 (approved by the decision № 24-22 of Kharkiv City Council as of 23.06.2004) outlines the development of the City Metro system. That includes extension of the lines up to 52.6 km and construction of a depot at an extended Green line.

The Program of Construction and Development of Kharkiv Subway for 2010-2015 (approved by the decision № 37/10 of Kharkiv City Council as of 24.02.2010) reasserted for 2010-2020 (by the decision № 643/17 of Kharkiv City Council as of 19.04.2017) confirms plans for a prospective construction of the section between Metrobudivnykiv and Odeska stations as well as the construction of the Oleksiivske depot with the connecting thread.

However, it should be noted that a strategic Environmental Impact Assessment (as applicable in the SEA Directive 2001/42/EC of the EU), has not been performed for the Master Plan and the Program due to lack of such requirement.

Design and Construction

The design encompasses the first stage in a shape of Feasibility Study for the extension of the Green line from station “ul Plekhanovskaya” (currently Metrobudivnykiv) to station Odeska that has been conducted in 1992 by design institute “Kharkivmetroproekt”.

The second stage - Basic Design Documents – has been developed by “Kharkivmetroproekt” (Depot in 2007, Extension – in 2008). The documents have passed the State Expertise (Depot - on 21.03.2008, Extension – on 23.12.2008) that concluded compliance with design, construction, environmental, sanitary, fire safety and energy efficiency norms and standards. Although the Conclusions (No. 93 for Depot, No/138-2008 for Extension) enabled obtaining of the construction permit this step has not yet been taken.

In 2015 the Basic Design Documents have been updated. According to MCC the only chapter that has been changed (compared to the approved changes) is Project costs estimates for both the Depot and the Extension.

At beginning of May 2016, the MCC has submitted the amended basic design documents for the Depot and the Extension to the State Construction Expertise. Based on the State Expertise review the expert were received. At the moment, the Project design documents are reviewed by the Cabinet of Ministers of Ukraine.

The Consultant has examined drafts of the EIAs and the final EIAs that are an integral part of the design documents. Several data gaps have been identified. The major gap is information on social impacts that is not presented in EIA despite of scale of these impacts expected by the Consultant. The further information on the data gaps is presented in subject–specific sections of this report.

In 2015 and 2016 the Basic Design Documents (including the EIA) have been updated and were subsequently approved by the State Expertise (the Extension: ref. No. 00-1599-16/ПБ (00-0548-16/ПБ) dated 20.01.2017; the Depot: ref. No. 00-1598-16/ПБ (00-0474-16/ПБ) dated 28.12.2016), subsequently approved by the Cabinet of Ministers of Ukraine (the Extension: No. 538-p dated 19.07.2017, Depo: No. 539-p dated 19.07.2017).

Further steps that must be taken in order to start the construction are as follows:

- the developer organises bidding and selects a construction contractor;
- the developer submits an application for construction permit to State Architectural and Construction Inspection of Ukraine (the Inspection);
- the designer prepares the detailed design;
- the Inspection issues a Permit for Construction Works (sometimes a separate Permit for Preparatory Works);

- the construction starts.

Construction should be executed strictly in line with EHS provisions stated in the EIA and Construction Method Statement (CMS) volumes of the Project Basic Design documents approved by the order of Cabinet of Ministers of Ukraine.

Operation

The developer issues an “Act of Readiness for Operation” that states the compliance of a facility to all applicable norms and standards. The State Architectural and Construction Inspection of Ukraine conducts verification and issues a ”Certificate of Commissioning” that allows the start of operations.

According to the Consultant’s understanding, from that point KMC takes over the control of the Project facilities. Since the operations of the facilities are associated with adverse environmental and social impacts and risks, the Company has to obtain (or update existing permits) permits.

- For emissions to atmosphere

All sources of emissions and the emitted substances of the Depot and the Extension should be characterised and listed in the permits. The calculations of polluting substances dispersion should be confirmed by sampling and analysis of pollutants’ concentrations at the adjacent residential areas.

- For disposal of waste

The total expected amount of waste exceeds the 1000 units (calculated as the sum of wastes’ weights multiplied by factors corresponding to the class of hazard).

- For special water use

As the new depot plans to discharge its storm water into the river the permit for special water use should be obtained. The permit is issued on the basis of the Specification for Maximum Discharge. The specification establishes the maximum load of a particular substance in water discharged to a particular place of a water body on an established regime per unit of time. The resulting concentration of a substance in a water body should be below the level established in sanitary standards for this substance for the particular class of a water body (depends on type of use).

1.3.2 Institutional Framework

Municipal company “Kharkiv Metro Construction Directorate” (Metro Construction Company – “MCC”), a subsidiary of Construction and Roads Department of Kharkiv City Council is responsible for the design and construction phase of the Project. The key function of the MCC is control over construction of the Metro facilities including selection and management of contractors from design to commissioning stages. MCC was established in 2011 based on the decision by Kharkiv City Council № 193/11. According to this decision an autonomous department of KMC was separated into a new legal entity. According to the Head of MCC the company staff is 20 employees.

Municipal company Kharkiv Metro (the “Company” or “KMC”) is a metro operator, wholly owned by the City. KMC is responsible for operational phase of the Project. For further details on the Company, please refer to Environmental and Social Audit Report.

1.4 History of the operation including alternatives considered

Green Line

The order of the Council of Ministers of the USSR “On the Construction of the Third Metro Line in Kharkov” was issued on January 22, 1984. Although the strategic development scheme of Kharkiv Metro with three lines intersecting at the centre was developed in the 1960s, there was a lively discussion about the routing of the second and the third metro lines. The rapid growth of a new housing estate in the north-eastern part of the city has determined the plans and the second subway line went in the direction Saltovka. At the same time, the direction of future Green Line was finally determined - from Oleksiivskyi housing estate to the airport. It was planned to construct a 15 km line with 11 stations (from Peremoha to Odeska) whereas sections Odeska - "Airport" and Peremoha - "Voroshilov" were seen as perspective.

Designers considered two options for the construction of the line. According to one of them, the first section to be opened was from station Sovnarkomovskaya (Architectora Beketova) to the station Peremoha, which would ensure a speedy connection from the new housing estate Oleksiivskyi to the city centre. However, this option would result in an uneven distribution of passenger flows and excessive workload for hubs Radyanska (Ploshcha Konstytutsii) – Istorychnyi Muzey and Dzerzhinskaya (Universytet) - Derzhprom.

Another option suggested first section of six stations - from Prospekt Lenina (Naukova) to Derzhavinska. Thus, with the commissioning of the section, Kharkiv would receive the long-awaited solution of the general transport scheme on the basis of the "classic triangle" that provides an even distribution of passenger traffic, and a trip to any station with one change only. Therefore, it was decided to implement this option; however, the station Derzhavinska was not included in the first section.

The design of the first section (from station Metrobudivnykiv to Naukova) was approved on 30 June 1984. Documentation was developed by SRI "Harkivmetroproekt". According to initial plans, the first section had to be put into operation in 1992, the second (stations Botanichnyi Sad and 23 Serpnya) - in 1995, the third (station Internationalna (Oleksiivska) and Peremoha) - in 2000. However, in 1991 the funding was interrupted and the nearly finished first section was significantly delayed.

The funds for the completion of the first section were allocated at the end of 1994. A possible reason for this was the fact that the maintenance of facilities was more expensive than its completion. On 6 May 1995 the third line of the Kharkiv Metro was opened.

The second section extending the line to the station 23 Serpnya opened on 21 August 2004. The opening date of the next section was delayed several times, so that the station Oleksiivska was only commissioned in 2010. This expansion made the Green Line the second longest of the system. Currently, 9 stations operate on the Green Line. The summary of the Green Line expansions is presented in Table 1.

No	Commissioning date	Section length, km	Station	SSt. of the axis
1	06.05.1995	5.2	Metrobudivnykiv imeni H.I. Vashchenka	116+76.0
2			Ploshcha Povstannya	104+87.0
3			Architect Beketov	82+27.0
4			Derzhprom	74+56.0
5			Naukova	63+61.0
6	21.08.2004	2.5	Botanichnyi Sad	48+88.0
7			23 Serpnya	38+15.0
8	21.12.2010	2.4	Oleksiivska	18+05.0
9	25.08.2016	-	Peremoha	03+38

Table 1: Summary of expansions of the Green Line

Extension

The Feasibility Study (FS'92) for the extension of the Green Line from station ul Plekhanovskaya (currently Metrobudivnykiv) to station Odeska has been conducted in 1992 by the design institute "Kharkivmetroproekt". The FS'92 considers several alignments with focus on three main alternatives:

- *Alternative I*: the tunnels under the storm water mail collector at 135+20
- *Alternative Ia*: the tunnels above the storm water mail collector
- *Alternative II*: the tunnels under the right side of Gagarina Avenue carriageway

Alternatives I and Ia have a different vertical alignment at 130+70 – 138+00. Alternative II differs from I and Ia horizontally at the section 135+50 – 148+00.

Besides that, a deep (up to 30 m) alignment was considered for the section between Derzhavisnka and Odeska stations. The option was rejected due to complexity of construction methods (freezing of the ground, use of cast iron lining of tunnels) determined by local hydrogeology. Several alternatives for crossing the railway bridge were considered in the FS'92 as well.

To minimise resettlement, two alternatives to the original design were studied, compared and assessed by the Consultant in the course of Feasibility Studies for the Bank. MCC jointly with the Metro Design Institute has examined the suggested changes in horizontal alignment and decided to keep the original design;

however, the alignment will be deepened in accordance with the Consultant's recommendations. According to MCC both suggested alternatives entail material difficulties related necessity of crossing the main sewer located under the avenue. The excessive cost of transferring the affected utilities network negates the possible social benefits.

The extension of the Green Line requires installation of the temporary construction camp for the use of 120 construction workers. The initial site selected for the camp is occupied with private garages, underground food storages and a playground. The Project would have required relocation of these facilities. To reduce the impact on the infrastructure and population, an alternative land plot for the construction camp has been selected. The new site, located in 200 metres to the North East from the initial one, is free of third-parties' property and public amenities.

Depot

Despite non-compliance with the standards of metro operating, according to which the metro line cannot be operated without its own depot, all the rolling stock of the Green Line is being maintained in the depot Moscovske of the Red Line. The dead-ends at the terminal stations Peremoha and Metrobudivnykiv are used for train parking during the night hours.

Various options for the depot location have been considered. In the late 80's - early 90's the depot was planned in the area of the Polyova Street (near the station Metrobudivnykiv). However this plan implied a largescale land acquisition and resettlement of about 200 households in the area. The depot had to be commissioned simultaneously with the first starting section, but the financing stopped in 1991. Therefore the resettlement had not been executed and the depot construction had not started. In 1995, a complete stop of a centralized housing program in Kharkiv removed the option of resettlement from the agenda. Another land plot at a swampy area to the west of the 842-th district nearby the Odeska Street was examined.

The current location outside the northwest sector of the city ring road was seriously considered first in 2004, after the opening of the second section of the line. It became clear that the depot would be preferably commissioned before the next section of the line reaches the Odeska station.

2 DESCRIPTION OF THE OPERATION

2.1 Extension

The Extension consists of two shallow stations (Derzhavinska and Odeska) and tunnels connecting the stations to current terminal station Metrobudivnykiv.

Derzhavinska Station will have an island-type passenger platform. The length of the platform will be 104 m that is enough for operation of a five-car train. The width is 10 m. The central part of the platform will be equipped with two elevators enabling passages with disabilities reaching the platform from the second level of the station that in its turn will be connected to the station entrance area. Dewatering units will be located under the staircases.

The combined traction substation will be placed to the left from vestibule No.1. The main ventilation chamber will be adjacent to vestibule No.2. Both vestibules are connected to underground pedestrian crossings that have exits to both sides of Gagarina Avenue.

Batteries will be charged at a dedicated room equipped with a separate ventilation system that sends the air through the above-ground ventilation shaft to the atmosphere.

Odeska station will become a terminal station of the line with tunnel dead-end behind it. Both end sides of the island-type platform (104 m long and 10 m wide) will be connected to vestibules with stairways (6 m wide). Vestibules are equipped with elevators for passengers with disabilities. Vestibules are connected to underground pedestrian crossings under the Gagarina Avenue and the Odeska and Heroiv Stalingrada Streets.

Similarly to Derzhavinska, the station will have dewatering units, combined traction substation, ventilation chamber and a battery room with separate ventilation.

Both stations will be connected to city utility networks:

- Water: 26.8 m³/day of water will be used and for drinking, sanitary and fire safety needs.
- Sewage: 26.8 m³/day of wastewater is expected to be discharged to the municipal sewage system
- Storm water: Drainage waters, waters after the washing of station, water used for fire extinguishing will be collected and pumped to the municipal storm water system. An average of 21.6 m³/day is the expected volume.
- Heating: Electric heating is envisaged.

The operations will be carried out 365 days per year in a four-shift schedule.

2.2 Depot

The Depot is designed for night parking of the rolling stock, and all kinds of its service and maintenance. It is planned to build:

- An administrative block (including canteen and restroom for train drivers);
- parking and maintenance premises with workshops, trains washing chamber, water recycling unit and gas boiler room;
- a recreational block;
- auxiliary workshops including diesel locomotive maintenance station, parking for emergency vehicles, battery charging station, electric substation, administrative and communal premises and gas boiler room;
- a compressor station;
- wastewater treatment facilities;
- a storage area;
- a loading/unloading area with electric crane.

3 DESCRIPTION OF THE EXISTING ENVIRONMENTAL AND SOCIO-ECONOMIC CONDITIONS

3.1 Climatic Conditions

Kharkiv's climate is humid continental. The seasonal average temperatures are not too cold in winter, not too hot in summer: −4.6 ° C in January and +21.3 °C in July. The average rainfall totals 513 mm per year, with the most in June and July. The maximum daily rainfall is 55.8 mm.

3.2 Geomorphology and geology

Extension

The extension route can be divided into the following areas by topography (Figure 2):

- The first segment is characterized by the relatively level daylight surface at the segment from chainage 121+62 to chainage 135+00 with the gradual reduction in absolute elevations from 116.0 m to 111.5 m.
- The second segment running from chainage 135+00 to chainage 136+50 is characterized by the pronounced depression being the bottom part of Hlybokyi Yar gully whose catchment area is located above the designed Metro line at a distance of 2 km.
- The third segment is distinguished by its much steeper left slope of the same gully at the section from chainage 136+50 to chainage 142 with the absolute elevation range from 115.00 to 131.50 m.
- The fourth segment has a levelled ground surface rising from 131.50 m to 137.30 m between chainages 142+00 and 155+67.

According to geological and hydrogeological conditions the extension can b divided into two sections beginning of the track to the PC 136 + 00 from the PC 136 + 00 to the end of the road.

The first segment is associated with the Pryluky/Uda terrace and the bottom of Sychovskyi Strumok gully. Geologically, the first segment consists of the sedimentary Quaternary and Paleogene rock. The tunnel and other structures will be excavated in alluvial sand and, to a lesser extent, the alluvial and aeolian-deluvial loamy soil.

The second segment is associated with the Pryluky/Uda, Lubny/Tylyhul and Zavadov terraces. Geologically, it consists of Quaternary and Paleogene deposits. The tunnel and other structures will be excavated in alluvial sands and sandy loams, aeolian-deluvial loamy soils and, to a lesser extent, in upper Kyivan sandstone rock and aleurolite siltstone.

Depot

In terms of geomorphology, the examined land plots are situated within Martonoshsko-Sulska, Shyrokynsko- Pryazovska and Beregovsko Berezanska quaternary terraces of the Lopan River. To the northeast from the ring road the Lopan valley is cut by the Lozovenka River vlaley (Lopan's confluent).

Absolute marks the ground heights are ranged from 145.0 to 158.0 m. The direction of the surface runoff is determined by slope stretching from the northeast to the southwest in the direction of the Lozovenka River. The major part of the depot territory is a a gully filled with the technogenic material.

A stream, formed mainly by runoff from the territory of residential districts 335, 339, 339th, adjacent to the ring road flows within the area of the access branch (from the PC-05 PC-04)

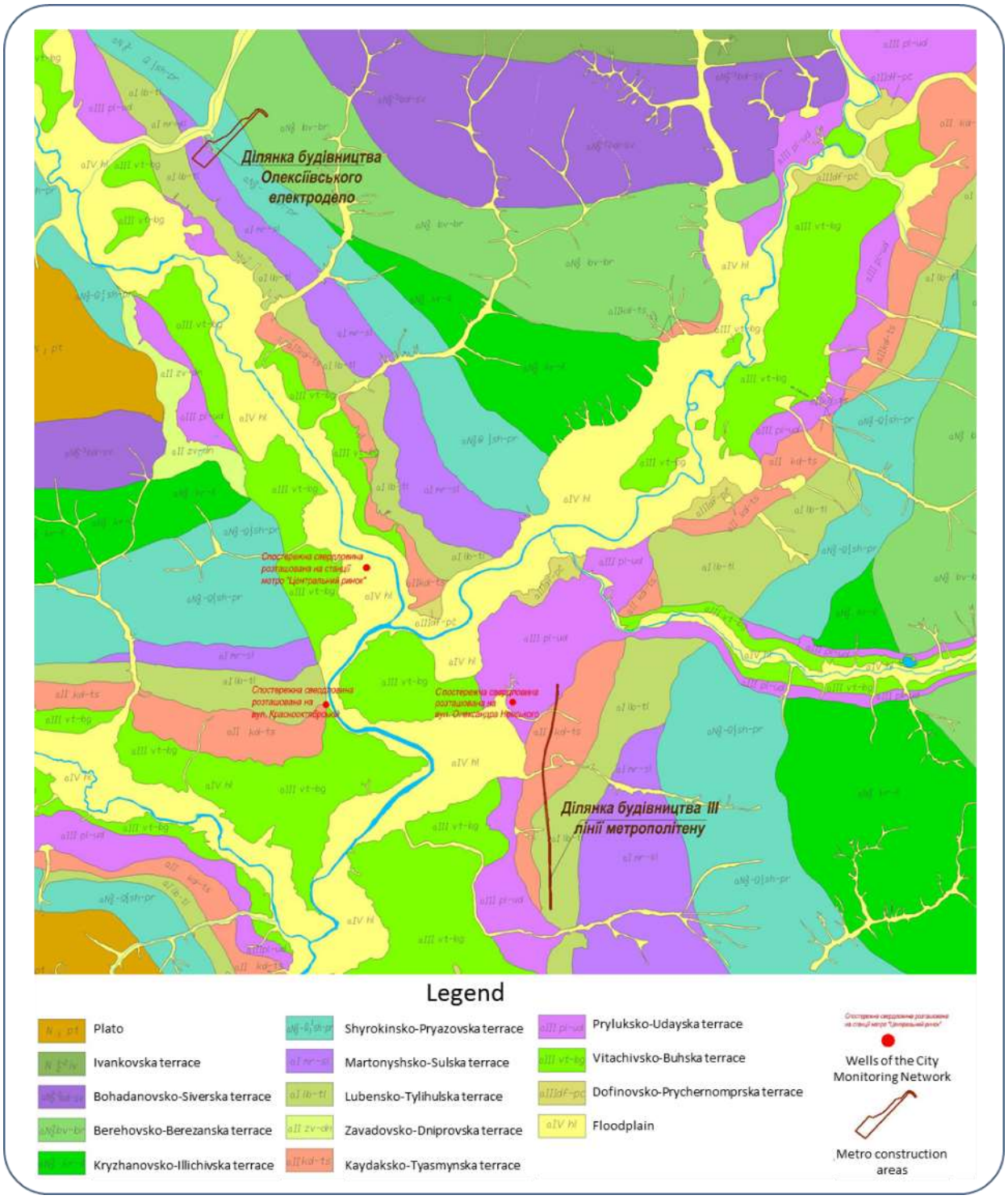


Figure 2: Schematic geomorphological map of Kharkiv. [Source: Geological and Environmental Surveys of the Industrial Urban Agglomeration of Kharkiv]

3.3 Hydrogeology

Extension

The project area has been inhabited for a long time. That results in secondary stabilization of natural and technogenic water regime. An overall supply of groundwater varies from $2.6 \bullet 10^{-4}$ m/day to $1.2 \bullet 10^{-3}$ m/day with prevalence of technogenic sources.

The general direction of groundwater flow in the project area is towards west - to the valley of the Lopan River. Hydraulic gradients range from 0.0083 to 0.02 on the northern section of the route to quite strong and stable 0.0167 – 0.025 at the southern area.

The extension route crosses several areas that vary in the degree of possibility for waterlogging (Figure 4).

Depot

An overview of potential waterlogging of the Depot site is presented in Figure 4.

3.4 Surface and Ground Water Quality

Extension

The waters of Quaternary-Obukhiv water-bearing complex in the area belong to the sulfate-hydrocarbon, hydrocarbon-magnesium-calcium type with dry residue from 0.95 to 1.29 g/l and total hardness of 9.9 to 14.9 mmol/l. The analysis shows the strong acidity (pH 4.8-5.2) and high content of iron. The most likely reason is anthropogenic pollution of shallow groundwater horizons with leakages from wastewater pipes and infiltration from sewage cesspits of residential development area.

When assessing the chemical composition of the project site groundwater, it's necessary to draw attention to the presence of an old tank farm next to the metro line between chainage 131+00 and 133+00. Geotechnical surveys conducted in 2014 for the oil farm reconstruction have revealed significant concentration of oil products in soil and groundwater. Although the actual scale of contamination has not been determined, there is a risk of infiltration of the contaminated groundwater to the drainage system of the line extension which will be located on the way of contaminated groundwater flow.

Depot

At the depot site and within the areas of access roads, Neogene aquifer water (upper range) is characterized by salt content 0.55-0.88 g / m³. This water does not meet the drinking water requirements (state Sanitary Standard 2.2.4-171-10) due to exceeding for the following parameters:

- total hardness exceeding (1.4 times);
- the magnesium (1.5 times),
- ammonia (25 times);
- oxidation (1.3 times),

Thus, any further use of this water requires its treatment.

The presented EIA for the depot lacks information on water quality and regime of the Lozovenka River (Figure 3) which is supposed to receive storm water from the depot territory.

Figure 3: Lozovenka River

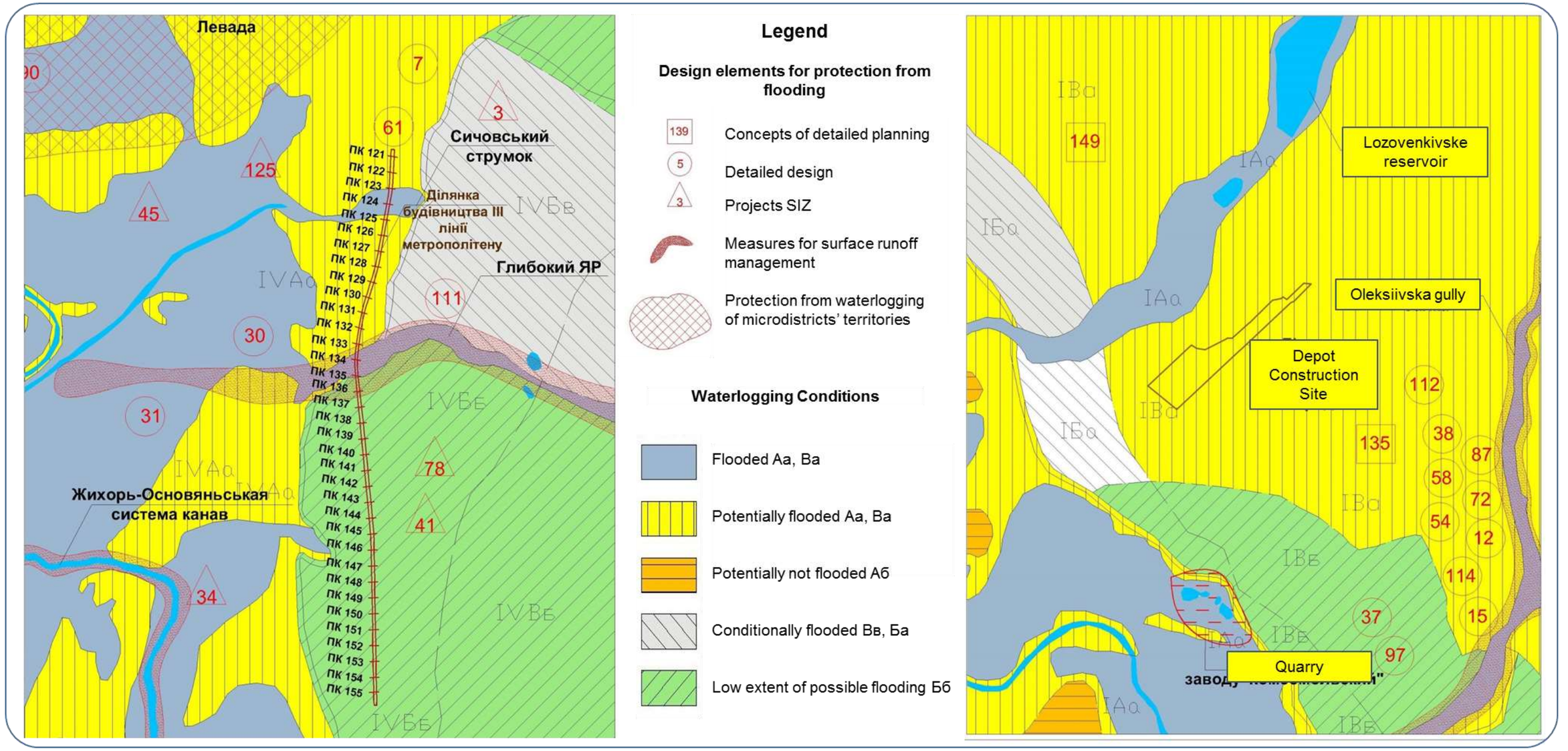


Figure 4: An overview of potential waterlogging of the Extension (left) and the Depot (right)

3.5 Landscape

Extension

The route of the Green Line extension runs along the left side of the Lopan River valley. A simple natural topography in the project area has a shape of a slightly inclined plain complicated by shallow gullies (Borodayevskiy Yar, Hlybokyi Yar) with very sloping sides.

Depot

The land plot has a shape of irregular polygon stretched from northwest to southeast. Its sloping terrain has a difference of heights 8-10 m in longitude dimension; 4.5 m in a transverse direction. The absolute heights vary from 145 to 158 meters above the sea level.

3.6 Ecology and Biotic Resources

Extension

The extension route passes through the urbanized area with no biotic resources except trees and bushes planted near the private households and along the roads.

Depot

When examining the land plots dedicated for the Depot piles of clay soil (Picture 1) delivered from the pit of Peremoha station for planning plot for building depot have been observed. The plots are partly occupied with unauthorised construction wastes landfill and informal gardens. A few trees and bushes cover the site.

3.7 Air Quality

Extension

The air quality in Kharkiv is permanently monitored by 10 stationary observation points (SOP) operated by Kharkiv regional center of hydrometeorology. Observations are carried out 24/7 except holidays. In 2014 over 47000 air samples have been taken and analyzed for 20 polluting ingredients. The dynamics of pollutant emissions from stationary sources is presented in Figure 5.

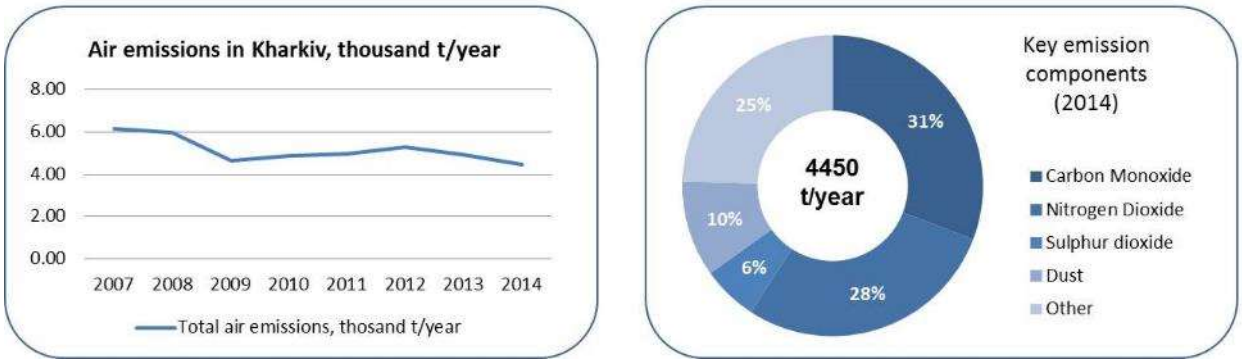


Figure 5: Air emissions in Kharkiv (2014)
[Source: based on "Report of Environmental Conditions of Kharkiv Region in 2014"]

The nearest observation point to the extended alignment is situated at Heroes of Stalingrad Avenue, 3, which is around 400 meters from the planned location of the Odeska station. The average concentrations of pollutants recorded at this SOP for 2012-2014 (presented in Table 2) were used for calculations of the estimated concentrations of the pollutants on the border of the nearest residential buildings and evaluation of the cumulative impact of the Project related emissions.

Substance	Class of hazard	Actual Concentration, mg/m³	Max. acceptable concentration, mg/m³
Nitrogen Dioxide	3	0.07	0.085
Carbon Monoxide	4	4.8	5
Sulphur Dioxide	3	0.02	0.05
Dust	3	0.26	0.5

Table 2: Current values for air quality near Odeska station. Source: EIA

Depot

According to the Order No 286 as of 30.07.2001 "On approval of determining the values of background concentrations of pollutants in the air" for cities with a population under 250000 people and other settlements, where regular monitoring of pollution is not held, in the absence of significant industrial sources of emissions background concentrations values for major pollutants are to be taken as given in Table 6:

Population, thousand people	Polluting Substance							
	Dust		Nitrogen Dioxide		Carbon Monoxide		Sulphur Dioxide	
	mg/m³	% of MAC	mg/m³	% of MAC	mg/m³	% of MAC	mg/m³	% of MAC
<50	0.05	10	0.008	9	0.4	8	0.02	4

Table 3: Values of background concentrations of pollutants in the air at the depot area. [Source: Order No 286 of Ministry of Ecology of Ukraine]

Background concentrations of other pollutants can be determined by application of a factor of 0.4 to their one time MAC.

Since all the listed conditions are met, the Consultant deems the application of the above-mentioned factors for calculation of the pollutants dissemination and its impact on the neighbouring residential areas at the current stage of the Project as reasonable.

Further permitting procedure for emissions (for the facility operational phase) includes the measurements of the actual concentrations on the border of neighbouring residential areas with subsequent regular monitoring.

3.8 Noise

As per discussion with the project EIA developer, Mr. Victor Surin, the noise impacts have been calculated without considering actual baseline levels of noise.

The Consultant involved a competent contractor for conducting measurements of baseline levels of noise. The venues of the research are numbered from 1 to 3 and have the following marking on the selection:

Point №1 - Oleksiivske depot;

Point №2 - Derzhavinska station;

Point №3 - Odeska station.

Measurement results are presented in Table 4.

№ p.	Place and time of the measurement noise.	Noise nature	The actual equivalent sound levels LAequ/ LAmax	Statutory equivalent sound levels LAequ/ LAmax
1	p. 1 - daily	Background	56/72	55/70
2	p. 1- nightly	Background	54/82	45/60
3	p. 2- daily	Background	46/84	55/70
4	p. 2- nightly	Background	56/82	55/70
5	p. 3- daily	Background	68/83	55/70
6	p. 3- nightly	Background	63/92	45/60

Table 4: Noise measurement results

Conclusion:

Sound pressure levels in octave bands 63; 125; 250; 500; 1000; 2000; 4000; 8000 Hz, equivalent and maximum sound levels in dBA measurement points exceed the standards for day and night time established by “Sanitary norms of allowable noise in residential and public buildings and residential areas”. This means that baseline conditions already exceed allowable levels.

3.9 Ground conditions

In order to assess the ground conditions, 15 soil samples were taken and analysed. The exact locations of sampling are presented on Figure 6 (Depot) and Figure 7 (Extension).

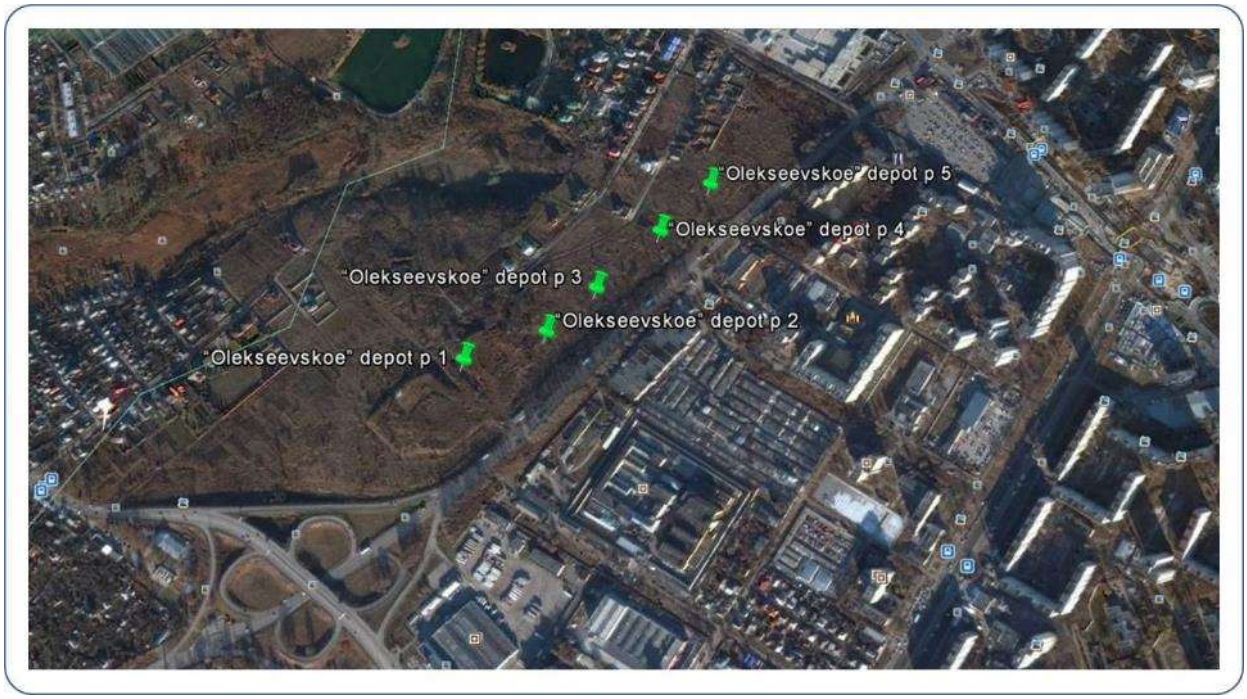


Figure 6: Soil sampling locations (Depot)

Figure 7: Soil sampling locations (Extension)

Conclusions:

- The concentrations of heavy metals (including mobile forms) of the 1st class of hazard in the samples are within acceptable standards and meet the requirements of Sanitary norms and rules No. 4433-87, No. 2264-80, No. 3210-85
- Activity of radionuclides radium (Ra226), Thorium (Th232) and Cesium (Cs137) in the soil samples is low (below or within background values). Total activity (C) in the samples does not exceed 370 Bq/kg. The content of radionuclides in the soil imposes no restrictions on residence, all kinds of construction, the cultivation and consumption of agricultural products.
- Concentration of petroleum products in the samples, the soil on the territory of the plots is within the statutory level and imposes no restrictions on residence, all kinds of building, the cultivation and consumption of agricultural products.
- Assessment of microbiological contamination of the soil was carried out by determining the total microbial number and by a quantitative analysis of the main indicator microorganisms. Based on the obtained data we can conclude that the studied soil belongs to the category ‘clean’.

3.10 Socio-economic and Cultural Issues

Key socio-economic performance indicators of Kharkov are presented in Table 5:

Key Performance Indicators	Measure-ment unit	2014 report	2015 estimate	2016 forecast	2016 to 2015, %
1	2	3	4	5	6
General					
Volume of products and services sales	Billion UAH	40.0	49.5	61.9	125.0
Foreign direct investment	Million USD	19.2	7.6	8.0	105.3

Key Performance Indicators	Measure-ment unit	2014 report	2015 estimate	2016 forecast	2016 to 2015, %
1	2	3	4	5	6
Population and labour market					
The population (annual average)	Thousand persons	1452.0	1451.9	1449.4	99.8
The number of workers employed		410.6	390.0	385.0	98.7
The number of unemployed persons registered at the Employment Service		22.5	25.0	24.8	99.2
Registered unemployment rate for population of working age (end of period)	%	0.95	0.88	0.83	x
Number of created permanent jobs	Thousand	19.9	15.1	16.4	108.6
Average official monthly salary	UAH	3270.0	3665.0	4105.0	112.0
Average monthly pension	UAH	1673.26	1820.0	1995.0	109.6
Passenger transport					
Metro	Million passengers	214.5	208.1	203.3	97.7
incl. passengers who paid		171.4	165.9	163.2	98.4
City electric transport		223.5	239.0	241.8	101.2
incl. passengers who paid		83.2	89.0	90.1	101.2
Buses		82.3	72.5	72.5	100.0
incl. passengers who paid		52.0	47.0	47.0	100.0
Housing					
Housing fund - total	Thousand m²	32041.9	32271.9	32511.9	100.7
The commissioning of residential buildings	Thousand m²	195.4	230.0	240.0	104.3
Total housing area per capita	m²	22.4	22.2	22.4	100.9
Number of condominiums	-	349	363	400	110.2
Municipal facilities					
Total water consumption	Million m³	135.3	116.1	113.0	97.3
Total discharge to sewage system		117.7	111.3	110.5	99.3
Heat supply by centralised heating system	Thousand Gkal	6550.3	5216.4	6036.8	115.7
Total length of roads	km	1680.7	1680.7	1680.7	100.0
Waste disposal. total	Thousand m³	2559.4	2960.0	2750.0	92.9
- incl. Derhachivski landfill		2124.3	1900.0	1800.0	94.7
- incl. landfill of LLC "Pererobnyi Zavod"		435.0	1060.0	950.0	89.6
Environmental expenditures					
Environmental expenditures total	Million UAH	40.7	45.0	60.0	133.3
- companies' costs		28.1	25.0	39.0	156.0
- local environmental fund		12.6	20.0	20.0	100.0

Table 5: Key socio-economic performance indicators of Kharkov
[Source: "Program of Economic and Social Development of Kharkiv in 2016"]

The Project areas are neither included to the local nor to the national register of cultural heritage. Therefore the Consultant does not expect any material impact on culture.

3.11 Land Use and Settlement Patterns

Extension

The extension is planned in a dense urban area, both residential and industrial, with no natural areas or cultural heritage. Yet, a number of residential and commercial facilities occupy the land plots needed for the Project.

The affected residential area is mostly occupied by private households with land plots attached to low-rise houses. Some of them are not connected to centralised utilities: water, sewage, heating. Poor technical conditions of the houses observed during the site visit can be assumed to be the reason for the owners' readiness for resettlement. The plans for land acquisition were first announced (and partly implemented) in early 1990s. Since that time the issue of resettlement is regularly raised as preventing people from investing in proper maintenance of the properties subjected to demolition.

Depot

The land plots (No.6322055900:10:000:0025) dedicated for the construction of the Depot are registered in the National Land Cadastre as a state property for the needs of the metro.

The land plot borders:

- To the North - with southern part of cottage village Florynka and a shopping mall under construction;
- to the East - with Kharkiv ring road (Lozovenkivskyi Avenue). There are student's dormitories, garages and penal colony on the opposite side of the ring road;
- to the South East there is a 110 kV overhead power line;
- to the South there is a Derhachivska crossroad and the village of Mala Danylivka;
- to the West there is a left side of the Lozovenkivska ravine with river Losovenka in the thalweg. An area between the Depot and the river is a slope (around 400 m wide) with rare trees and bushes.

When examining these plots, piles of clay soil (Figure 8) delivered from the pit of " Peremoha" station for planning plot for building depot have been observed. The plots are partly occupied with unauthorised construction wastes landfill (Figure 9) and informal gardens.

Figure 8: Piles of clay at the Depot site

Figure 9: Unauthorized landfilling at the Depot site.

The land plots for connection of the planned depot to the 'Green' line (No. 6310136300:17:001:0002and No.6310136300:14:007:0071) are referred to in the Cadastre as a communal property for the needs of electric transport. These land plots stretch along the Lyudvig Sloboda Avenue from the Peremoha terminal metro station to Lozovenkivskyi Avenue and continues along Lozovenkivskyi Avenue to the depot site respectively. This land is partly occupied with informal gardens.

4 DESCRIPTION AND ASSESSMENT OF THE SIGNIFICANT ENVIRONMENTAL AND SOCIAL IMPACTS

4.1 Impacts associated with Construction

4.1.1 Climatic Conditions

The emissions of GHG associated with construction of the extension and depot are presented in the respective EIAs. Application of GWP allows summarising the impact expressed in CO_2 equivalent (Table 6)

GHG	Emission, t		GWP	CO_2e, t	
	Extension	Depot		Extension	Depot
CO_2	1082	94.59	1	1082	94.6
CH_4	0.1438	0.019	25	3.6	0.5
N_2O	0.0401	0.003	298	11.9	0.9
SubTotal				1097.2	96.0
Project Total					**1193**

Table 6: GHG emissions anticipated by EIA [Source: calculations based on information in EIA]

The major share of GHG accounted in EIA result from motor fuel combustion. However the calculations consider the GHG that will be emitted at the construction sites. At the same time construction of the line extension requires massive transportation of spoil material to the deposition site totalling around 3.8 million tkm. Based on presented estimates for fuel consumption the total GHG emission from fuel combustion was defined (Table 7)

GHG	Diesel				Gasoline				Emissions Total, t	GWP	CO2e, t
	SE, kg/t	VTC	Consumed, t	Emissions, t	SE, kg/t	VTC	Consumed, t	Emissions			
CO_2	3138	1	942.5	2957	3183	1	586.6	1867	**4824**	1	**4824**
CH_4	0.25	1.4	942.5	0.33	0.64	1.8	586.6	0.68	**1.01**	25	**25**
Total											**4849**

Table 7: GHG emission from fuel combustion [Source: Calculations based on official "Method of Calculation of Pollutants and GHG Emissions into the Atmosphere from Vehicles"]

The total impact of the Project construction phase on global climate is expected at the level on nearly 5000 tons of CO_2 equivalent.

4.1.2 Surface and Groundwater Quality

There will be insignificant or no impact on surface and ground water during the construction phase of the Project (both the Extension and the Depot) under the condition of implementation of measures listed in the EIAs and CMS volumes of the design documents.

4.1.3 Landscape

Extension

A possible change of landscape can occur due to the deposition of spoil. The total volume of excavated spoil will be 618.14 thousand m³. 277.23 thousand m³ will be used for backfilling of the pits.

The land plot for deposition of the remaining spoil was selected by the Department of City Planning and Architecture (Figure 10). In the letter as of 20.11.2007 the Department suggests the deposition at the lands earmarked for the City cemetery that is located in 5.8 km to the south of the Odeska station. The site that currently belongs to the City will be provided for the Project on the basis of decision of the City Council.

The chosen area is adjacent to municipal wastewater treatment plant facilities and silt fields in the North and West, Gagarina Avenue and agricultural lands to the East, and agricultural lands and Bezlyudivka village to the South. The distance to the nearest residential area is over 370 m.

Figure 10: The land plot for deposition of the remaining spoil [Source: Attachment to the letter of City Planning and Architecture Department as of 20.11.2007 – left; satellite map of the land plot and surrounding area – right]

Thus, the possible changes of landscape can be considered as acceptable.

Depot

The key changes of the landscape will be associated with levelling of the land plot that stipulates extraction of 57.4 m³ of spoil and backfilling with 121.400 m³ of clay soils.

4.1.4 Ecology and Biotic Resources

Extension

The extension is planned in the dense urban area both residential and industrial with no natural areas on its way. Therefore direct impacts of the ecology and biotic resources are not expected.

Depot

The land plot dedicated for the construction of the depot is partly occupied with unauthorised construction waste and informal gardens. Wild bushes and small trees cover around 20 % of the land plot. The key impact on ecology and biotic resources will be cutting the trees and bushes when preparing the land plot for levelling. Topsoil will be excavated and used for further re-cultivation of the territory.

4.1.5 Air quality

According to presented EIA the construction is associated with the emissions to the atmosphere. The pollution loads for the whole period of the extension and the depot construction are presented in Table 8.

The pollution related to construction of the line takes into account emissions from 16 construction sites and excludes emissions associated with spoil and materials transportation outside the construction site. The Consultant spotted a mistake in calculations of benzopyrene emissions.

Substance	Class of hazard	Pollution load, t		
		Extension	Depot	Project Total
Benzopyrene	1	0.0000000099	0.0000000006	**0.0000000105**
Manganese	2	0.0469	0.0143	**0.0612**
Nitrogen Dioxide	3	10.1256	0.791	**10.9166**
Sulphur Dioxide	3	1.4818	0.129	**1.6108**
Iron Oxide	3	0.4303	0.1309	**0.5612**
Suspended Solids	3	2.2869	0.1386	**2.4255**
Dust (With Silicium Dioxide)	3	3.1246	0.0757	**3.2003**
Xylene	3	-	0.10125	**0.1013**
n-butyl alcohol	3	-	0.03375	**0.0338**
Carbon Monoxide	4	22.7945	4.4486	**27.2431**
Saturated Hydrocarbons	4	3.1065	0.4482	**3.5547**
Ammonia	4	0.000058	0.00004	**0.0001**

Table 8: Annual Emissions to atmosphere during construction phase of the Project (Extension) [Source: EIA]

Based on the estimated volumes of gasoline (586 t) and diesel fuel (943 t) the Consultant has calculated the total load of emissions from fuel combustion (Table 9) regardless the location of the process (inside/outside the construction site).

Substance	Diesel				Gasoline				Emissions Total, t
	SE, kg/t	VTC	Consumed, t	Emissions, t	SE, kg/t	VTC	Consumed, t	Emissions	
CO	36.2	1.5	942.5	**51.18**	197.8	1.7	586.6	**197.25**	**248.43**
NO_2	31.4	0.95	942.5	**28.11**	21.6	0.9	586.6	**11.40**	**39.52**
SO_2	4.3	1	942.5	**4.05**	1	1	586.6	**0.59**	**4.64**
NMVOC	8.16	1	942.5	**7.69**	28.5	1	586.6	**16.72**	**24.41**
Soot	3.85	1.8	942.5	**6.53**	0	1	586.6	**0.00**	**6.53**
Benzapyrene	0.03	1	942.5	**0.028**	0	1	586.6	**0.00**	**0.03**

Table 9: Total emissions from fuel combustion (Extension) [Source: calculations based on official "Methodology of Calculation of Pollutants and GHG Emissions into the Atmosphere from Vehicles"]

4.1.6 Noise

Both EIAs contain modelling of noise from the construction works. Although the expected levels of noise do not exceed the standards, the modelling does not consider the background noise levels. It can't be guaranteed that the total noise levels (background + construction) will stay below the statutory limits.

4.1.7 Ground conditions

The proposed construction methodology mentions an application of bentonite and foam to the soil excavated from the tunnels for its easier transportation. The volume of the extracted ground with bentonite and foam is 117,000 m³.

As to application of bentonite the Consultant does not treat it as a pollutant due to its neutral or even positive impact on the soil. Studies carried out by The International Water Management Institute and partners in 2002–2003 focused on the application of locally sourced bentonite clays to degraded soils. These applications were carried out in structured field trials. Applying bentonite clays effectively improved yields of forage sorghum grown under rain-fed conditions.

4.1.8 Socio-Economic and Cultural Issues

From socio-economic perspective the construction phase of the project can have both positive and negative impacts:

Subcontractors' EHS performance

Current practice of cooperation with construction contractors does not stipulate Client's (MCC) control over contractors' EHS performance. This can be the reason for poor contractor's EHS performance observed during the visit of the station that is currently under construction. Several examples are presented in Figures 11-16.

Figure 11: Openings were not covered at Peremoha station

Figure 12: Openings were not fenced. Poor lighting of workplaces at Peremoha station.

Figure 13: Work at height without safety belts by construction contractor personnel at Peremoha station

Figure 14: Electrical equipment usage at Peremoha station

For the full list of observations please refer to the Site Visit Report.

- Use of asbestos-containing materials (ACM)

Two uses of ACM in the Peremoha station as pipes and as boards/panels for architectural finishes have been observed by the Consultant during the site visit. Presumably ACM may be also used for cladding (fire protection or fill material).

The impact of the ACM upon workers' and community health can be divided into:

- Short-term: Cutting of asbestos-based materials underground, which releases fibres. This poses a high risk to construction workers, and a latent risk to station users (since it is very difficult to remove the airborne fibres once released). The health risk is primarily mesothelioma along with other diseases caused by asbestos.
- Long term: By using asbestos-based materials in construction elements, any repair, reconstruction or upgrading works done in the long-term will encounter the materials. Even if the materials have not degraded, there is the risk of cutting into them. If they are degraded the risk is obviously significantly increased.
- Life cycle implications: The necessity of future replacement / rehabilitation / disposal and the cost of treating persons with asbestos-caused illnesses.

Figure 15: Use of asbestos materials at Peremoha station

Figure 16: Use of asbestos materials and lack of appropriate PPE by construction contractor personnel at** Peremoha **station

Traffic congestion

Due to route alterations for construction sites bypass. Access to Striletskyi, Polyovyi, Sychevskyi and Zolotyi lanes from the side of Derzhavinska Street and Gagarin Avenue will be limited.

Additional traffic associated with the project such as the transportation of spoil results in over 600,000 km travelled by tippers inside the City.

Local economic growth

The Project will facilitate the demand for construction materials, engineering services, equipment most of which can be supplied by local, regional or national suppliers and contractors.

New employment opportunities

The need for construction personnel is estimated at the level of

- 1400 persons for the Extension.
- 390 persons for the Depot.

4.1.9 Land use and settlement patterns

The Project will have a significant impact on land use and settlement patterns. The open cut method of the stations (and partly tunnels) construction requires acquisition of land plots for digging the pits, placement of construction materials, equipment, workshops, warehouses, temporary administrative and communal facilities for workers, construction site roads. Since certain land plots are currently occupied by residential and commercial properties the acquisition of these lands triggers resettlement and economic displacement.

Although the tunnelling by means of a shield does not necessarily affect the properties on the ground surface (and settlement monitoring will be carried out on the ground surface), the operations of the metro entail restrictions to be imposed on the use of the buildings that fall within the planned route corridor (Technical Zone). According to the national construction standard buildings that fall within the Technical Zone can't serve as accommodation, yet can be used for other purposes.

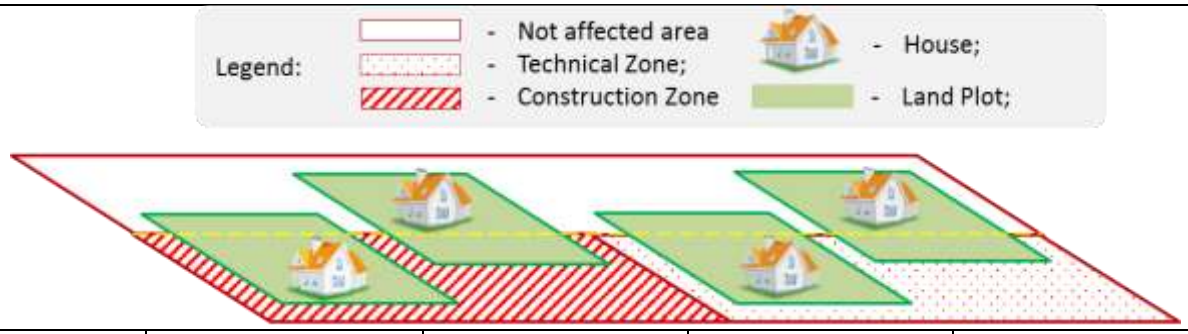
According to PR 5, involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and economic displacement (loss of assets or resources that leads to loss of income sources or means of livelihood) as a result of project-related land acquisition and/or restrictions on land use.

Resettlement is considered involuntary when affected individuals do not have the right to refuse the land acquisition which results in displacement. Since the Law of Ukraine "On Acquisition of Private Land and Other Immovable Property Located at Them, for Public Needs or Social Necessity" recognise the transport infrastructure as a subject of public necessity the City has a right to acquire the needed land plots through court decision if negotiations with the seller fail. Thus the Bank's requirements on involuntary resettlement are fully applicable to the Project.

The subsections below provide a general overview of social impacts that result from different types of displacement caused by the project. For further details please refer to the RAP/LRP that is a separate document of the ESDD.

4.1.9.1 Physical displacement

In total 42 private households and 3 blockhouses will be directly affected by the construction and operations of the Extension. 249 tenants are registered in the affected premises . Table 10 presents four common types of impact on affected properties (hereinafter referred as A, B, C, and D) and summarises the associated consequences.



	A	B	C	D
Type of Impact	Land plot wholly or mostly falls within the Construction Zone. The house or business facilities are on the affected part of the land plot	Land plot partly falls within the Construction zone. The house is on the unaffected part of the land plot.	Land plot wholly or mostly falls within the Technical Zone. The house is on the affected part of the land plot.	Land plot partly falls within the Technical Zone. The house is on the unaffected part of the land plot.
Consequences	Acquisition of the entire land plot, house and other immovable assets located on it.	Acquisition of the entire land plot, house and other immovable assets located on it or acquisition of the affected part of the land plot.	Acquisition of the entire land plot, house and other immovable assets located on it	Acquisition of the entire land plot, house and other immovable assets located on it, or acquisition of the affected part of the land plot or registration of the use rights for the affected part of the land plot
Affected Properties	20 private	Land plots of 3	11 private house-	Parts of land plots

	households and 1 block house	private house-holds will be partly used for relocation of the gas network. The houses will not be affected	holds and 2 block houses	and non-residential structures belonging to 8 private households

Table 10 Types of the Project's impact on residential housing and other real estate

4.1.9.2 Economic displacement

Businesses

A number of local businesses and public facilities (city ambulance depot) are located in the vicinity of the planned Derzhavinska Station and along the associated open-pit tunnels, as well as at the planned Odeska Station. These businesses will be affected by the project and will have to be moved as a result of the construction.

At the same time businesses located within the Technical Zone will not be required to move. The restrictions cover the residential houses only.

4.1.9.3 Loss of public amenities

The temporary construction camp for the use of 120 construction workers was planned in the yard of several apartment blocks. The land plot earmarked for the shower complex is currently occupied with private car garages, underground food storage pits and a children's playground.

After careful consideration, an alternative land plot for the construction camp has been selected. The new site, located in 200 metres to the North East from the initial one, is free of third-parties' property and public amenities (Figure 17 Selection of an alternative land plot for the construction camp near Odeska station.Figure 17). Two cafes adjacent to the new land plot will continue their operations.

Figure 17 Selection of an alternative land plot for the construction camp near Odeska station.

4.1.9.4 Displacement of informal land users at the Depot site

The construction of the connector thread will partly occupy the land plots (owned by the City[3]) that are currently used for informal gardening. No permanent structures or perennial crops have been identified during the site visit.

After careful consideration, the MCC finds it feasible and makes a commitment to avoid withdrawal of these land plots through narrowing the construction area of the connection line. The application of appropriate construction practices that enable the narrowing will be controlled by the MCC.

4.2 Impacts associated with operation

4.2.1 Climatic conditions

The main volumes of GHG will be associated with (indirect) emissions from production of energy that will be used for transportation on the extended distance of the line with decreased headway time (from 5 to 2.5 minutes (peak) and 4.0 minutes (off-peak)). Operations of the depot will add GHG resulting mainly from combustion of the natural gas for heating, although these are expected to be offset by reductions in emissions at existing depots.

Traction energy will be saved due to savings in train movements from the Red Depot to the Green Line and back, new Rolling Stock with more efficient motors and recuperation from braking. The commissioning of the extension will save mileage (and associated emissions) through the shortening of the trolleybus and bus routes and removal of trolleybuses and buses from service, and switching from cars to metro due to increased attractiveness of the metro system. Additionally the indirect decrease of GHG will be achieved through prevention of the modal shift from metro to cars.

Two cases have been modelled:

1. The “Without Operational Improvements” Case calculates the GHG due to project implementation without any change in metro operation parameters from the current level of service. This case is associated with the lower bandwidth of ridership as determined by the demand forecast, which peaks at 53,100 trips per day.
2. The “Operational Improvements” Case calculates the GHG due to project implementation with an improved level of service in terms of headways and operating hours. This case is associated with the higher bandwidth of ridership as determined by the demand forecast, which peaks at 77,000 trips per day. Specific operational improvements are:
    a. Headways are reduced to 4 minutes at off-peak times, 2.5 minutes at peak times
    b. Operating hours are extended by one hour of off-peak time
    c. The emissions from metro components other than traction remain unchanged from the “Without Operational Improvements” Case

4.2.1.1 GHG Calculation Assumptions

1. All project components are considered: Metro extension, depot and rolling stock
2. GHG emissions produced by the new Green Line depot are balanced by an equal reduction in GHG emissions from the Red Line depot. A further consideration supporting this is that less (heavy duty) maintenance is required on new Green Line rolling stock.
3. New Rolling Stock is approximately 5 % more energy efficient due to new motors at IE4 efficiency.
4. Energy savings due to recuperation from braking are estimated as the average of two values (6% and 13%) given by the sources: *Zeitschrift Elektrische Bahnen Ausgabe 11/2016* and *https://www.forschungsinformationssystem.de/servlet/is/343025/*

[3] According to the Official Public Cadaster Map of Ukraine (http://map.land.gov.ua/kadastrova-karta)

5. Saved mileage calculations are based on the demand analysis carried out by the FS Consultant. For the "Without Operational Improvements" Case the lower boundary of the bandwidth is used; for the "Operational Improvements" Case, the upper boundary of the bandwidth.
6. Passenger demand is based on analysis carried out by the FS Consultant. Passenger numbers on the existing metro are based on the current ridership;
7. The post-investment ridership is the bandwidth mid-point for the highest ridership period.
8. Specific fuel/energy consumption values were set as follows:
    a. Trolleybus: 1.90 kWh/km
    b. Bus (diesel): 0.25 l/km
    c. Car (gasoline): 0.10 l/km
9. CO_2 emission factors for fuels are derived from the "Method of Calculation of Pollutants and GHG Emissions into the Atmosphere from Vehicles" (Order No.452 of 13.12.2008 of State Statistic Committee of Ukraine).
10. CO_2 emission factor for electricity of 392 g/kWh is taken from the EMEP/EEA Emission Inventory Guidebook (2013) – Ukraine Energy Mix, GESF CO_2 rate.
11. Weights of rolling stock as per information from KMC.
    Existing rolling stock: Total weight of 72 waggons on Green Line is 2420.5 tons. Therefore, weight of a 5-car train is 168.1 tons.
    Weights of newest rolling stock in operation: Head waggons: 33 tons; intermediate waggons: 32 tons. Therefore, weight of a 5-waggon train is 162.0 tons.
12. Power supply to metro is from JSC "Kharkivoblenergo" that transmits electric energy from the wholesale electricity market of Ukraine operated by State Enterprise "Enerhorynok". "Enerhorynok" receives electricity from all types of generating facilities in Ukraine (and from imports) including thermal and nuclear power stations, CHPs and renewables.
13. The split in power consumption 70 % traction, 30 % other is as per information from KMC.

4.2.1.2 GHG Reductions due Distances Travelled

GHG reductions can be attributed to:

- Shortening/cancelling of trolleybus routes:

Based on an occupancy of 48 persons per vehicle, 22 daily runs and an annual distance of 60,000 km per trolleybus, an estimated 540 to 720 thousand km are saved.

- Shortening/cancelling of bus

Based on an occupancy of 12 persons per vehicle, 20 daily runs and an annual distance of 75,000 km per bus, an estimated 8.63 to 12.53 million km are saved.

- Increased attractiveness of the metro, therefore switch from car to metro

For the *"passenger flow increase for the extended metro due to increased attractiveness"* a local increase of 3% of the PT users was assumed. This results in 1.4 - 1.7 million additional metro trips due to the metro extension in the Osnovyanskyi and Slobidskyi Districts. For calculating the saved car trips an average trip distance of 8.5 km and an occupancy rate of 1.2 was used. For calculating the emissions it was assumed that, if the metro extension was not constructed, 40 % of these additional trips would be car trips. These car km are 3.97 - 4.82 million km.

- Saved car and bus trips due to those which would have been generated due to development close to Odeska station

For the *"new development west of new metro station Odeska (2025)"*, 20-30 million trips per year were estimated whereas 6.9-10.3 million would be PT trips and 2.8 - 4.2 million of the PT trips are considered metro trips. For calculating the emissions it was assumed that, if the metro extension was not constructed, 42 % of these additional (metro) trips would be car trips. For calculating the saved car trips an average trip distance of 8.5 km and an occupancy rate of 1.2 was used. The result is that about 8.33 - 12.50 mill. car km can be saved. Furthermore, the remaining 58 % of trips were assumed to be by bus. Based on an occupancy of 12 persons per vehicle, 20 daily runs and an annual distance of 75,000 km per bus, an estimated 1.58 to 2.33 million km are saved.

- Saved car trips due to preventing the shift from PT to car (compared to the "Do Nothing" scenario)

The amount of trips saved continuously increases each year as the modal shift is prevented. An average trip distance of 8.5 km and an occupancy rate of 1.2 was used.

- Saved metro trips from the Red Line Depot

Train movements from the Red Depot to the Green Line and back, a saving of 20 trips of approx. 4 km each per day.

4.2.1.3 GHG Increases due Distances Travelled

Extra GHG generation (additional to the "Do Nothing" scenario) can be attributed to:

- Metro trips on the Green Line extension

The increased length of a roundtrip is 6,938 m. The number of trips per day is calculated using the headways for each scenario.

- Metro trips to the Green Line Depot

Train movements from the new Green Line Depot to the Green Line and back, an increase of 20 trips of approx. 0.6 km each per day.

4.2.1.4 Calculation Formulae

The total change in GHG emissions (ΔGHG) brought about by investments can be defined as:

$$\Delta\mathrm{GHG} = GHG_{pi} - GHG_{bl}$$

Where

GHG_{pi} - post-investment emissions. The annual amount of emissions following the implementation of the project investment)

GHG_{bl} - baseline emissions. The annual amount of emissions that would have occurred in the absence of the Project.

Post-investment emissions.

The amount of post-investment emissions can be defined as:

$$GHG_{pi} = GHG_{ext} - GHG_{s}$$

Where

GHG_{ext} - GHG emissions of the extended Green with decreased headway time (from 5 to 2.5 minutes (peak) and 4.0 minutes (off-peak))

GHG_{s} - GHG emissions decrease due to the planned partial elimination of both public and private road transportation

Extension Emissions

The annual volume of GHG expected for the extended Green Line during its operation phase of the Project can be defined as:

$$\mathrm{GHG}_{ext} = \frac{R_{pr} \cdot F \cdot E_{Ukr}}{0.7} \cdot 365$$

Where

R_{pr} – daily ridership on the extended line

F – reference value for specific energy consumption for Kharkiv Metro system. 52.9 Wh/tkm

E_{Ukr} – CO_2 emission factor (g/kWh) for electricity in Ukraine. 0.392 kg/kWh

365 – days of operations per year

0.7 – approximate share of electric energy spent for traction in total electricity consumption.

Daily ridership on the extended line with decreased headway can be defined as:

$$R_{pr} = S_{pr} \cdot W_{pr} = \left(T_{pt} + T_{op}\right) \cdot L_{pr} \cdot \left(W_{tr} + W_{p}\right)$$

Where.

S_{pr} – total daily distance travelled by all trains of the line.

W_{pr} – weight of a 5 car train with passengers

T_{pt} – number of roundtrips per day during the peak time

T_{op} – number of roundtrips per day during the off-peak time

L_{pr} –distance of the roundtrip after the extension. 28.874 km

W_{tr} – average value for 5 car train weights that are operated by KMC 168.1 t for existing fleet, 162.0 t for the new fleet).

W_{p} – daily average total weight of passengers travelling at a 5 car train.

Daily average total weight of passengers travelling at a 5 car train can be defined as:

$$W_{p} = \frac{D_{pr} \cdot W_{1}}{T_{pt} + T_{op}} \cdot 33\%$$

Where.

D_{pr} –estimate of a daily transportation demand for the line

W_{1} – reference value for an average weight of a passage. 78kg

33% – assumed share of a roundtrip that a passenger undertakes at one trip. Equals to two thirds of a line length.

Depot Emissions

The EIA for the Depot presents the estimated volumes of direct GHG emissions. Application of global warming potential (GWP) factors suggested by EBRD Methodology for Assessment of Greenhouse Gas Emissions enables consolidation of the results (Table 13).

GHG	Expected load, t	GWP	CO_2e, t/y
CO_2	3956.139	1	3956.139
CH_4	4.174	25	104.35
N_2O	0.007	298	2.086
Total			**4062.575**

Table 11: The Depot annual direct GHG emissions
[Source: calculations of the Consultant based on EIA data]

Decreased road transportation

The volume of decreased emissions can be defined as:

$\mathrm{GHG}_s = \sum_i (S_i \cdot F_i \cdot E_i)$

Where

S_i – Annual distance travelled by all vehicle of each type.

E_i – CO_2 emission factor g/l (g/kWh for trolleybus) for each vehicle type

F_i – Specific fuel consumption l/km (kWh/km for trolleybus)

4.2.1.5 Results

The results for the “Without Operational Improvements” and “Operational Improvements” Cases are shown in the diagrams below. Significant savings are shown in each case.

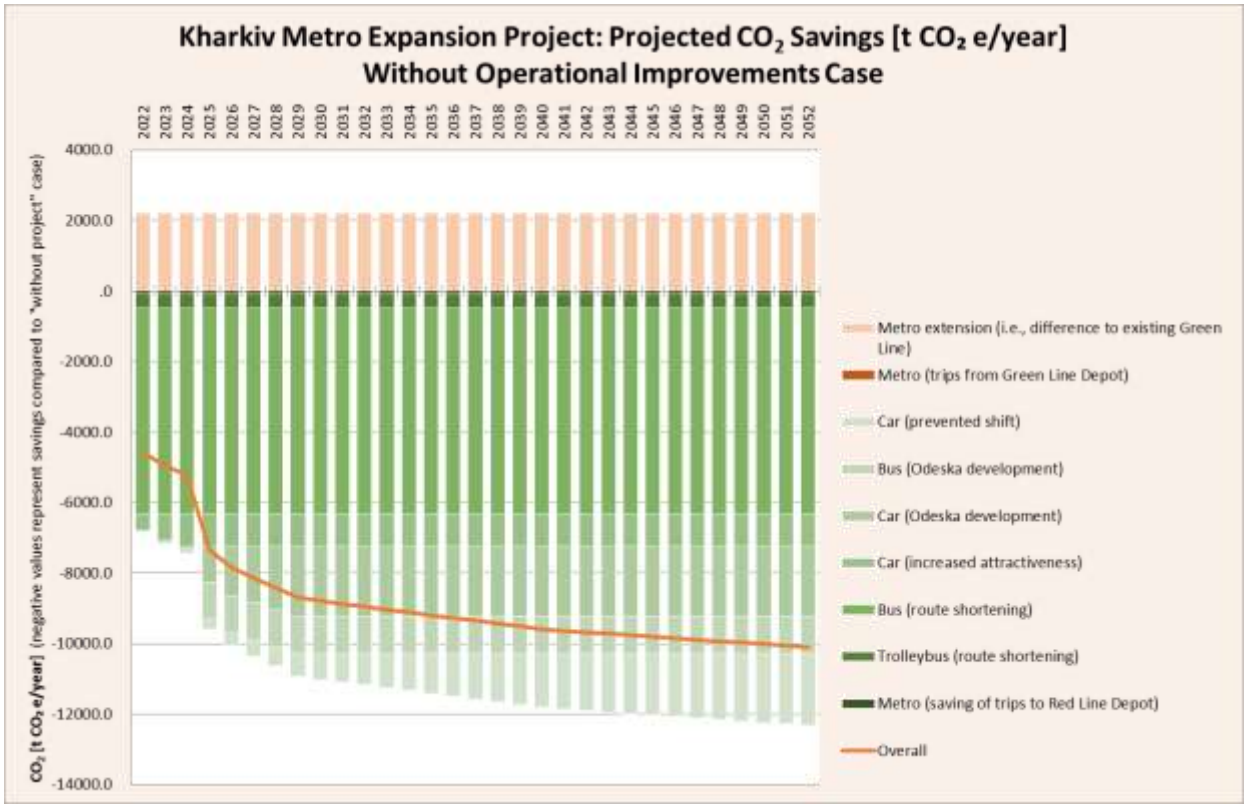


Figure 18: Projected GHG emissions (positive values) and savings (negative values) categorised by transport type for the "Without Operational Improvements" Case

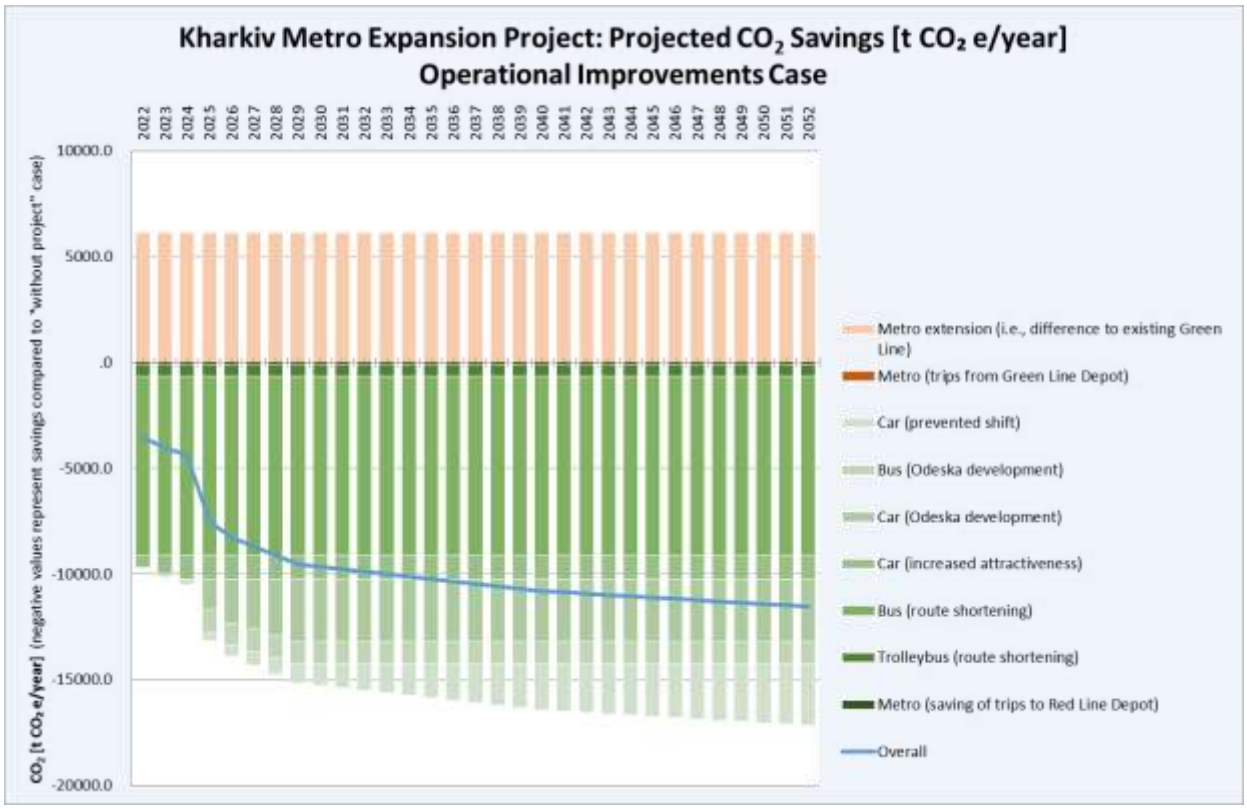


Figure 19: Projected GHG emissions (positive values) and savings (negative values) categorised by transport type for the "Operational Improvements" Case

For the two cases, an overall GHG saving expressed in tonnes CO_2 equivalent associated with operational phase of the Project is presented in Figure 20**Error! Reference source not found.**.

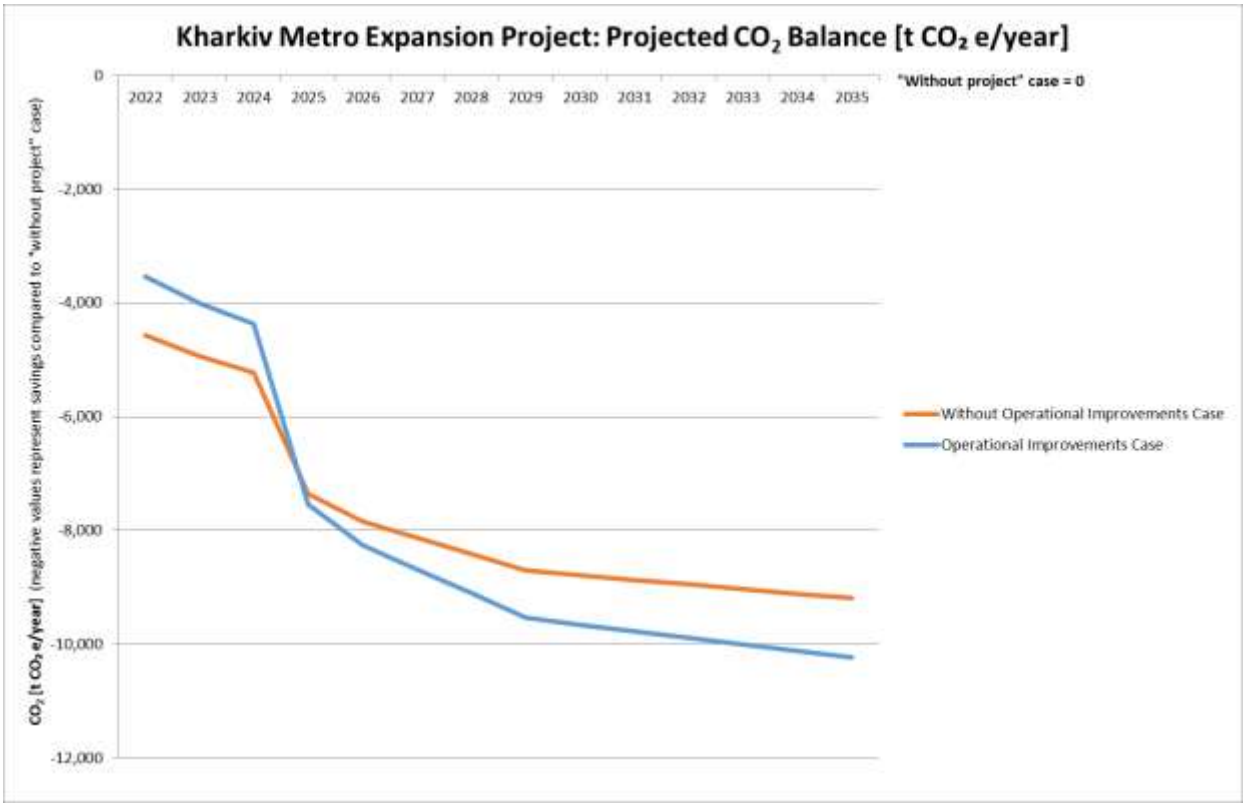


Figure 20: GHG balance of the Project operation phase

4.2.2 Surface and ground water quality

Depot

Operations of Oleksiivske metro depot will not have a significant impact on underground hydrosphere.

Sanitary wastewater will be discharged to the municipal sewage system.

Recycled water will be used for washing of trains. The wastewater after washing will be treated (physically and chemically) onsite and used repeatedly.

Storm water collected from the territory of the depot will be treated at the onsite wastewater treatment plant prior to discharge to the Lozonveka River. The EIA provides parameters of the WWTP (Table 12):

Component	Discharge water parameters, mg/l	
	Before treatment	After treatment
BOD	20	15
Suspended Solids	1200	10-12
Oil	20	0.3

Table 12: The estimated parameters of the storm waters [Source: EIA]

However, the sufficiency of the treatment for discharge to the river cannot be confirmed without establishing its assimilation capacity, which depends on water regime and background concentrations. Further permitting procedure for discharge to the river includes the measurements assimilation capacity of the river and other parameters that should be controlled for prevention of adverse impacts on the river ecosystem.

4.2.3 Hydrogeology

Extension

Almost the entire section of the Green Line under review is positioned perpendicular to the groundwater flow direction. Thus, the underground flow can be dammed in the segments, where the tunnel body will have to be laid below the underground water level (in part or in full) in the mass of the watered soil.

The calculations carried out during the 2007 hydro-geological survey indicate that the damming effect would be manifested at the segment from chainage 120+62 to chainage 138+00. This may lead to an increase in the underground water level upstream that results in flooding of certain areas of the extension route. The Consultant has doubts that the measures suggested by the Basic Design Documents will be enough to exclude the damming effect.

The design of the tunnels will be revised and deepened by at least 3.0 m. The impact of deepening the design of tunnels on the intensity of the damming effect and the need for additional measures to eliminate the risk of flooding will be determined after additional geological survey is conducted. Under the terms of the tender for the survey, announced by the MCC on August 11, 2017, the survey will be completed by December 20, 2017.

Depot

The environmental condition can deteriorate after the construction of the facility under review mainly due to the elevation of the groundwater table in the metro connector line area due to the additional recharge from the neighbouring residential areas and the damming effect.

It will also be necessary to take account of the potential metro depot impact of the additional recharge in the area between embankments of the ring road and the metro depot, as well as the potential increase in the backfill soil dampness and the deformation of its surface.

However, the Depot operation will not have any substantial impact on the underground water in case of the trouble-free operation of all services and systems of the Metro depot.

4.2.4 Ecology and biotic resources

Extension

The extension is planned in the dense urban area both residential and industrial with no natural areas on its way. Therefore direct impacts of the project ecology and biotic resources are not expected.

Depot

The land plot dedicated for the construction of the depot is partly occupied with unauthorised construction wastes landfill and informal gardens. Wild bushes and small trees are in place as well. The impact on ecology and biotic resources will be limited to discharge of the storm water to the Lozovenka River from the territory of the depot.

4.2.5 Air quality

Extension

Direct emissions to atmosphere during the operations of the extension will be limited to two new sources in a shape of aboveground ventilation cabins for ventilation of battery rooms at Derzhavinska (Source 1) and Odeska (Source 2) stations.

The distance between both sources of emissions to the nearest residential facilities exceeds 50 m.

The third source of emissions mentioned in the EIA is exhaust pipe of diesel power plant installed in the adjacent emergency shelter that is outside of the scope of the Project.

Although the Project is likely to result in material increase of indirect air emissions from production of electricity, the direct emissions of CO, NOx, SO_2, NMVOC, soot, and benzo-pyrene are expected to decrease due to the planned partial elimination of both public and private road transportation. The commissioning of the extension will save mileage (and associated emissions) through the shortening of the bus routes and switching from cars to metro.

Further savings in mileage and associated emissions for cars and buses are expected due to new residential area development west of new metro station Odeska. Finally, the project prevents a modal shift from public transport to car.

As for the CO_2 calculations, the overall volume of decreased emissions is estimated for both "No [Metro] Operational Improvements" and "Operational [Metro] Improvements" Cases. 2030 was taken as a representative year.

Substance	Class of hazard	2030 emissions, t No Operational Improvements Case	2030 emissions, t Operational Improvements Case
Benzo[a]pyrene	1	0.065	0.095
Soot (PM)	3	15.02	21.87
SO_2	3	10.46	15.18
NO_x	3	86.75	–125.35
CO	4	–499.90	–711.36

Table 13: Annual amounts of emissions savings due to decrease of road transportation [Source: Calculations of the Consultant]

The volumes were defined by application of specific emission (SE) factors and vehicle technical conditions (VTC) factors as (specified in the official "Methodology for Calculation of Emissions of Pollutants and Greenhouse Gases into the Atmosphere from Vehicles") to the mass of fuels that will be saved annually.

Substance	Diesel (mostly used by buses), saved fuel 2168 t/year			
	SE, kg/t	VTC	2030 emissions, t No Op. Imp. Case	2030 Emissions, t Op. Imp. Case
Benzo[a]pyrene	0.03	1.00	0.065	0.095
Soot	3.85	1.80	15.02	21.87
SO_2	4.30	1.00	9.32	13.57
NO_2	31.40	0.95	64.66	94.13
CO	36.20	1.50	117.70	171.35

Table 14: Annual amounts of emissions savings due to decrease of bus transportation [Source: calculations based on official "Methodology of Calculation of Pollutants and GHG Emissions into the Atmosphere from Vehicles"]

Substance	Gasoline (cars), saved fuel 1137 – 1606 t/year			
	SE, kg/t	VTC	2030 emissions, t No Op. Imp. Casef	2030 Emissions, t Op. Imp. Case
Benzo[a]pyrene	0.00	1.00	0.00	0.00
Soot	0.00	1.80	0.00	0.00
SO_2	1.00	1.00	1.14	1.61
NO_2	21.60	0.90	22.10	31.22
CO	197.80	1.70	382.21	540.01

Table 15: Annual amounts of emissions savings due to decrease of car transportation [Source: calculations based on official "Methodology of Calculation of Pollutants and GHG Emissions into the Atmosphere from Vehicles"]

Depot

Annual emission of pollution substances during the Depot operation phase according to the EIA is presented in the Table 16.

Substance	Class of hazard	Pollution load, t/year
Lead	1	0.0000304
Chromium	1	0.0000041
Sulfuric Acid	2	0.011
Fluorides	2	0.007
Hydrogen Fluoride	2	0.0007
Manganese	2	0.0006
Acrolein	2	0.000105
Nitrogen Dioxide	3	4.32
Sulphur Dioxide	3	0.015
Ferrum Oxide	3	0.007
Tin Oxide	3	0.000145
Nitrogen Monoxide	3	0.000134
Saturated Hydrocarbons	4	0.058
Carbon Monoxide	4	5.094
Ammonia	4	0.000026
Silicium Dioxide	-	0.007
Emulsol	-	0.07
Methane	-	4.174
Sodium Hydroxide	-	0.205
Total		**13.966**

Table 16: Annual emission of pollution substances during the Depot operation phase [Source: EIA]

The results of computer modeling (ЭОЛ 3.5) of the pollutants' dissemination show that concentrations on the border of a standard sanitary protestation zone (50 m) and on the border of the neighbouring residential area are below legally established limits.

4.2.6 Noise

In order to assess the impact of noise on residents of the sites, both background and estimated noise levels should be considered. As per discussion with the EIA developer, Mr. Victor Surin, the noise levels expected during the operations of the Project facilities have been calculated without considering the actual baseline levels of noise. Thus the total level of noise has not been defined properly.

The results of the background noise tests conducted by the Consultant revealed that the statutory levels are exceeded.

Since the road traffic is the major source of noise in the Project area, it is expected that the Project will have a positive impact through decrease of road transportation and associated noise levels.

4.2.7 Ground conditions

The design documents for both extension and the depot contain measures for prevention of ground contamination (paved roads with collection of the surface runoff, proper waste handling, fuelling only at stationary petrol stations, etc.).

4.2.8 Socio-economic and cultural issues

The project will have a positive impact on Socio-economic and cultural aspects of life in the city. Additional workplaces: 132 - Extension, 453 – Depot.

4.2.9 Land use and settlement patterns

The Project operation will facilitate the further development of the area adjacent to the line extension. Improved transportation is likely to attract new residents and trigger development of the new residential area to the west of Odeska station with gradual replacement of cottages with apartment blocks.

4.3 Impacts associated with Closure and Decommissioning

The metro is a strategic infrastructure for the City that is not subject to closure and decommissioning under normal conditions. According to the Metro Construction Standard (ДБН В.2.3-7-2010) the designed lifetime of tunnels and stations is at least 250 years. For this reason the presented EIAs do not assess the associated impacts. Should a decision on decommissioning be taken, the expected impacts will be similar to those during construction phase.

4.4 Cumulative Impacts

Cumulative impacts of the Project are relevant for:

- Emissions to atmosphere.

The computer modelling of the pollutants dissemination and its impact on neighbouring residential area has taken into account a background concentration of the substances that will be emitted by the Project facilities. The data on key pollutants' background concentration near Odeska station was provided by the adjacent stationary observation point. For the depot site standard values of background concentration were used in line with national regulations (for further details please refer to 3.7)

In addition the modelling considered the cumulative impact of different substances that will be emitted by the Project facilities. The modelling program ЭОЛ 3.5 automatically considers the summation effects including the summation effect of NO_2 and SO_2 that is relevant for construction and operation phases of the Depot and Extension.

- Discharge to water bodies

The impact of the storm waters discharged to the river can be cumulative in case the receiving water body contains the same pollutants as the discharged water. The presented EIA for the depot does not contain the background concentration of pollutants in the river.

4.5 Identification of Key Uncertainties and Data Gaps

The deliverables presented by the Consultant are based on the assumption that the original design presented by MCC will be implemented with deepening. Should the alteration of the alignment be accepted, the need for additional studies arises.

4.6 Comparison of Impacts associated with Variants, including the do-nothing Variant

The alternative locations of the Green line and the Depot have been strategically considered (Chapter 1.3).

Variant for the vertical and horizontal alignment of the line extension were examined by the Feasibility Studies in 1992. The FS considered and compared mostly technical aspects of the development such as crossing the existing utility lines and complexity of construction works. However environmental and social impacts are partly taken into account. Thus, Variant 2 that was planned under the right side of the Gagarina Avenue carriageway was rejected because of expected inconvenience due to traffic congestion and changed bypass roads. The damming effects from the metro tunnels under the storm water collector together with high mineralization of the groundwater were considered as a drawback of Variant 1. For the variant that was deemed optimal, Basic Design Documents have been developed.

The Consultant has considered the “do nothing” variant from the perspective of the sustainability concept. It can be concluded that for the environmental component the “do nothing” variant will be rather beneficial mainly because it allows avoiding direct and indirect emissions of pollutants and GHG to the atmosphere. At the same time both social and economic components will suffer from lost opportunities that the Project bears for the development of the City.

4.7 Summary of Least-Cost Analysis of Variants

The least-cost analysis of variants is limited to comparison of construction costs for alternatives considered in FS’92. No evidence for evaluation of any alternative solutions that go beyond expansion of the metro (such as development of other transports or demand reduction) has been presented.

5 DESCRIPTION OF MITIGATION MEASURES AND/OR MEASURES TO ENHANCE ENVIRONMENTAL BENEFITS

5.1 Climatic conditions

Extension

KMC demonstrates its commitment to reduction of adverse environmental impacts through more efficient use of resources. Major efforts are taken for energy savings that in its turn reduce associated emissions including GHG. It can be recommended to spread the practices that are currently used by KMC:

Administrative:

- Adjustment of the traffic schedule to actual demand
- Adjustment of ventilation system schedules
- Optimisation of lighting

Technical:

- Smooth start of escalators. Short escalators activation/deactivation based on passengers flow (at stations Malysheva, MarshalaZhukova and Kholodna Hora).
- LED lighting at stations and tunnels
- Motion sensors for lighting of technical premises at three stations
- Frequency controllers for fan engines
- Highly adjustable autonomous electrical heating

Depot

A good example of using renewable energy has been identified in the course of KMC E&S Audit. Currently, the Saltivske depot switches to autonomous thermal energy supply by installing:

- Sun thermal collectors of total capacity of 65 Gkal/year. 42 collector units together with accumulation tank cover the depot's hot water needs;
- decentralised heating system that consists of three biomass boilers (98kWt each) and three electric boilers (90 kWt each) for heating.

These measures could be replicated in the Oleksiivske depot resulting in reduction of GHG emissions associated with burning fossil fuels for production of thermal energy accompanied by financial savings.

5.2 Geomorphology, Geology and Hydrogeology

In general, the negative impact of the new metro line construction and operation on the underground water can be fully mitigated in case of the implementation of the designed measures and the incorporation of the following recommendations in the course of the development of the detailed design, the construction and the operation of structures:

- the prospecting wells for the purposes of soil investigations at the detailed design stage must be drilled down to the top of the impervious Kyivan marl and clay, and a package of well logging measurement activities have to be carried out in order to ensure the availability of objective data on the bottom boundary of the watered section and the distribution of water inflows over the depth intervals;
- It would be appropriate to build a horizontal, vertical or radial drain at the segment from chainage 128+00 to chainage 138+00 where the tunnel body can dam the underground water flow and the tunnelling method prevents the trailing drain from being built.

5.3 Surface and Groundwater Quality

Extension

- The probable presence of oil products in the underground water and soil in the area adjacent to the old petroleum tank farm makes it necessary to carry out the soil investigation for the ascertainment of the degree of the soil and underground water contamination with hydrocarbons at the segment from the chainage 130+00 to chainage 135+00. If oil products are detected, it will be necessary to make arrangements for the interception and pumping of the contaminated water, and the purification thereof before the discharge in order to prevent accidents during the construction.
- If drained water is to be used for process purposes by KMC, it is advisable to develop technical specifications for the use and the discharge thereof taking into account the quality and composition of this water.

Depot

In order to guarantee safe water use and to protect the river ecosystem the Company should develop and comply with the Specification for Water Discharge. The Specification establishes the maximum load of a particular substance in water discharged to a particular place of a water body on established regime per unit of time. The resulting concentration of a substance in a water body should be below the level established in sanitary standards for this substance for the particular class of a water body (depends on type of use). The list of standard controlled components (established by KMU directive No 1100 as of 11.09.1996) should be amended with other substances in case of its presence in the discharged water.

5.4 Landscape

Mitigation measures are not required.

5.5 Ecology and biotic resources

The key impact on biotic resources through the discharge of storm waters to the Lozovenka River can be mitigated by complying with qualitative, quantitative, and regime conditions for the discharge stated in the Permit for the Special Water Use.

5.6 Air quality

Extension

Since the major impact on air quality during the construction phase of the Project is associated with motor fuel combustion the mitigation should be focussed on operations of trucks and other vehicles.

From a technical perspective, attention should be paid to dust and the Contractor's truck fleet, especially as the construction sites are close to residential areas. Impact on air quality is related to dust from ground works and exhaust gases from machineries. Dust emissions are expected to be generated from land clearing, digging, demolition works and potentially construction of temporary roads to the spoil dumping site. Heavy machineries such as excavators, concrete mixers, etc. used during construction phase generate harmful pollutants like SO_2, NO_x, and particulate matter (PM) to air caused by the combustion of various fuels such as diesel (i.e. the main fuel). Depending on the level of activity, the specific operations, soil moisture, silt content in the soil, and the prevailing meteorological conditions, the dust conditions at site can vary substantially from day to day. A large portion of the emissions can result from equipment traffic over temporary roads at the construction site.

Given the proximity of construction activities and the potential for short-term dust nuisance to the nearby local population, simple mitigation measures are proposed that would reduce risk of dust nuisance during the construction phase. As most of the dust emissions originate primarily from land clearing, mitigation measures to control dust formation are recommended, as presented in the following table.

Aspect	Mitigation Measure
Dust nuisance	• Water spraying at regular intervals and other dust suppression techniques such as covering storage piles and setting a maximum speed limit.
Exhaust emissions	• Trucks used in construction site should comply with recent requirements for exhaust emissions. The following vehicle standards are recommended as the minimum requirement: - Heavy duty road vehicles: EURO IV - Light duty road vehicles: Euro 3 - Non-road vehicles: EU Stage IIIa. • The usage of low sulphur fuel is preferred. It is also good practice to switch off all engines, equipment and machinery when not in use to reduce emission and wastage. • Drivers should be instructed on the benefits of driving practices that reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits. • Regardless of the size or type of vehicle, fleet owners /operators should implement the manufacturer recommended engine maintenance programs.

Table 17: Mitigation measures to control dust formation

As to administrative measures, the optimal operational regimes and routes should be considered in the detailed design and followed by contractors in their operations.

The impact of the extension's operations will mostly from indirect emissions resulting from electric energy production. Since the structure of the national energy market does not allow choosing a supplier with "cleaner" energy, the only way of mitigation is the reduction of energy consumption. The extension should be included to corresponding Energy Efficiency Action Plans that are being prepared and executed by KMC for its existing facilities.

Depot

Although the estimated level of air quality at the border of the Depot's sanitary zone is in line with standards, the negative impact of emissions of NO_x and CO can be further mitigated by partial or total replacement of combustion of natural gas (for heating) with application of solar thermal collectors as is done at the Saltivske Depot.

5.7 Noise

Since the road traffic is the major source of noise in the Project area, it is expected that the Project will have a positive impact through decrease of road transportation and associated noise levels. So the Project operations can be considered as a mitigation measure.

5.8 Ground conditions

It is not required under condition that the foam, used for tunnelling will be consisting solely of bentonite.

5.9 Socio-economic and cultural issues

Subcontractors' EHS performance

For better control over construction subcontractors' EHS performance it is recommended to extend the force of existing "KMC Policy on Health and Safety for Subcontractors" to construction subcontractors' operations. It can be done by MCC (acting as a client for metro construction) adopting this Policy and subsequent annexes in contracts of MCC with its construction contractors.

Use of asbestos-containing materials (ACM)
To prevent the adverse impacts on human health the Consultant suggests replacement of ACM with alternative materials that are readily available in Ukraine:

1. Pipes: Polyethylene/PVC pipes are typically appropriate and used in European metros
2. Boards and panels: Composite (e.g., steel sheet with cement core or steel sheet with rock wool core), calcium silicate boards, mineral-bound calcium silicate boards
3. Cladding (fire protection): Aramid fibre-based materials, although a sufficient thickness of concrete can also provide the required fire protection

Yet the final choice of the alternative material will be made by the Contractor according to the contractual requirement for not using ACM.

Although the replacement options are associated with higher direct cost it is negligible in comparison to the total project cost. Furthermore, life-cycle cost of using ACM includes expenses related to the necessity of future replacement / rehabilitation / disposal and the cost of treating persons with asbestos-caused illnesses.

The replacement will not have any implications on the Project schedule. The procurement of alternative materials can be planned by the Contractor in advance.

Traffic congestions

The Contractor jointly with City Council Infrastructure Department should develop and announce measures for mitigation of traffic congestion (bypass routes, schedules for project related transportation).

Cultural heritage

Although the Project sites are not registered in the local and national cultural heritage databases there is always a possibility for revealing of archaeological items during the excavation works. Should it happen, the local authorities should be informed immediately.

5.10 Land use and settlement patterns

As a general rule, involuntary resettlement should be avoided. The client should consider feasible alternative project designs to avoid or at least minimise physical and/or economic displacement. Where it is unavoidable, resettlement should be minimised and appropriate mitigation measures should be carefully planned and implemented.

The Policy requires the client to offer compensation for loss of assets at full replacement cost and other assistance to all displaced persons and communities. The range of mitigation measures applicable to an affected person is determined by the type of displacement (physical or economical) and the status of the person's ownership rights over the affected assets.

The subsections below provide a general overview of applicable mitigation measures. For further details please refer to the RAP/LRP.

5.10.1 Physical displacement

Owners
The owners of households that fall under category of PAP *who have formal legal rights to the land* (according to ESP PR5) are eligible for monetary compensation. Granting of in kind compensation will be considered during the negotiation process.

If the owner of the land that is earmarked for acquisition owns of the house, other buildings, perennial crops located thereon, the requirement of land acquisition is considered jointly with the requirement for termination of the ownership for the specified assets. The purchase price includes the value of these assets.

In case of partial acquisition of a land plot when the rest of the area cannot be efficiently used for the intended purpose, the whole land plot will be acquired upon the request of the owner.

Users

According to the Residential Code if the building with state/municipal-owned residential premises is subject to demolition due to the land acquisition for state or public needs, the displaced persons will be provided with alternative comfortable residential premises.

The City will provide tenants who are officially registered at the City-owned flats at the affected houses with an alternative adequate accommodation (a flat or its part).

In the case of residents exercise their right to privatize the premises they occupy (under the Law of Ukraine "On privatization of public housing"), these residents will be entitled to the same type of compensation as the owners of the premises.

The owners registered at their households are eligible for monetary compensation. Granting of in kind compensation will be considered during the negotiation process. Although the right of informal users is not recognised by the national legislation, this group is also eligible for its interests, housing and assistance needs being considered according to the PR5.

5.10.2 Economic displacement

The majority of the official businesses affected by the Project lease the land plots from the City. The lease agreements contain provision for early termination due to the start of the Project. According to the provision, businesses agree to remove their facilities at their own cost when the metro construction starts.

The City will involve the affected businesses to selection of alternative land plots that will be offered for lease and subsequent relocation of commercial assets and operations. However, no further compensation (lost profits, transaction costs) will be offered.

The owners of facilities occupied by businesses located on the private land plots are eligible for monetary compensation. Granting of in kind compensation to the affected business owners will be considered during the negotiation process.

Some of the (household-based) businesses may be informal and not entitled to any compensation as per current Ukrainian standards except the compensation of assets located on the acquired land plots.

Registered household based businesses are subject to compensation of assets and lost profits.

5.10.3 Loss of public amenities

Due to selection of an alternative site for temporary household facilities for construction workers, the loss of public amenities will be avoided. Mitigation measures are not required.

5.10.4 Displacement of informal land users at the Depot site

Since the displacement of informal land users at the Depot site will be avoided by means of narrowing the construction area, mitigation measures are not required.

6 OUTLINE OF AN ENVIRONMENTAL AND SOCIAL MONITORING PLAN

6.1 Monitoring during the construction phase

6.1.1 Climatic conditions

Not applicable to the construction phase.

6.1.2 Geomorphology and geology

Not applicable to the construction phase.

6.1.3 Surface and ground water quality

Old petroleum tanks farm can be a source of material oil contamination of the soil and groundwater. There is a high probability of contaminated water's being drawn to the drainage structures of construction and operation-phase dewatering systems that will be located downstream the underground water flow. For this reason, it will be necessary to carry out the soil survey at the detailed design stage for the discovery of oil products in all their forms (dissolved in underground water, streaks on the top surface of the groundwater, contaminated soils, and the presence of gases in the aerated zone) along the construction site between chainage 130+00 and chainage 135+00.

Measures for monitoring of the groundwater and soil quality should be developed based on the survey results.

6.1.4 Landscape

The site for deposit was assigned by the City Department Architecture, which is responsible for the landscape. It is known that the suggested area is planned for the cemetery. The area is located in the industrial far from residential areas.

6.1.5 Ecology and biotic resources

Not applicable to the construction phase.

6.1.6 Air quality

Monitoring inspections should control:

- technical conditions of the vehicles and construction machinery; control of exhaust gases.
- storage and transportation of bulk materials by a construction Contractor.
- compliance with the restriction for onsite waste incineration by a construction Contractor

6.1.7 Noise

Monitoring inspections should control:

- the application of mufflers and soundproof screens for compressor equipment;
- hours of operations (in order to exclude noisy works in proximity to residential areas during night hours)

6.1.8 Ground conditions

The extracted spoil should be monitored for possible oil contamination. The sampling intensity should be commensurate to the risk of contamination at particular sections of the extension (especially between chainage 130+00 and chainage 135+00). Initially the spoil can be analyzed every 200 m of the alignment. In case the revealed concentrations exceed the standard, a more detailed sampling should be undertaken in order to define the exact area of contamination.

6.1.9 Socio-economic and cultural issues

For better control over construction subcontractors' EHS performance it is recommended to extend the force of existing "KMC Policy on Health and Safety for Subcontractors" to construction subcontractors' operations. Monitoring procedures listed in the Policy should be applied.

Since there is always a possibility for revealing of archaeological items during the excavation works the personnel dealing with excavation should be instructed on monitoring of the soil in pits/tunnels and extracted spoil for presence of archaeological items.

6.1.10 Land use and settlement patterns

Monitoring of the resettlement and livelihood restoration process will be carried out in accordance with PR 1 and should involve the participation of key stakeholders such as affected communities.

An external completion report of the RAP/LRP will be commissioned to determine that the provisions have been met. The completion report should be undertaken after all inputs in the process, including any developmental initiatives, have been completed. The report may identify further actions to be completed by the client. In the majority of cases, the completion of corrective actions identified by the completion report should bring the client's obligations for resettlement, compensation, livelihood restoration and development benefits to a close.

6.2 Monitoring during operation phase

6.2.1 Climatic conditions

Emissions of GHG should be monitored and reported once a year. The EBRD's Methodology for Assessment of Greenhouse Gas Emissions can be used for accounting of the emissions.

6.2.2 Geomorphology and geology

The impact of the damming effect (an increase in the groundwater table) in adjacent areas has to be controlled by means of the monitoring of the underground water levels using a specifically arranged network of monitoring wells in parallel with the control over the sound operation of drainage facilities subject to the inspection and the preventive maintenance thereof in the course of the operation in accordance with the properly developed time schedule. It would be appropriate to arrange monitoring stations within inundation areas (from chainage 121+62 to chainage 138+00 along the line). The specific locations of monitoring wells shall be specified in the specific detailed design taking into account the specific features of the terrain.

The levels of the groundwater and the Neogene sand aquifer in the Metro depot and connector line areas should be monitored through monitoring stations as well.

6.2.3 Surface and ground water quality

KMC (or competent contractor) should monitor the quality of storm water (subject to discharge to Lozovenka River) after the onsite treatment on a regular basis. The frequency and scope of sampling will be defined in the course of development of Discharge Specification.

6.2.4 Landscape

Not applicable to the operation phase.

6.2.5 Ecology and biotic resources

Not applicable to the operation phase.

6.2.6 Air quality

The quality of air should be monitored by KMC. The scope and frequency of sampling will be defined in the course of development of background documents for obtaining a permit for emissions for the depot.

The air quality monitoring for the extension is applicable to the emission sources that are outside of the project scope (diesel power plant of the shelter).

6.2.7 Noise

Not applicable to the operation phase.

6.2.8 Ground conditions

Not applicable to the operation phase.

6.2.9 Socio-economic and cultural issues

KMC should spread its OHS monitoring system to the extension’s operations.

Standard transportation KPIs like ridership should be measured in order to meet the transportation demands in an optimal way.

6.2.10 Land use and settlement patterns

Not applicable to the operation phase.