ENVIRONMENTAL ASSESSMENT AND RECOVERY PRIORITIES FOR EASTERN UKRAINE

ASSESSMENT OF ENVIRONMENTAL DAMAGE IN EASTERN UKRAINE AND RECOVERY PRIORITIES

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ENVIRONMENTAL ASSESSMENT AND RECOVERY PRIORITIES FOR EASTERN UKRAINE

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AFU	Armed Forces of Ukraine
BAWR	Basin Administration of Water Resources
CCF	Coke and Chemicals Facility
CHD	Henry Dunant Centre for Humanitarian Dialogue
EPL	ICO "Environment-People-Law"
EU	European Union
IBRD	International Bank for Reconstruction and Development (World Bank)
ICO	International Charity Organization
LLC	Limited Liability Company
MAC	Maximum Allowable Concentration
Minecology	Ministry of Ecology and Natural Resources of Ukraine
MLRS	Multiple Launch Rocket System
MTOT	Ministry of Temporarily Occupied Territories and Internally Displaced Persons of Ukraine
NGO	Non-governmental organization
NPP	Nuclear Power Plant
OJSC	Open Joint Stock Company

ORP	Oil Refinery Plant
OSCE	Organization for Security and Co-operation in Europe
OSCE SMM	OSCE Special Monitoring Mission
PJSC	Private Joint Stock Company
RLP	Regional Landscape Park
SD BAWR	Siverskyi Donets BAWR
SESU	State Emergency Service of Ukraine
TPP	Thermoelectric Power Plant
UHHRU	Ukrainian Helsinki Human Rights Union
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children's Emergency Fund
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USA	United States of America
WASH Cluster	A coordination mechanism of humanitarian response in the area of water supply, water disposal, sanitation and hygiene

FOREWORD

For nearly two decades, the OSCE Project Co-ordinator in Ukraine (PCU) has assisted Ukraine in its efforts to build a stable and democratic society. The crisis in eastern Ukraine has given rise to new challenges, including security issues and humanitarian and economic crises. As a result of these developments, efforts aimed at restoring stability, peace and security have been added to the PCU's mandate.

We are working towards creating a platform to promote dialogue in the most challenging sectors of the eastern part of the country, supporting the social integration of internally displaced persons, enhancing the national capacity for humanitarian demining, and strengthening chemical safety and security in this highly industrialized region of Ukraine.

Environmental issues in the Donbas region resulting from the crisis have had a widespread negative impact on Ukrainian society, their effects being felt in the nation's social, economic, humanitarian and political spheres. The region's acute environmental safety and security issues cannot be neglected and require attention from stakeholders and the general public.

In 2017, acting on a request from the Ministry of Ecology and Natural Resources of Ukraine, the PCU launched the "Assessment of the Environmental Damage" project in eastern Ukraine. The effort is tasked with conducting environmental assessments and preparing recommendations outlining a strategy for the region's recovery. We are grateful to the Governments of Canada and Austria for their timely response to this pressing issue, providing necessary financial support for the project.

This publication presents the results of the initial environmental damage assessment conducted during project implementation, consisting of site research findings and their interpretation. In this assessment, the authors have assembled and analyzed information gathered from a range of sources and offer a number of specific measures targeting the recovery of the region both short- and long-term.

We are hopeful that this result of our joint effort is both timely and sufficient to allow state and intergovernmental bodies, as well as non-governmental organizations to consider taking immediate action to remedy the situation. It is with this purpose in mind that the PCU and our distinguished national and international partners continue our efforts to address urgent environmental issues in eastern Ukraine.

OSCE Project Co-ordinator in Ukraine
Ambassador Vaidotas Verba

The Donbas region of eastern Ukraine bears both the nation's and Europe's most significant man-made environmental burden. The area has long been a source of concern, its current pressing issues predating the ongoing armed conflict. With the onset of hostilities the environmental situation in the east has only grown more dire.

Currently, the issues of surface and ground water pollution are critical. Frequent disruptions to the operation of both the water supply and water disposal systems have resulted in repeated, unscheduled discharges of pollutants into freshwater sources. Among the most critical hazards are those posed by the flooding of mines being used as waste storage. The combustion of munitions and subsequent explosions and the extensive deployment of heavy military equipment cause further, related damage by significantly polluting soils, which will eventually require reclamation and rehabilitation. Forest fires and illegal tree cutting have resulted in the loss of woodlands and windbreak strips, had severe impact on nature reserves, and disrupted the balance of ecosystems. Hostilities have also exacerbated waste management issues, especially in towns along the contact line.

Apart from the immediate, overall effects of the armed conflict on the environment, challenges to the proper functioning of the environmental protection system as a whole are also of great concern. The conflict has disrupted the operations of the environmental monitoring system, prevented observations in certain locations, and resulted in the loss of archive data, equipment, and documentation. The resulting shortage of information, limited reliable data, irregular observations, and lack of access to environmental information in territories beyond government control present major obstacles to an efficient and prudent administrative decision making process, a factor which is often decisive in crisis conditions.

In order to adequately collect, systematize, and analyze information on the environmental impact of the hostilities, and to further obtain support in environmental risk assessment and recommendation development, the Ministry of Ecology and Natural Resources of Ukraine turned to the OSCE PCU for assistance. This collaborative approach has facilitated the gathering of data for analysis and subsequent identification of specific high-priority measures.

This publication is the result of the work of professionals active in a broad range of specialized disciplines who have attempted to provide a comprehensive overview of the non-standard environmental situation that obtains in the industrial Donbas region under conflict conditions. The Ministry of Ecology and Natural Resources of Ukraine would like to express its gratitude to the OSCE Project Co-ordinator in Ukraine for the work that has been conducted. We remain committed to cooperation with the international community in analyzing the environmental situation, assessing and minimizing environmental risks resulting from the hostilities in eastern Ukraine, and, with the eventual restoration of peace in the Donbas, restoring and rehabilitating the environment of the affected territories.

Minister of Ecology and Natural Resources of Ukraine
Ostap Semerak

SUMMARY AND MAIN CONCLUSIONS

Armed conflict in eastern Ukraine has resulted in a regrettable range of harm to the region's lands and terrain, its surface and subterranean water systems, and its vegetation and wildlife. Hostilities also bring a significant increase in the risk of incidents at industrial and infrastructure facilities.

Under conflict conditions the chief threat is manifest in the risk of environmental pollution resulting from major operational disruptions and related incidents occurring at industrial and other large-scale facilities. Prior to the onset of conflict, the Donetsk and Luhansk regions were home to some 4,500 potentially environmentally hazardous enterprises. Between 2014 and 2017, companies in the region reported over 500 cases of operational disruptions and related incidents, some of which were fraught with potential hazard for both the local population and the environment.

The following list includes industrial facilities damaged during the hostilities that pose the greatest hazard for the environment: the Yasynivka, Avdiivka, and Yenakiieve Coke Plants; the Yenakiieve, Makiivka and Donetsk Metallurgical Plants; the Toretsk Ferroalloy Plant; the Alchevsk Metallurgical Complex; the Lysychansk Oil Refinery; the Donetsk State-Owned Chemicals Plant, Siverskodonetsk Plant "Azot" ["Nitrogen"] and the Horlivka "Styrol", Sloviansk, Luhansk, Vuhlehirsk and Myronivka Thermal Power Stations

In the course of the conflict, multiple reports were received of damaged infrastructure and power outages at coal mines, leading to the shutdown of mine-water drainage systems, and in a number of cases, resulting in the full-scale flooding in the mines. Currently, in the entire region between Horlivka and Yenakiieve, in the vicinity of Pervomaisk, and in portions of Donetsk, Makiivka, Shahtarsk and Toretsk water drainage systems are largely non-functional. Thirty six of the region's mines are either being flooded with waste material or have already been flooded completely, rendering them non-operational. Some damaged and suspended mining operations in the Donbas have already been dismantled.

Of particular concern is the danger posed by the flooding of the Oleksandr-Zakhid and Vuhlehirsk mines, as well as the troubling case of the Yunyi Komunar mine – the site of a 1979 underground nuclear explosion, where the groundwater may already be radioactive.

The continued large-scale flooding of area mines will inevitably result in both surface flooding and subsidence of the surrounding area, rendering buildings unusable, engineering and communication infrastructure – gas lines, sewage and water supply systems – inoperative, and polluting surface and groundwater with iron, chlorides, sulfates, other mineral salts and heavy metals.

During the course of the conflict, repeated disruptions of water supply and water disposal systems and facilities have been reported, some describing the discharge of pollutants directly into water sources. Chemical tests conducted at these sites show heightened concentrations of nitrogen and phosphorus in the water of the Siverskyi Donets, Kleban-Byk, Kalmius, and Kalchyk rivers, a result

that is potentially traceable to the disruption of operations at municipal wastewater treatment facilities.

When compared with data assembled in 2008, sediment drawn from the Karlivske and the Kleban-Bytske reservoirs reveals significant levels of pollution with non-radioactive strontium and barium, both of which are substances used routinely in heavy industry and munitions. In the areas affected directly by the hostilities, the soil reveals systemically elevated concentrations – by a factor of 1.1 to 1.3 – of mercury, vanadium, cadmium and non-radioactive strontium, as well as gamma-radiation in excess of the respective background values measured in areas unaffected by the fighting. Typically, maximum differences with background values reached levels of 1.2 to 2 times higher in some parameters, with occasional pollution values reaching 7 to 17 times that of the background levels. Data assembled by other organizations, including samples taken from within shell craters and other sites revealed heightened pollutant concentrations ranging between 1.2 and 12 times that of background values.

The conflict has rendered the management of household waste problematic, affecting in particular communities located along the contact line. The solution to this household waste problem faces further challenges arising from the presence of the remnants of discarded military equipment, ruined buildings, structures, and infrastructural elements. Their disposal requires additional renovation capacity, and is impossible to undertake without a prior demining of the territory and a thorough clearing of unexploded munitions. Yet, even in the event of a comprehensive demining of the area and disposal of munitions, any future use of land ravaged by combat maneuvers, military exercises, fortification construction, explosions, and the combustion of munitions will require a reclamation and re-cultivation of the topsoil.

Fire, mechanical damage, and illegal logging in the conflict area have destroyed significant sections of forest and valuable windbreak strips. This critical reduction in woodland coverage in the Donetsk and Luhansk regions has had a severe negative impact on the field-protective, soil-protective, water-protective, and recreational functions provided by forests and green spaces.

The conflict in eastern Ukraine has damaged roughly 60 natural protected areas in the Donetsk and Luhansk regions. Currently, a lack of personnel, the suspension of funding for environmental protection activity, and insufficient coordination between environmental bodies and the Ukrainian Armed Forces pose a significant threat to any preservation and/or rehabilitation of the affected areas. The region is also undergoing a developing imbalance in its biological diversity with some species having disappeared and others spreading uncontrollably, exposing both the agricultural and the epidemiological security of the region to heightened risk.

With the onset of armed conflict, environmental activities in eastern Ukraine were virtually paralyzed. The effect of this initial course of destruc-

tion on the environmental protection system in the conflict area is plainly evident.

Much archival material has been lost and not yet restored, environmental monitoring is generally inoperative in parts of the territory, and financial, logistical and manpower issues persist.

On the positive side, an increase in environmental protection expenditures in government-controlled territories is fostering the gradual restoration of the region's environmental protection system. Specific initiatives aimed at restoring environmental monitoring, water supply and sanitation systems, waste management, forest protection, and the development of nature preserves have been addressed in local planning as well as the national programme, and are in the process of being implemented by local authorities.

These recent, positive changes, however, do not reflect the existence of a systemic, long-term approach. Still lacking is a comprehensive analysis of the environmental situation in the conflict area that demonstrates local needs and which is coordinated with national and international priorities and policies of environmental protection and sustainable development.

The recommendations proposed herein are based on an analysis of the environmental issues confronting eastern Ukraine as developed in supplementary studies conducted by the OSCE Project Co-ordinator in Ukraine; comments and proposals expressed during round-table discussions with national authorities on 4 September 2017; and suggestions offered in other professional publications and raised during additional processes addressing environmental issues, not excluding the question of the eventual environmental rehabilitation of eastern Ukraine.

The recommendations are broken down into four distinct categories:

"Yesterday": actions required as a foundation for addressing broader issues, and whose implementation should already have begun or is to begin presently.

- Systematize all available data on the environmental situation and the genesis of environmental hazard in the conflict area, and enable both the broad dissemination of and access to the respective data to facilitate decision-making.
- Take inventory of gaps in information on the environmental situation and sources of environmental hazard in the conflict area, and organize targeted studies to fill those gaps.
- Arrange for unimpeded access to supplemental information about the state of the environment and natural resources in the Donetsk and Luhansk regions.

"Today": actions required for the reduction of environmental risk, and whose implementation is required in the near future.

- Regularly update the inventories of industrial and municipal facilities that currently stand,

or possess potential, as significant sources of environmental hazard in the wake of hostilities.

- Implement urgent measures to reduce the risk posed by the largest industrial and municipal sources of environmental hazard, including the establishment of sufficient means and resources necessary for effective rapid response to emergencies in hazardous areas.
- Political measures that assure the cessation of hostilities near sources of elevated environmental hazard, enable international monitoring, and take a preventive approach to issues affecting high-hazard installations.

"Tomorrow": actions required for the restoration of environmental activities in the area, and which are TO BE included in mid-term governmental action planning.

- Restore and improve the organizational and legislative foundations of environmental protection.
- Restore, expand, and automate pollution monitoring, control, and environmental reporting in the conflict area.
- Restore and upgrade industrial and municipal waste management systems.
- Modernize the use and protection of the region's surface waters based on the basin approach; restore and modernize water supply and waste water treatment systems.
- Ensure full management of natural protected areas, taking into account the need for rehabilitation of areas affected by the hostilities.
- Restore other damaged lands, bodies of water, forests, and windbreak strips.
- Respond to the impact of the altered flow and deterioration in quality of mine water, updating principles and practices of both operating and closing mines, as well as the rehabilitation of areas damaged by mining.
- Expedite the introduction of principles and methods aimed at reducing the environmental impact of defense activities into the operational procedures of Ukraine's Armed Forces and National Guard units deployed in the region.
- Expand awareness-raising activities on environmental protection in the conflict area.

"The Day after Tomorrow": actions targeting "the greening" of the Donbas, long-term.

- Develop a comprehensive concept addressing the economic restructuring of the Donbas on the basis of green economy principles and reflecting effective adaptation to climate change.
- Foster broad discussion on the greening concept among national and regional authorities, local governments, and representatives from business, industry, and the public.

INTRODUCTION

Despite the long-term adverse impact of hostilities on all aspects of both the environment and the local population, environmental protection nonetheless occupies the area of lowest priority in the course of military planning and action.

Armed conflicts affect lands and terrain, surface and ground waters, vegetation and wildlife in a number of ways. Hostilities significantly increase the risks of incidents at industrial and infrastructure facilities. Especially hazardous for the environment are conflicts that take place in industrialized regions possessing a large concentration of environmentally hazardous installations and facilities, as is the case in the Donetsk and Luhansk regions.

The industrialization of the Donbas began in the 19th century with the intensive development of the coal-mining and chemical industries, metallurgy, machine building, and other environmentally hazardous activities. Following decades of natural resource exploitation, a number of environmental issues have aggregated in eastern Ukraine, and any additional man-made burden may precipitate a host of unpredictable environmental consequences.

In light of the shortage of official information on the environmental situation in eastern Ukraine, this project has attempted to analyze and summarize all available information sources in order to assess the present level of damage, and assisting in the development of a reasonable projection of the potential scale of the environmental impact arising from the conflict in the Donbas.

Through a comprehensive analysis and synthesis of the available information, including recently published sources and additional research and consultations performed under the aegis of the OSCE Project Co-ordinator in Ukraine, the authors offer these practical recommendations for both short- and long-term steps required to further assess and address areas of grave environmental concern extant in eastern Ukraine.

ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF THE ARMED CONFLICT IN EASTERN UKRAINE

What do we know about environmental issues in the conflict area

The environmental consequences of armed conflict have only relatively recently become an area of active concern. Among prominent studies addressing this issue are those issued by the United Nations Environment Programme (UN Environment) on the environmental consequences of conflict in the former Yugoslavia, in Afghanistan, and in the Middle East[1]. In 2006, the OSCE and UN Environment evaluated the scale of the spread of grass fires in the Nagorno-Karabakh region, and in 2008, they studied the environmental consequences of the armed conflict in Georgia. Today, a range of inter-governmental and non-governmental organizations are involved in the assessment of the environmental consequences of hostilities in Syria and Iraq.

In eastern Ukraine, any assessment of the situation in the conflict area is reliant upon a severely limited number of sources. Currently, entire sections of the territory lack any environmental monitoring activities, and many industries are operated under a regime of non-transparency, offering little in the way of reliable information on the nature of damages to their facilities and related infrastructure. State Environmental Inspections in the Donetsk and Luhansk regions operate under conditions of great difficulty.

From the start of the conflict, organizations tasked with gathering environmental information in the Donetsk and Luhansk regions began to experience disruptions in their operations. Most lost their instruments of measurement, as well as all technical, material, and transportation facilities, archives and documentation. The scope of official statistical reporting has been severely hampered.

Simultaneously, beginning in 2015, and based on available information, the Ministry of Ecology and Natural Resources of Ukraine (Minecology) has prepared monthly informational and analytical reports on the environmental situation in eastern Ukraine. Information on the humanitarian situation in communities, as well as information on disruptions to water, gas, and electricity supplies have been made available daily in reports produced by the Information and Analytical Center of the National Security and Defense Council of Ukraine[2].

Operating within the framework of its designated activities, the OSCE Special Monitoring Mission has also prepared daily operational reports drawn from reports of specific on-site incidents and which contain, inter alia, information on operational disruptions at critical infrastructure and industrial facilities.

The UN Water, Sanitation and Hygiene Cluster (WASH cluster), coordinated by UNICEF, gathers and disseminates information on the hostilities along the contact line, documenting their impact on the water supply and sanitation[3].

In those areas of the Donetsk Oblast not currently under Ukrainian government control, UNICEF provides risk evaluation of the water supply, an activity which includes visits to critical infrastructure facilities.

Given the dearth of reliable information, mass media reportage and online social networks have become important data sources, albeit sources whose accuracy and credibility often require further corroboration.

Selected studies and overviews of environmental issues and priorities in eastern Ukraine

1. *World Bank – EU – UN analysis and reconstruction programme (IBRD, EU, UN 2015)*
2. *Analysis by ICO "Environment-People-Law" (Kravchenko 2015)*
3. *Publications by Zoï Environment Network (Denisov et al. 2015a, 2015b, 2017)*
4. *Research for the Trilateral Contact Group (Kaschka 2015, 2016, Petry 2016)*
5. *Report of the OSCE Special Monitoring Mission (OSCE SMM 2015)*
6. *Draft of the State programme for reconstruction and peace-building in Eastern Ukraine (MTOT 2016)*[4]
7. *Report by the Center for Humanitarian Dialogue (Yakovliev and Chumachenko 2017)*
8. *Analysis by Bellingcat (Zwijnenburg 2017)*
9. *Report by the Ukrainian Helsinki Human Rights Union (Bushchenko 2017)*
10. *Study commissioned by UNICEF* [5]
11. *Study commissioned by UN OCHA (Nicole and Ferraro 2017)*
12. *Materials by OSCE Project Coordinator in Ukraine (Averin 2017, Denisov, et al. 2017)*

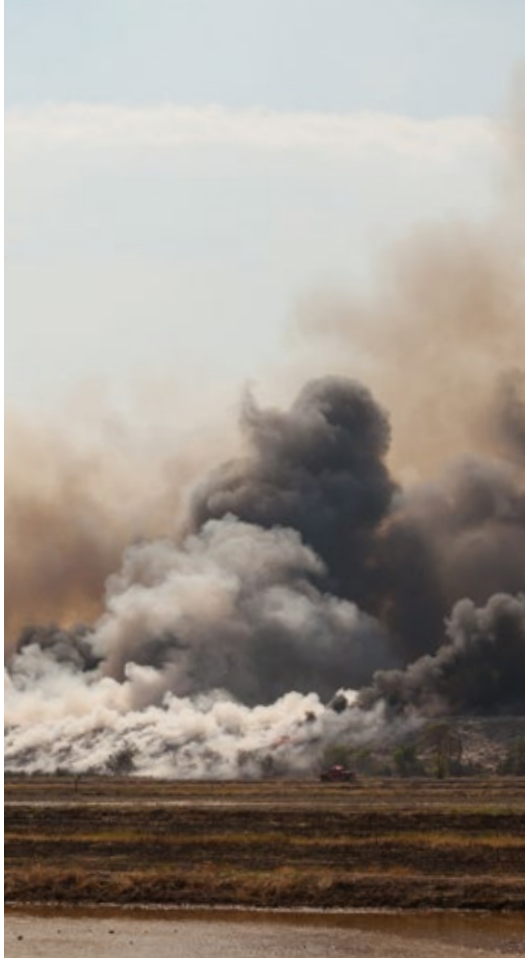
	1	2	3	4	5	6	7	8	9	10	11	12
TYPE OF ORGANIZATION / PROCESS												
Intergovernmental	■			■	■					■	■	■
Governmental						■						
Non-governmental		■	■				■	■	■			
ANALYTICAL APPROACH												
Literature review	■	■					■		■		■	■
Analysis of mass and social media		■	■					■	■		■	■
Analysis of other organizations' data	■	■	■	■	■		■	■		■	■	■
Own field studies		■		■	■	■	■		■	■	■	■
AVAILABILITY OF RESULTS												
Publicly available on-line	■	■	■		■	■		■	■			■
Restricted circulation				■			■			■	■	

	1	2	3	4	5	6	7	8	9	10	11	12
PRIORITIES OF ANALYSIS AND RECOMMENDATIONS												
Environmental situation in general	■	■	■						■			■
Direct impact of hostilities on the environment		■	■			■			■			■
Atmospheric air			■			■						
Ground waters				■			■					
Surface waters		■				■	■					■
Soils and land		■					■					■
Forests	■	■	■			■						■
Plants, animals, natural protected areas	■	■	■			■			■			■
Natural and industrial emergencies	■		■			■	■	■			■	■
Water supply, sanitation, waste	■	■		■	■	■	■			■	■	■
Environmental protection in the conflict area	■		■						■			■
TYPES OF RECOMMENDATION												
Overall / strategic	■	■	■				■				■	■
Information	■	■	■			■	■		■		■	■
Legislation		■							■			
Administration	■	■							■	■	■	■
Engineering / technology	■			■		■				■	■	
Foreign policy		■			■			■	■	■		

National mass media outlets providing the most complete coverage of the issue include Correspondent magazine and the UNIAN press information service. The Ostrov ("Island") information agency is also worthy of mention as a mass media outlet which was in operation prior to the onset of hostilities, particularly in those territories not currently under the control of the Ukrainian government, and which has provided continuing covering of ongoing events despite relocating to facilities located outside the conflict area.

The initial comprehensive overviews of the environmental situation in the conflict area in Eastern Ukraine were published at the beginning of 2015. The World Bank, the EU, and the UN analyzed the impact of the conflict and the need for addressing it[6]. These reports included analysis of environmental aspects and immediate needs for reconstruction (the environmental portion was valued at 30 million USD; the restoration of both water supply and water disposal systems were valued at additional 40 million USD).

At this time, the Environment-People-Law (EPL) international charitable organization performed



and subsequently published a series of field and desk studies[7], with the Swiss-based Zoï Environment Network and the UK Toxic Remnants of War project publishing a parallel analysis drawn from available resources, mass media materials, and in-house research[8]. Environmental issues in the conflict area have since registered on the political agenda, and Ukrainian and foreign mass media, governments, and international organizations have begun showing interest in the topic.

During 2015-2016, in support of meetings of the Trilateral Contact Group under the Minsk Negotiation Process, Austrian and German specialists were engaged in studies of specific security issues related to the water supply and waste water treatment in the conflict area[9], and addressing the prospects of restoring and developing the coal industry in eastern Ukraine, with an eye on the consequences resulting from the flooding of coal mines[10]. The issues of water supply security and sanitation were also the subject of an analytical report prepared by the OSCE Special Monitoring Mission in Ukraine[11]. At the end of 2016, the Ministry of Temporarily Occupied Territories and Internally Displaced Persons

(MTOT) developed and presented for public discussion a draft of the first State reconstruction and peace-building programme in eastern Ukraine (hereinafter, MTOT State Programme), estimating the total cost of its environmental component at approximately 50 million Euros[12].

Throughout 2017, the issue continued to draw increased attention, and the amount of available analytical material grew dramatically. At a session chaired by the Deputy Prime Minister of Ukraine in May 2017, the decision was made to establish the Interagency Environmental Working Group for the Donetsk and Luhansk regions, which was to operate under the aegis of MTOT.

In June 2017, the Verkhovna Rada Committee for Environmental Policy, Management of Natural Resources, and Response to Chornobyl Accident held a round-table dedicated to Donbas environmental issues[13]. Based on open-source data, the international non-profit network Bellingcat published a detailed analysis of the damages caused during the conflict and the environmental hazards posed by a number of industrial facilities[14]. The Ukrainian Helsinki Human Rights Union published its own detailed report on the consequences of conflict, offering particular focus to the issue of nature reserves[15].

Finally, by request of the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), Swiss specialists performed a rapid field assessment of the environmental hazards that may result from potential industrial incidents along the contact line[16]; and acting on a request from UNICEF, an Austrian contractor performed a comprehensive analysis of the Voda Donbasu ["Donbas Water"] company and risks to the regional water supply[17].

Based on a preliminary desk study[18] and additional results – including field studies – assembled under the "Assessment of Environmental Damage in Eastern Ukraine" project led by the OSCE Project Co-ordinator in Ukraine, and offering these in comparison with the conclusions of the aforementioned studies, publications, and independent sources, this document reflects an attempt to summarize all currently available information on the serious environmental issues confronting eastern Ukraine.

Direct pollution in the aftermath of the hostilities

Typically, the attention of the public, political operatives and professional environmentalists is primarily drawn to the danger of the immediate environmental effects resulting from military activities, with particular attention paid to the affects of chemical pollution. Previous research experience suggests that armed hostilities contribute to human-based pollution by introducing into the environment munitions fragments and combustion products, damaged parts of civil and military equipment, wrecked infrastructure, and other industrial elements, e.g., petroleum products, oil, and lubricants. The effects of pollutants that end up in the natural environment may persist for an extended period and have been shown to be mobile, working their way through the food chain, often posing immediate toxic, carcinogenic, and mutagenic threats to the population.

Research into the chemical pollution of the conflict area in eastern Ukraine is limited by the unavailability of access to sections of the territory for full-scale inspections. Further challenges arise from the elevated spatial variability of this type of pollution, differences in the methodologies of field observations and sample taking, and the complexity of comparing recently obtained data with levels of pollution that obtained prior to the conflict. The latter condition has proven to be particularly troubling in the Donbas, where access to reliable information has been sporadic, at best. The most reliable conclusions are formulated through field research of pollutants present in slow-moving media that readily accumulate chemical concentrations, namely, soils, bottom sediments, and biological tissue. Additional conclusions may be drawn on occasion from the analysis of data collected via regular (ideally continuous) environmental monitoring conducted within, or in the case of water sources, near the conflict area, and evaluating these results in the context of the intensity of armed engagement in the region under consideration (see the graphic in the next section).

Extensive field studies of pollution in the conflict area in eastern Ukraine have been performed by three organizations: Ecology-People-Law, 2014 (soils, surface waters)[19]; Center for Humanitarian Dialogue, 2016 (ground waters, soils)[20]; and Siverskyi Donets Basin Administration of Water Resources, under the aegis of the present study commissioned by the OSCE Project Co-ordinator in Ukraine (soils, bottom sediments). According to the first two studies, in the majority of cases the concentration of heavy metals in the soil samples taken from areas of armed engagement (in EPL protocols, mainly shell crater soil samples gathered shortly following the suspension of hostilities) exceeded background pollution values by a factor of between 1.2 to 12[21]. According to the analysis performed by the Siverskyi Donets BAWR in 2017[22] (see the box), values of chemical pollution in samples taken from ten locations equaled, on average, background values obtained in adjacent locations subject to similar exposure factors but which were exempt from hostilities. Values for mercury, vanadium, cadmium, non-radioactive strontium, and gamma radiation on average exceeded background levels by a factor of 1.1 to 1.3.

Typically, maximum differences with background values reached levels of 1.2 to 2 times higher in some parameters, with occasional pollution values reaching 7 to 17 times that of the background levels from samples taken in

the towns of Sloviansk and Shchastia. In virtually all samples collected as part of the Siverskyi Donetsk BAWR study, the fact that some values were higher in locations of armed conflict in comparison with those taken from background locations did not alter their position regarding acceptable sanitary Maximum Allowable Concentrations (MACs) of pollutants for soils in Ukraine[23]. In individual cases, according to both the EPL and Siverskyi Donets BAWR studies, samples were shown to exceed background levels by more than 100 times, with their distinction attributed to factors including the selection of sampling locations, high variability in pollution background values (EPL, SD BAWR), or variations from average regional values (CHD).

Field studies of the impact of the hostilities on soil and bottom sediments pollution

In order to identify the environmental impact of hostilities, on request of the OSCE Project Co-ordinator in Ukraine, the Siverskyi Donets Basin Monitoring Laboratory of the Basin Administration of Water Resources has investigated the chemical composition of soils and bottom sediments in the territories affected by the conflict. Sampling locations were chosen to represent a variety of natural and developed environments:

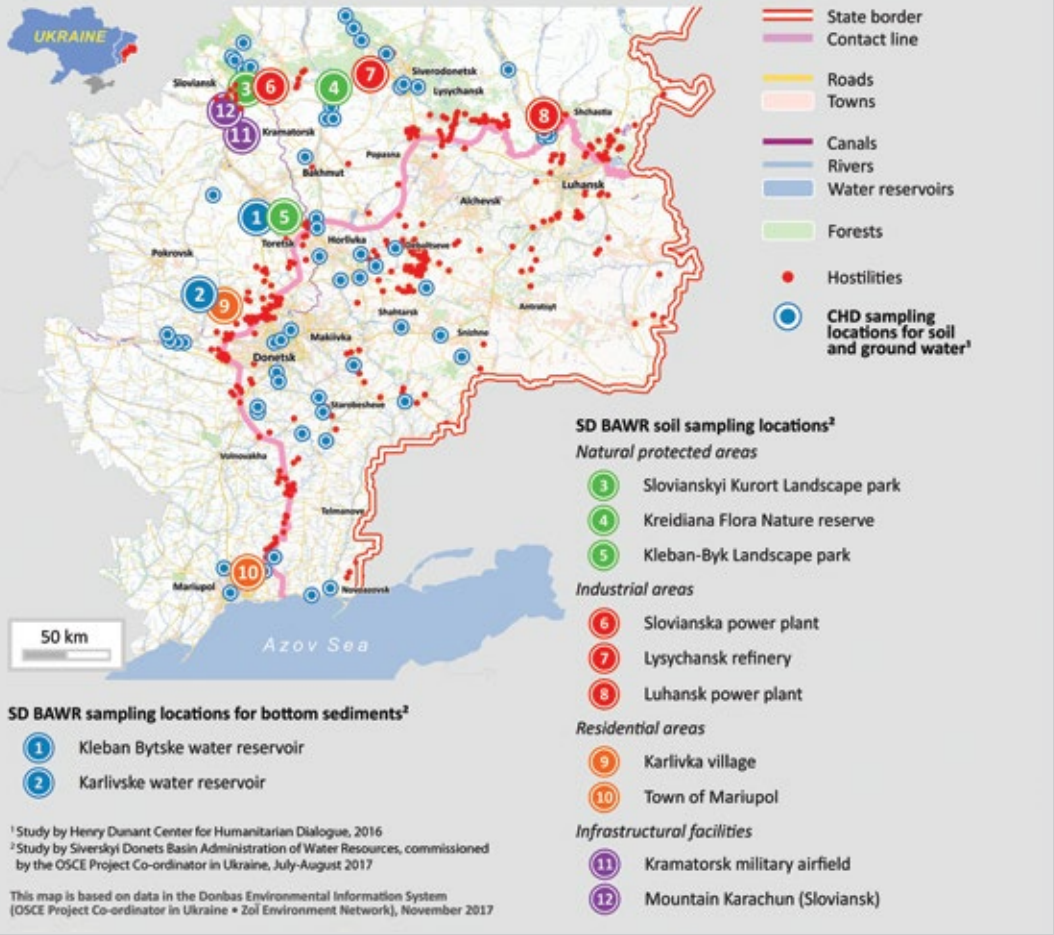
- nature reserves (the Slavic Resort Regional Landscape Park; the National Academy of Sciences of Ukraine Chalk Flora Ukrainian Steppe Natural Reserve; the Kleban-Byk Regional Landscape Park);
- the territory and outskirts of industrial facilities (Sloviansk TPP; Luhansk TPP and vicinity; Lysychansk Oil Refinery and vicinity);
- residential developments (the village of Karlivka; the city of Mariupol);
- transportation facilities (the vicinity of the Kramatorsk military airfield);
- communication (broadcasting) facilities (Karachun, Sloviansk).

To study the soils, the selected sites included territories directly affected by hostilities that were struck by munitions of various calibers and the movement of military equipment, etc. Basin Laboratory specialists recorded sampling location coordinates and obtained samples in the presence of either local residents or representatives from local adminstrations. The background samples were taken in areas which, based on visual observation and information provided by local residents, were not directly affected by armed conflict. On the outskirts of population centers sites were selected at a distance of 500 meters from the reference sites. Within population centers allowances were made for local peculiarities (buildings, paved roads, etc.), and in some cases sampling points were selected at a distance of 300 meters from

reference sites. The soil samples were taken from a sampling area employing the method of "envelope sampling", by averaging the results from five different samples.

The average chemical pollution values in the areas affected by hostilities conformed, on the whole, to background levels. Systematic exceedance by the factor of 1.1 to 1.3 was recorded for mercury, vanadium, cadmium, non-radioactive strontium, and gamma-radiation. By individual indicators, the background level was typically exceeded at a maximum factor of 1.2 to 2, only in several cases – samples taken in the towns of Sloviansk and Shchastia – was it exceeded by a factor of 7 to 17. In one case (non-radioactive strontium), the background was exceeded by a factor of 116.

Location of soils and bottom sediments sampling sites



¹ Study by Henry Dunant Center for Humanitarian Dialogue, 2016
² Study by Siverskyi Donets Basin Administration of Water Resources, commissioned by the OSCE Project Co-ordinator in Ukraine, July-August 2017

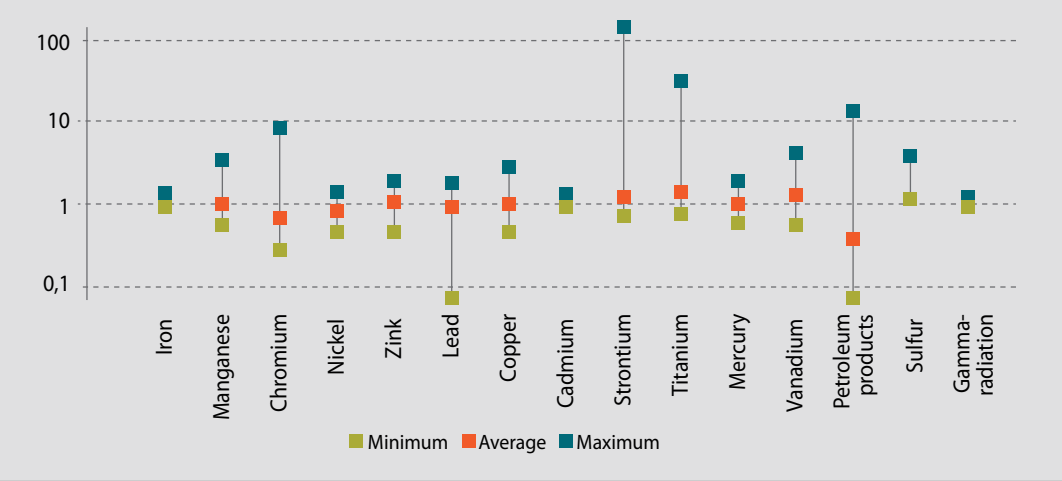
This map is based on data in the Donbas Environmental Information System (OSCE Project Co-ordinator in Ukraine • Zoï Environment Network), November 2017

Summary results of the chemical analysis of soil composition*

INDICATORS	Number of point pairs	Points beyond the hostilities-affected areas			Points within hostilities-affected areas			MAC
		min.	avg.	max.	min.	avg.	max.	
Total iron (mg/kg)	10	2200	3178	3982	2618	3104	3929	–
Manganese (mg/kg)	10	101.1	321.5	428.7	170.9	276.4	429.0	1500
Total chromium (mg/kg)	10	32.14	98.10	157.8	36.45	77.32	246.7	100
Nickel (mg/kg)	10	38.59	75.40	192.8	33.17	68.90	114.2	80
Zinc (mg/kg)	10	17.52	43.41	97.09	31.26	44.03	88.54	20
Lead (mg/kg)	10	0	10.45	32.41	0	13.33	71.57	30
Copper (mg/kg)	10	2.900	7.965	10.94	6.060	8.025	11.98	55
Cadmium (mg/kg)	10	0.51	0.54	0.62	0.50	0.59	0.70	0.5
Strontium (mg/kg)	10	0.20	0.20	21.9	0.20	5.63	25.6	–
Mercury (mg/kg)	10	0.006	0.325	0.800	0.006	0.525	2.05	2.1
Titanium (mg/kg)	10	548.3	1078	1978	794.6	1119	1690	–
Vanadium (mg/kg)	10	28.96	73.93	117.3	56.94	92.29	122.0	150
Petroleum products (mg/kg)	7	10	50	2270	0	40	110	–
Sulfur (mg/kg)	2	4.74	–	21.15	16.19	–	22.33	–
γ-radiation (μR/hr)	10	9	10.5	11	9	11.5	13	30**

* The values have been rounded to four significant figures and the median value was taken as the average
** Radiation Safety Norm in Ukraine (NRBU-97)

Relative difference of soil pollution in conflict-affected areas vs. the background level



The analysis of the differences between the content of heavy metals testifies to the possibility of combat-sourced impact. An increased sulfur concentration in Shchastia is, most probably, related to the influence of the Luhansk TPP.

Factor by which the background soil pollution was exceeded in some areas, and the possible causes of combat-sourced impact

INDICATORS	Industrial facilities			Residential areas		Infrastructure		Nature reserves		
	Sloviansk TPP	Luhansk TPP	Lysychansk Oil Refinery	Karlivka	Mariupol	TV- radio center, Sloviansk	Airfield, Kramatorsk	Slavic Resort	Chalk Flora	Kleban-Byk
Iron	1.0	1.2	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Manganese	1.0	1.7	1.0	0.9	1.0	0.7	1.0	2.8	0.8	0.9
Chromium	0.7	1.5	0.7	0.5	0.8	0.4	0.8	7.7	0.4	0.9
Nickel	1.0	1.3	0.8	0.9	0.7	0.7	0.9	0.6	0.6	0.8

INDICATORS	Industrial facilities			Residential areas		Infrastructure		Nature Reserves		
	Sloviansk TPP	Luhansk TPP	Lysychansk Oil Refinery	Karlivka	Mariupol	TV- radio center, Sloviansk	Airfield, Kramatorsk	Slavic Resort	Chalk Flora	Kleban-Byk
Zinc	0.9	1.8	0.8	0.8	0.9	0.6	0.7	1.4	1.0	1.5
Lead	0.9	1.6	1.3	1.2	0.9	–	–	0.0	0.8	–
Copper	1.0	2.1	0.8	0.8	0.9	0.5	1.0	1.8	0.9	1.3
Cadmium	1.1	1.1	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.1
Strontium	1.0	12.8	1.3	1.0	15.3	116.0	1.3	1.0	0.7	1.0
Mercury	0.9	16.7	1.1	1.0	1.0	2.2	1.6	1.7	2.3	1.0
Titanium	1.1	1.4	1.2	1.0	0.9	1.0	1.7	0.8	0.6	0.9
Vanadium	1.3	1.8	1.6	1.1	1.0	0.6	1.0	3.2	1.4	0.6
Petroleum products	–	–	0.5	0.7	–	11.0	0.0	0.6	0.0	0.5
Sulfur	1.1	3.4	–	–	–	–	–	–	–	–
γ-radiation	1.2	1.2	1.0	1.1	1.2	1.1	1.1	1.1	1.1	1.1
min.	**0.7**	**1.1**	**0.5**	**0.5**	**0.7**	**0.4**	**0.0**	**0.0**	**0.0**	**0.5**
avg.	**1.0**	**1.7**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.1**	**0.9**	**1.0**
max.	**1.3**	**16.7**	**1.6**	**1.2**	**15.3**	**116.0**	**1.7**	**7.7**	**2.3**	**1.5**
POSSIBLE CAUSES OF COMBAT-SOURCED IMPACT										
Small arms		■		■		■		■	■	
Grenades		■		■		■		■	■	
Artillery	■	■			■	■		■	■	
Tanks				■		■		■		■
MLRSs		■	■		■		■			
Other factors	■	■	■				■		■	

Summary results of the chemical analysis of bottom sediments*

INDICATORS	Kleban-Byk water reservoir		Karlivka water reservoir	
	2008	2017	2008	2017
Total iron (mg/kg)	27070	2667	28390	3240
Total chromium (mg/kg)	444,7	99,1	393,7	97,14
Nickel (mg/kg)	63,50	104,9	61,90	44,55
Zinc (mg/kg)	173,1	41,7	164	28,22
Lead (mg/kg)	35,8	35,8	35,6	0
Copper (mg/kg)	284,7	7,13	271,7	4,56
Cadmium (mg/kg)	5,10	1,21	4,76	2,23
Strontium (mg/kg)	90,3	481,6	85,6	464,5
Titanium (mg/kg)	4944	2158	4592	2218
Vanadium (mg/kg)	93,5	43,24	90,2	96,22
Barium (mg/kg)	750,3	13350	724,1	15200

* The values are rounded to four significant figures.

Sources: Siverskyi Donets BAWR 2017; S. Chumachenko, Ukrainian Civil Protection Research Institute of the State Emergency Service of Ukraine; Donbas Environmental Information System (OSCE Project Coordinator in Ukraine).

Samples of bottom sediments were obtained from the banks of the lower portions of the Karlivka and Kleban-Byk water reservoirs. Samples obtained from the dams of these reservoirs in 2008 were used for comparison as background values.

A comparative analysis of the 2017 results with the 2008 data shows higher values for non-radioactive strontium and significantly higher values for barium. Notably, the results also show a significant decrease in the concentration of iron, chromium, zinc, and copper, and some decrease in the concentration of titanium, which may be explained partly by differences in sampling techniques.

The potential impact of the conflict on both surface and ground water and atmospheric air quality is evident. However, initial comparisons of field data with a series of regular observations of surface water and atmospheric air qualities did not identify immediate and clear effects produced by hostilities (see box).

Analysis of multi-year data on the quality of the Donetsk Region's surface waters

The rapid assessment attempted to determine possible effects of the hostilities on the quality of the Donetsk Region's surface waters. The region's main rivers were selected as the target of the study.

Taking into account the nature of Donbas industrial and municipal facilities which either suffered partial damage or were completely destroyed, the parameters selected for the study as reliable indicators of significant environmental impact included overall water mineralization, mineral forms of nitrogen and phosphorus, heavy metals, and oil products.

The following data were considered:

- observations by the Siverskyi Donetsk Basin Administration of Water Resources of the State Water Resources Agency of Ukraine (SD BAWR). Preference was given to locations that have undergone a series of observations between 2000 and 2017; and
- information from the AquaGuard information and analytical system of the Ukrainian Hydrometeorological Institute, containing data from the State Hydrometeorological Observation Network of the State Emergency Service of Ukraine (SESU). This system contains a series of observations of water quality dating back to the 1960s (the analysis used series dating from 1996 to 2016).

The SD BAWR and SESU locations for data collection are shown in the figure below. The location upstream of the town Izium on the Siverskyi Donets was chosen as a reference point because of its upstream location from the conflict area and its sufficient distance from the industrial hub of Kharkiv.

Research into the possible impact of the conflict in eastern Ukraine on surface water quality and potential changes did not produce unambiguous conclusions regarding the consequences of conflict-sourced impact.

Increased concentrations of nutrients (mineral forms of nitrogen and phosphorus) were observed in both the Siverskyi Donets and other rivers. A rather dramatic increase in the concentration of ammonium nitrogen in the Kleban-Byk beginning in 2015 may be explained by effluent pollution. A near-identical increase in the concentration of ammonium nitrogen was observed in the Kalmius and Kalchyk Rivers, which may likewise be interpreted as the consequence of disruptions of operations at municipal wastewater treatment facilities. In comparison with levels taken at the Siverskyi Donets River, increased concentrations of nitrate nitrogen were observed in the Kazenyi Torets and the Kryvyi Torets Rivers. Beginning sometime in 2013, these concentrations have been measured within a range of 20 mg/dm^3 which may also point to water pollution with nitrogen compounds from effluents.

Monitoring locations for the multi-year analysis of surface water quality

Post-2013, analysis of water from the mouth of the Kazennyi Torets showed an increased concentration of copper. Also, oil-based products were observed in the Siverskyi Donets in the vicinity of the town Lysychansk, as well as in virtually all the rivers included in the study, with the highest concentrations found in the the Kazennyi Torets and the Kryvyi Torets.

The absence of clear conclusions about the impact of armed conflict on the quality of surface water may be attributed to the fact that water samples are taken at specific locations once a month or per hydrological phase, rendering the "interception" of local accident-sourced pollutants problematic. Once the source of pollution is removed (e.g., damaged water treatment facilities are repaired), the self-cleaning capacity of natural waters subsequently restores water quality to pre-accident levels. For more conclusive readings, rapid monitoring tools would be required to identify the effects of short-term pollutant exposure, like that encountered during armed conflict.

Source: Yu. Nabyvanets, Ukrainian Hydrometeorological Institute of the State Emergency Service of Ukraine[24]; Donbas Environmental Information System (OSCE Project Co-ordinator in Ukraine).

Data from the Center for Humanitarian Dialogue on the quality of ground water confirmed high levels of pollution, however an absence of comparing measured results against background or historical values precludes definitive statements on the effects of the conflict on ground water. Nonetheless, a comparison of recent Siverskyi Donets BAWR data on the concentrations of metals in sediments drawn from the Karlivka and Kleban-Byk water reservoirs with pre-conflict (2008) levels demonstrates a five-fold increase in the concentration of non-radioactive strontium and significantly elevated concentrations of barium (13,000 to 15,000 times). These substances are commonly used in industrial processes, but are also standard components of modern munitions[25]. Conversely, sediment comparisons of concentrations of iron, chromium, zinc, copper, and titanium taken from these reservoirs show decreases in the levels of these elements[26]. Depending on the nature and efficiency of the territory's rehabilitation in the future, with gradual decomposition of the fragments of munitions, machinery, and infrastructural facilities remaining in the ground, it is reasonable to expect a release of pollutants into the environment over a long period of time[27]. This will require long-term monitoring of the delayed consequences of the conflict.

CONCLUSIONS

- The analysis of the Siverskyi Donets BAWR field data commissioned by the OSCE Project Co-ordinator in Ukraine indicates, on average, that soil pollution in areas affected by hostilities does not increase or shows insignificant increases compared to the background level (systematic increase of 1.1 to 1.3 times was observed for mercury, vanadium, cadmium, non-radioactive strontium and gamma radiation). According to data of other organizations, including data for the samples taken in shell craters, pollution exceeded the average regional background level by 1.2 to 12 times. Selective cases of significantly higher differences may be related to sampling techniques and the variability of the geochemical background.
- The bottom sediments of the Karlivka and Kleban-Byk water reservoirs showed significant pollution with non-radioactive strontium (5 times) and barium (thousands of times) when compared to the 2008 data.
- The analysis of the series of regular observations on the quality of the atmospheric air and surface waters did not allow for immediate conclusions concerning the environmental impact of hostilities.

Industrial pollution

Throughout the entire period of the industrial development of eastern Ukraine, the region's natural environment was subjected to significant volumes of discharge of pollutants and high levels of industrial emissions[28]. Diminished industrial and agricultural activity in the region as a result of the armed conflict make it reasonable to expect an overall drop in emissions and the production of industrial waste. According to Ukrainian government statistics[29], emissions into the air in 2015 were reduced to 87% of 2014 levels, and to 92% in 2016 in those territories of the Donetsk and Luhansk regions controlled by the Ukrainian armed forces.

However, in areas not under government control, the reduction of emissions due to decreases in production between 2013 and 2014 are not known. Since 2013, the number of businesses in the Donetsk and Luhansk regions which report to the State Statistics Service of Ukraine has dropped from 40,000 to 14,000, with the number of major industrial facilities submitting environmental pollution reports dropping from 131 to 37[30]. Eyewitness reports, nonetheless, underscore a reduction in production volumes and an improvement in air quality in those territories that lie beyond the control of the Ukrainian government.

Unfortunately, a lack of information on air quality currently prevents a full-fledged assessment of changes in air quality during the conflict period. In the territories not controlled by the Ukrainian government located near the contact line, atmospheric air automated observation posts are non-functional. Donetsk Regional Hydrometeorological Center air quality monitoring posts located in the cities of Donetsk, Makiivka, Gorlivka, Yenakiieve, and Toretsk are non-operational. And posts in Luhansk and Alchevsk maintained by the Luhansk Regional Hydrometeorological Center for gauging atmospheric air quality have been shut down.

However, according to informational and analytical reports from 2015-2017 developed by Minecology, no incidents of intense pollution with concentrations five times above MAC were recorded in the towns of Mariupol, Kramatorsk, Sloviansk, Lysychansk, Siverodonetsk, and Rubizhne.

Water quality observations documented by the Siverskyi Donets BAWR and State Emergency Service of Ukraine testify to a relatively stable level of surface water pollution in the region, one that generally corresponds to pre-conflict levels (see the previous section). Several cases of high pollution characterized by ten-fold and greater excesses of MAC levels were identified in the Donetsk and Luhansk regions during 2015-2016.

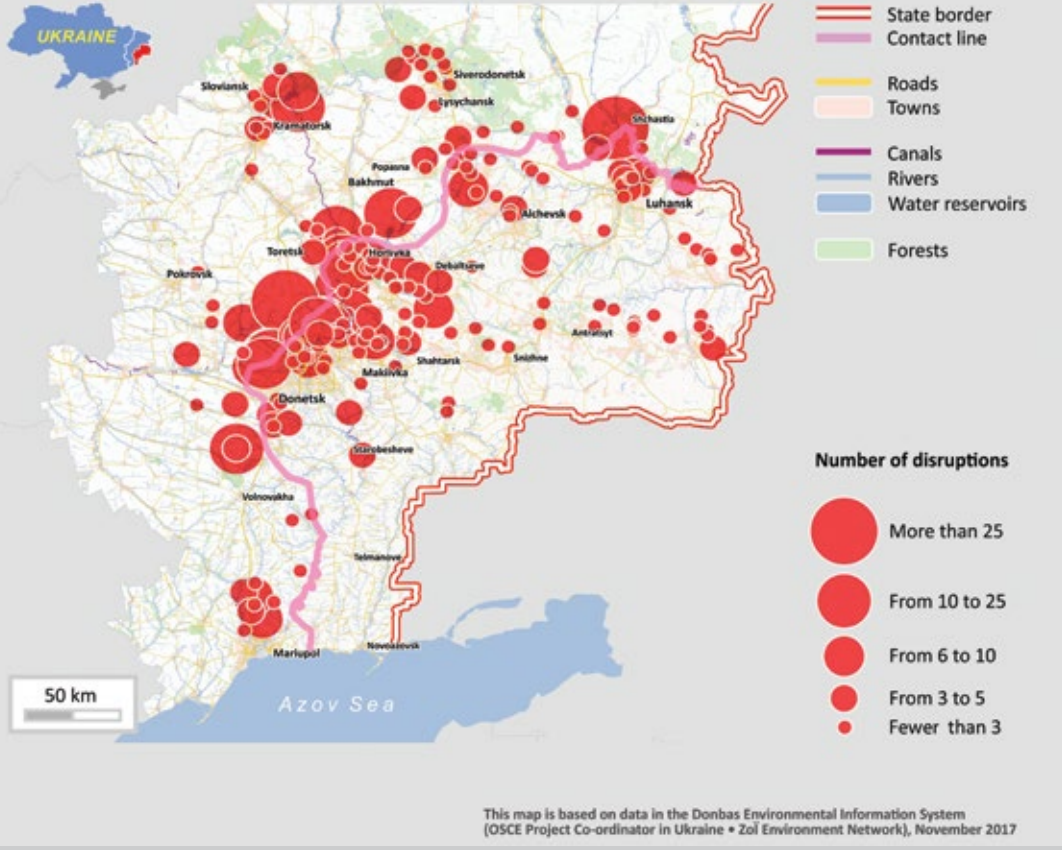
Cases of intense pollution with excess concentrations of manganese, sulfides, chromium, and zinc were observed in the Kalmius River, which crosses the contact line, and excess concentrations of manganese and sulfides were observed in the Kalchyk River.

Under conflict conditions, the primary threat of significant episodes of environmental pollution stems from the potential of major operational disruptions and incidents at industrial and related facilities. Prior to the onset of hostilities, the Donetsk and Luhansk regions were home to some 4,500 potentially hazardous businesses[31]. Between 2014 and 2017, regional companies experienced over 500 cases of operational disruptions and related incidents (see graphic), some of which were fraught with potential hazard to both the environment and the local population.

Incidents and operational disruptions at industrial facilities during the conflict

This list of industrial facilities damaged by hostilities includes the most environmentally hazardous enterprises: Yasynivka, Avdiivka, and Yenakiieve Coke and Chemical Plants; Yenakiieve, Makiivka, and Donetsk Metallurgical Plants; Alchevsk Metallurgical Complex; Lysychansk Oil Refinery; Donetsk State-Owned Chemicals Plant; Sloviansk, Luhansk, Vuhlehirsk and Myronivka Thermal Power Plants; and chemical industry facilities – the Azot [Nitrogen] Siverodonetsk facility and Styrol in Horlivka. The majority of industrial facilities were affected by conflict during 2014-2015. In 2016-2017, as reported by the Information and Analytical Center of the National Security and Defense Council of Ukraine, the intensity of the conflict was significantly reduced. During that period[32], damage was reported at the Avdiivka Coke and Chemicals Plant, Toretsk Phenol Plant, Donetsk State-Owned Chemicals Plant, Stakhaniv Ferroalloy Plant, and other related facilities located near the contact line. Interruptions in the electrical supply and damage to equipment resulted in continuous episodes of mine flooding occurring in the Donetsk, Horlivka, Yenakiieve, and Zolote areas.

Incidents and disruptions at industrial facilities during 2014-2017

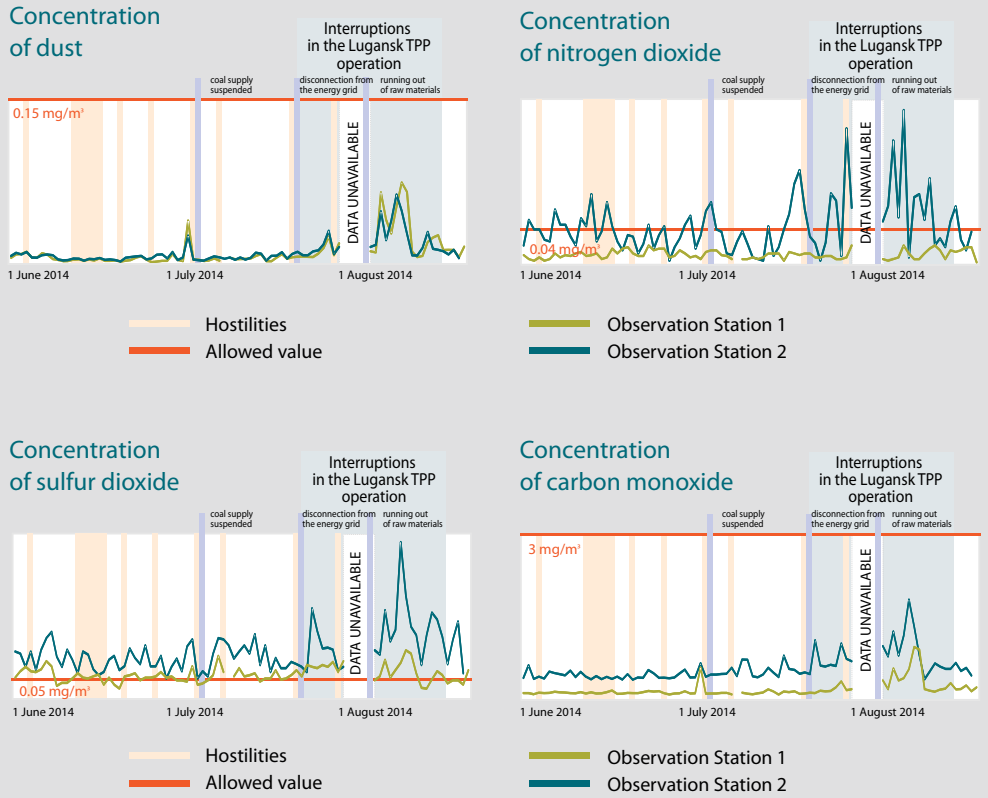


Operational disruptions at industrial facilities in eastern Ukraine increase the risk of environmental pollution. These incidents stem directly from armed conflict affecting industrial facilities, e.g., the destruction of equipment and infrastructure during shelling, or the disruption of production processes indirectly caused by interruptions in gas, electricity, or water supply, lack of access to raw materials, equipment or other materials, and reductions in the availability of personnel, etc.

For example, in the event of the disconnection of a mine ventilation system from the power supply during power restoration burst releases of colliery gases occur which include methane and other hazardous admixtures. During the conflict, outages were recorded at the majority of mines located in the Donetsk and Luhansk regions[33].

In May 2015, a fire at the Avdiivka Coke and Chemicals Plant resulted in the emission of coke gas with high concentrations of benzene, toluene, naphthalene, hydrogen sulfide, mercaptan, hydrocyanic acid, and ammonia. During the conflict, fires also occurred at the Donetsk State-

Changes in air quality near Luhansk Power Plant during 2014 hostilities



Owned Chemicals Plant, Donetsk TochMash [Precise Machine Building] Plant, Lysychansk Oil Refinery, Yasynivka Coke and Chemical Plants[34], Horlivka Styrol Plant[35], Dokuchaievska Inert Dust Factory, Luhansk TPP, the Trudovska Mine, and other environmentally hazardous facilities.

Examples of the indirect influence of armed conflict include changes in air quality in the immediate vicinity of the Luhansk TPP. Assessment of the data on air pollution obtained in 2014 from two automated monitoring stations located in the town of Shchastia in the Luhansk Region did not show a significant increase in the concentration of pollutants during active hostilities.

At the same time, the DTEK Holding Company reported the suspension of coal deliveries by railroad to the TPP following the destruction of a bridge at Nova Kindrashivka. The loss of the bridge and subsequent damage to power transmission lines effectively isolated the Luhansk TPP from the Ukrainian power grid. As a result, the power plant, which provides electricity to over 90% of customers located in the Luhansk region, was forced to independently regulate power grid frequency through the use of the available supply of high-sulfur and high-ash coal, resulting in a dramatic deterioration in air quality in the region (see figure).

Sources: Averin 2017, et al. Denisov et al. 2015a, 2016b; OSCE Project Co-ordinator in Ukraine Donbas Environmental Information System.

A significant number of environmental consequences stemming from similar incidents have been recorded (see box), with the causes of the most severe consequences being quickly removed or remedied where circumstances permitted[36]. To reduce further potential threats, hazardous substances were removed entirely from the premises of some of the region's industrial enterprises[37], and at a number of water treatment facilities active chlorine was replaced with less hazardous agents (see next section).

A Swiss-based mission for the UN Office for the Co-ordination of Humanitarian Affairs (UN OCHA) which studied the situation in a 20-kilometer zone along the contact line[38], concluded that while the number of environmentally hazardous industrial sources is certainly significant, yet the general history of the conflict testifies to the absence of a sustained, targeted assault on industrial facilities[39]. In addition, as outlined in the Minsk Agreements, the category of heavy weaponry capable of inflicting major damage to industrial infrastructure (e.g., tailings pond dams) is banned on the territory of the conflict, a condition which, while it did not lead to a complete removal of heavy weaponry, severely curtailed its use. These factors, combined with the high degree of readiness among emergency services at major enterprises and among field units of the State Emergency Service of Ukraine indicate, in the mission's opinion, that there is no acute risk of significant incidents occurring under the conditions that currently obtain in the region, which could significantly aggravate the already unfavorable environmental situation in the region. The mission estimated the overall risk level as "low" or "medium"[40].

Yet any violation of any of these conditions (e.g., intensification of hostilities, alterations to the character of the conflict, obstructing emergen-

cy services' access to facilities with significant stocks of hazardous substances) would certainly significantly increase the risk of unprecedented environmental hazard, and thus, the rapid expert assessment reflected in the study commissioned by the OSCE Project Co-ordinator concludes that under the most unfavorable scenarios the potential for accidents which bear serious environmental consequences remains precariously high (see box).

Nearly 75 enterprises and municipal water facilities have been identified which require special attention. Areas with the highest risk includethe Mariupol agglomeration, the agglomeration of Toretsk – Horlivka - Yanakiieve, Makiivka – Donetsk – Yasynyvate – Avdiivka. Other high risk zones include the agglomerations of Mariupol, Khartsyzk-Zures, Alchevsk-Irmino-Zolote and Luhansk-Shchastia.

Comparative analysis of hazards and risks affecting Donbas industrial facilities

A large part of Ukraine's heavy industry facilities are concentrated in the Donetsk and Luhansk regions, with the main areas of production in eastern Ukraine centered on coal mining, the coke-and-chemicals and chemical industries, metallurgy, and other environmentally hazardous branches of industry. In the aggregate, there were more than 5,500 industrial facilities in operation in the region in 2013. The most environmentally hazardous types of production include coke and chemical plants, metallurgical works, power plants, and chemical-related industries. Damaged processing equipment employed in these industries pose a potential threat to the environment and population centers near the facilities. Unscheduled, accidental releases of pollutants impact air, surface and ground water, and soil integrity. Tailing ponds located at mining and industrial facility premises also pose significant environmental risks from the contaminants that fill ash and sludge ponds, industrial waste sediment ponds, industrial waste storage locations (e.g., slag dumps), spoil tips, and raw material storages.

The risks of damage occurring to tailing pond dams along the entire contact line are significant. For example, the tailing pond of the Inkor and Ko Research and Production Association of the Phenol Plant Coke and Chemicals Enterprise, containing 400,000 cubic meters of waste, is located in the town of Novohorodske in the Donetsk Oblast near the contact line, a mere 400 meters from the military positions of the opposing sides. Failure of the tailing pond dam, which has already been partially damaged during shelling, may release significant chemical pollutants into the Kryvyi Torets and the Siverskyi Donets rivers, both sources of drinking water for the Donetsk and Luhansk regions[41]. A similar risk exists for the Bakhmutka and the Siverskyi Donets rivers in the event of damage to the tailing pond dam of OJSC Bakhmut Agrarian Union of the Donetsk Region[42].

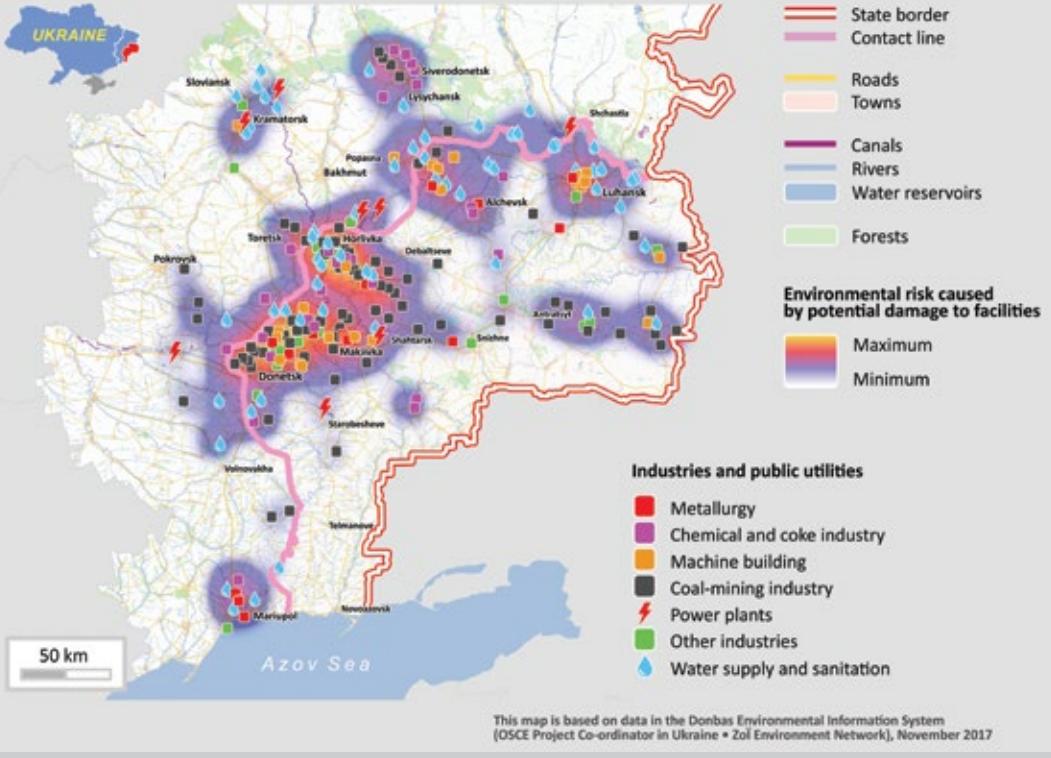
The tailing ponds of the Horlivka Chemicals Plant, Styrol, Azot, Lysychansk Soda, and other facilities of the mining, mining and processing, metallurgical, coke-and-chemical and chemical

branches of the industry also present potentially severe environmental hazard.

The workshops and related divisions of Azovstal Metallurgical Works located in Mariupol on the shore of the Sea of Azov, close to the contact line, pose a significant hazard for chemical pollution. Further environmental threats are found in the portion of the Sea of Azov which has been set aside to house a sludge pond, and a TPP ash collector and a cinder dump from an open-hearth and converter steelmaking plant are located immediately on the sea-shore. If damaged, these facilities would result in major chemical pollution of the Sea of Azov. Other potential sources of pollution for the Azov Sea include the Siverskyi Donets, Kalmius, Mius or Mokryi Yelanchyk rivers, all of which flow near the contact line and through territories beyond the military control of the Ukrainian government.

Taking into account the nature, location, and vulnerability of industries within the conflict area, likely routes of the accidental spread of contaminants and their potential environmental impact, the OSCE Project Co-ordinator in Ukraine has produced a rapid expert risk assessment identifying more than 70 industrial and 10 municipal facilities which meet designated criteria and are classified as highly hazardous sites requiring special attention.

Environmental risk assessment in the conflict area



Sources: D. Averin 2017; V. Yermakov, Center for Donbas Environmental and Resource Restoration, State Environmental Academy of Postgraduate Education, Ministry of Ecology and Natural Resources of Ukraine; Donbas Environmental Information System (OSCE Project Co-ordinator in Ukraine).

CONCLUSIONS

- Following the onset of armed conflict in eastern Ukraine, the number of enterprises reporting pollution emissions and discharge statistics to the State Statistics Service of Ukraine has fallen by 65%. By 2016, atmospheric emissions as reported by enterprises submitting statistical reports had fallen to 96% of 2014 levels. Statistical reporting for industrial emissions in territories beyond Ukrainian government control is virtually absent.

- According to data received from regular measurements conducted at operational environmental observation stations, air and surface water quality has, on average, remained stable since 2014. There were isolated reports of elevated levels of sulfates, chromium, zinc, and manganese (in excess of 10 MAC) in the Kalmius and Kalchyk Rivers. In this same period there were no reports received of accidental air pollution in excess of 5 MAC.

- From the onset of hostilities more than 500 incidents and operational disruptions at industrial facilities have been recorded, some of which resulted in environmentally hazardous situations. A significant number of industrial facilities persist in a state of high-risk potential as sources of accident-induced pollution.

- According to a UN OCHA Special Mission, the current risk of an industrial accident with significant environmental consequences occurring as a result of the armed conflict ranges between "low" and "medium". According to an expert evaluation developed within the framework of a study by the OSCE Project Co-ordinator in Ukraine, if unfavorable scenarios materialize, the potential risk of incidents with grave environmental consequences remains significant. More than seventy enterprises and ten public utilities require particular attention.

Operational disruptions and flooding of mines

The mining industry – primarily the coal mining industry – comprises the foundation of the region's economy. Prior to the start of the conflict in eastern Ukraine, more than 150 regional coal mines operated in water drainage mode (see box). The conflict in the Donetsk region has caused disruptions in the overall operation of the enterprises or of pump equipment at mines in the following locations: Komsomolets Donbasu, Lidiiivka, Vuhlehirska, Chervolyi Profintern, Bulavynska, Olkhovatska, Trudivska, Cheliuskintsiv, Kirovska, Pivnichna, Poltavska, Yasynivska-Hluboka, Kholodna Balka, Zhovtnevyi Rudnyk, Chaikino, Shcheglovska-Hluboka, Yuzivska, Yunkom, Butivska, Sviatoi Matrony Moskovskoi, as well as the Abakumov, Skochynskiy, Rumiantsev, Gaiiovoho, Karl Marks, Zasiadka, Lenin, Kalinin, and Bazhanova mines.

In the Luhansk region, operational disruptions were recorded for mines at the following locations: Sukhodolska-Shidna, Pryvolnianska, Nikanor-Nova, Kyivska, the Rovenkivske Mine Administration, Dovzhanska-Kapitalna, Tsentrospilka, Kharkivska, Chervonyi Partyzan, Samsonivska-Zakhidna, Pershotravneva, Proletarska, Bilorichenska, and also at the Frunze, Vakhrusheva, Cosmonautiv, Dzerzhinskogo, and Sverdlova mines.

During the ongoing conflict there have been multiple reports of infrastructure damage and power outages at coal mining facilities, leading to disruptions in mine water drainage, and in the complete submersion (flooding) of several mines. Currently, water drainage capacity is virtually non-existent on the entire territory lying between the towns of Horlivka and Yenakiieve, in the area of Pervomaisk, and partially absent in the towns of Donetsk, Makiivka, Shahtarsk, and Toretsk.

More than 35 regional mines are under imminent threat of flooding or have been flooded completely rendering them inoperative. Several damaged or closed mines in the Donbas have been dismantled.

The flooding of mines and their adjacent territories caused by power outages and damaged equipment at mining industry facilities is a prime factor in the potential pollution of ground and surface waters that may come in contact with mine waters contaminated with e.g., iron, chlorides, sulfites, and other mineral salts and heavy metals. An especially acute danger is posed by the flooding of mines that had been purposed as waste storage facilities – a present risk at the Oleksandr-Zakhid, Vuhlehirsk, and Kalinin mines located in the town of Horlivka in the Donetsk Region.

The situation at the Yunyi Komunar mine poses a singular threat: in 1979, an experiment on reducing rock tension to enhance the safety of coal bed processing[43] was conducted employing an underground nuclear explosion at the site. Any present destabilization of the mine via flooding could release up to 500 cubic meters of radiation-contaminated mine waters into the ground water table. Specialists state[44] that, given stable conditions and adherence to all technological specifications of site maintenance, the risk of radioactive contamination release outside the Yunyi Komunar – Klivazh system is virtually non-existent. However, violations of these specifications combined with the failure to implement further stabilizing measures make it impossible to rule out the mine's eventual fail-

ure and subsequent release of radioactive material into underground aquifers.

According to some estimates[45], during the period of conflict the total annual water drainage in the Donbas has shrunk from 800 million to 400-450 million cubic meters. If this trend should persist, within a few years mine waters will begin escaping into underground aquifers. The probable chemical consequences of the polluted mine water coming into contact with the fresh water table of the Donbas have not been studied on a quantitative level, however some specialists point to the long-term danger of deterioration in the quality of water employed in irrigated farming, potentially resulting in the partial salinization of agricultural lands, and moving beyond Ukraine to affect adjacent Russian territories[46]. Large-scale mine flooding will inevitably result in flooding of the surrounding territories and surface subsidence, rendering buildings, structures, and communication systems inoperative, and further affecting underground gas lines, sewage and waterline systems, as well as elements of the Siverskyi Donets – Donbas water supply system (see box).

Scale and possible impacts of mine flooding

According to estimates obtained by specialists operating within the research framework of the OSCE Project Co-ordinator in Ukraine, more than 35 mines on both sides of the confrontation line are currently in the process of being flooded[47].

Status of mines in eastern Ukraine

Coal mines	Controlled territory	Uncontrolled territory	Total
Operating mines	29	75	*104*
In water draining mode	1	16	17
In flooding stage	1	*35*	*36*
In liquidation stage	6	64	70
Total	**37**	**190**	**227**

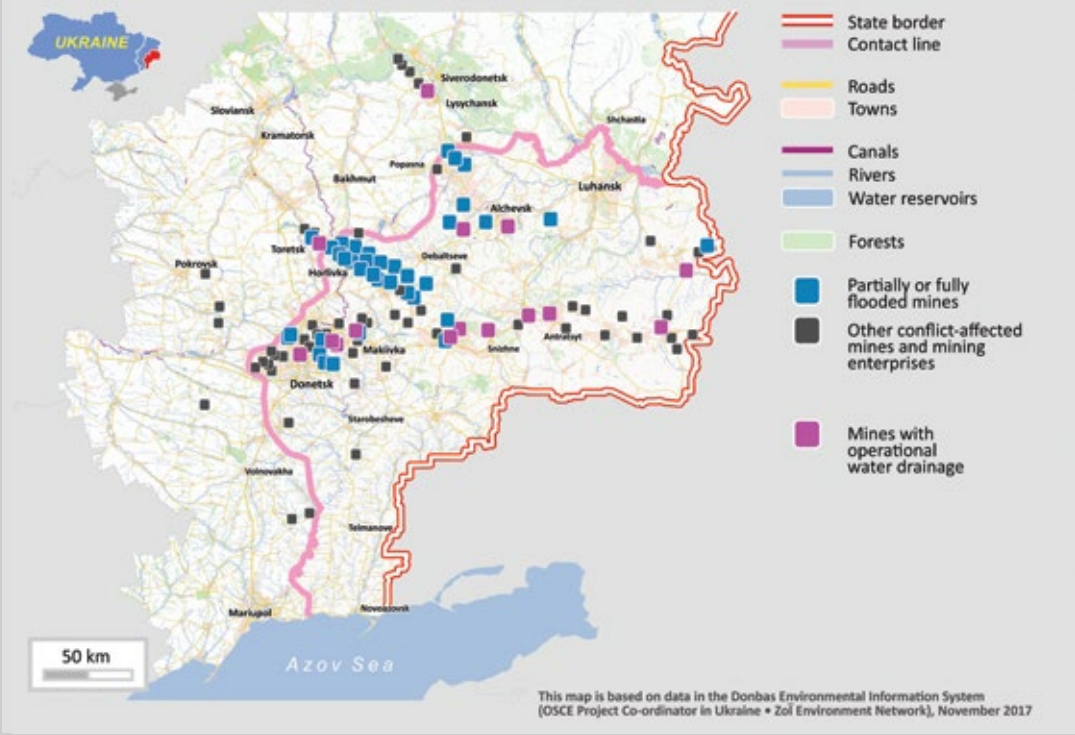
*The estimates were obtained through rapid expert assessment. Numbers in italic are approximate.

In the future, some mines which are currently in the liquidation stage will also be flooded[48], with the remainder shifted into water draining mode.

The hydraulic interplay of mines is complicated. For instance, today in the Luhansk region there exists a threat of hydrogeological hazard due to the uncontrolled release of mine water into mine openings at Pervomaisk and Holubovsk – inoperative mines located beyond Ukrainian controlled territory. These facilities have hydraulic connections with operational mines at the Pervomaiskvuhillia state enterprise, with mines at Zolote, Karbonit, and Hirska.

The Pervomaiska mine has been undergoing flooding since September 2015 when hostil-

Flooding of mines in eastern Ukraine



ities disrupted the power supply to the mine. The current rate of rise in water level in the mine's vertical shaft is 20 cubic centimeters per day. If overflow levels are reached, the total additional volume of water moving from the Pervomaiska and Holubovska mines toward the operational Zolote mine will be approximately 1,060 cubic meters per hour. In the aggregate, the water influx at the Zolote mine will equal approximately 1,500 cubic meter per hour.

Structured studies[49], and observations taken across decades illustrate that the flooding of the Donbas mines happened before, including during wartime (1941-1944). The practice often coincided with the release of colliery gases to the surface, deterioration in the quality of aquifer and surface water[50], flooding of buildings, structures and communications, and changes in the physical and mechanical properties of the underlying rock strata.

The Central Donbas water-bearing complex is peculiar for its stacking of rock and coal beds. The natural hydrogeological structure of the rock mass has been disturbed by both coal and mercury mine water drainage. Despite drainage effects present at mine openings, the ground water level of the near-surface zone is often located at depths of 0-10 meters beneath the surface.

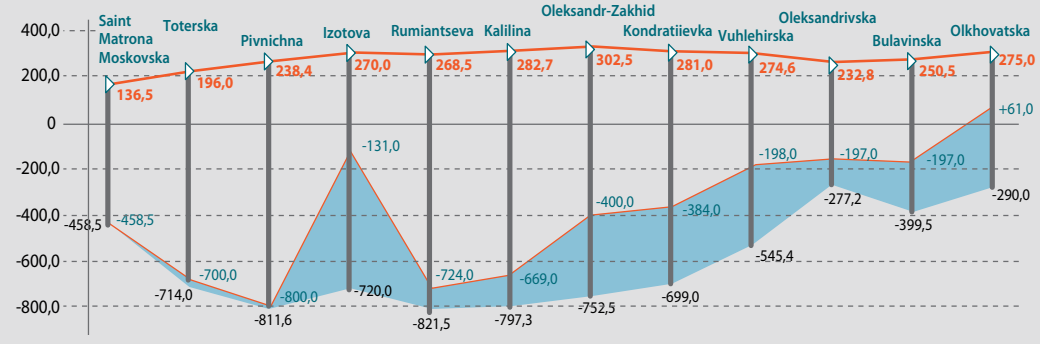
In residential communities, it is not uncommon to find large territories which are waterlogged

(with groundwater depth up to two meters), and potentially waterlogged (groundwater at depth between two and five meters). A 200-meter wide territory adjacent to the Siverskyi Donets – Donbas Canal is identified as waterlogged. Thus, waterlogged areas tend to occur in areas where the groundwater moves perpendicular to the strike line of the rock. River flood planes, ravine bottoms, and slopes are permanently waterlogged or potentially waterlogged.

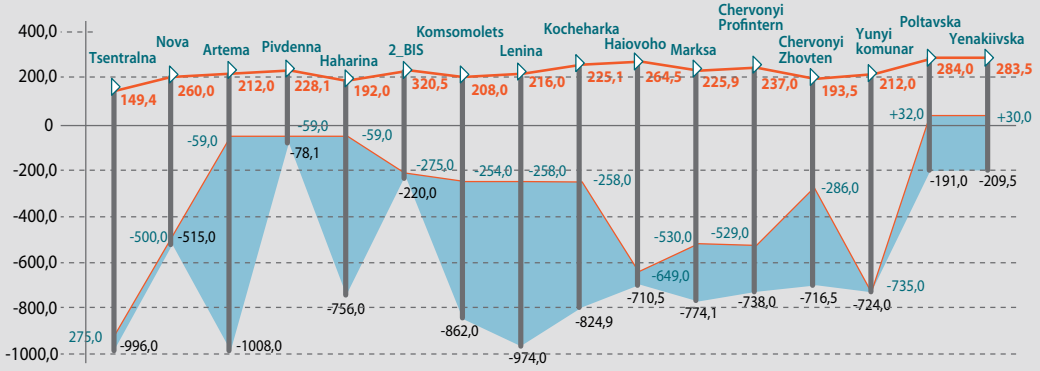
Any disruption to the pumping out of mine waters at the Pervomaisk and Holubovsk mines may result in the outflow of these mine waters to the surface and the subsequent waterlogging of residential communities that are home to 80,000 residents (the towns of Kirovsk, Pervomaisk, Zolote, Hirske, and Karbonit), agricultural lands, and natural sites (fields, meadows, forests).

Shaft and mine opening collars that rise to the surface can potentially collapse and adjacent territories subside, and colliery gases escape to the surface in an uncontrolled and uncontrollable flow. Furthermore, processes of rock shifting and

Level of coal mines flooding in the northern section of central Donbas*



Level of coal mines in the southern section of central Donbas*



157,1 Land surface above sea level, meters
-228,0 Mine water above sea level, meters
-401,0 Mine bottom above sea level, meters
Mine water layer

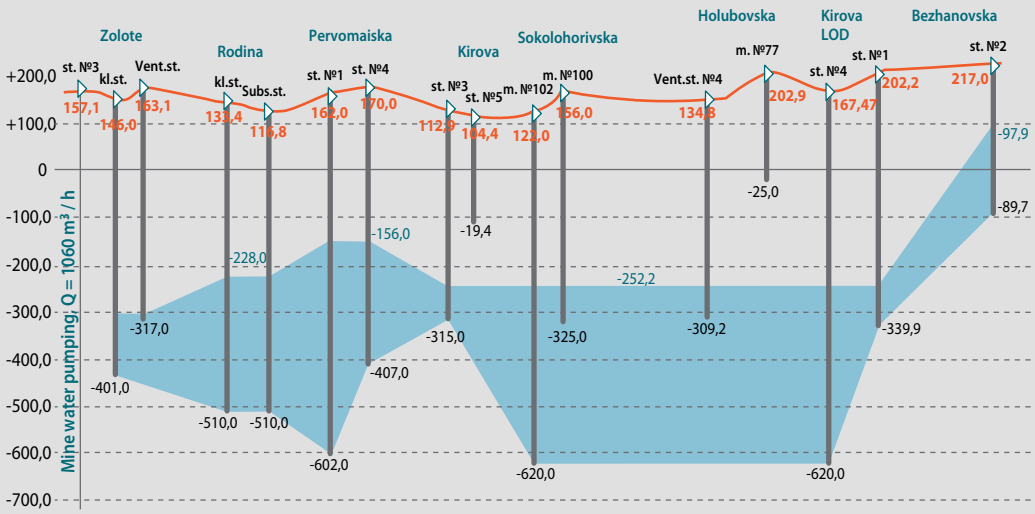
Approximate data
Mine shaft
Koper

deformation (due to soaking) may be intensified resulting in additional damage to buildings and structures. In the case of a complete flooding of the mines in the territory, nearly 6,000 hectares of highly mineralized contaminated mine water would be discharged into freshwater pools and tributaries, jeopardizing individual wells and large water intakes that provide drinking water to the Pervomaisk-Stakhanov area.

Based on the particular hydrogeological situation that obtains in these mining areas, and the established empirical material on hydrofiltration processes, a study evaluating natural and man-made factors and commissioned by the OSCE Project Co-ordinator in Ukraine presents here its expert summary of findings on the environmental vulnerability of the underground aquifers of the Stakhanov – Pervomaisk mining and residential agglomeration.

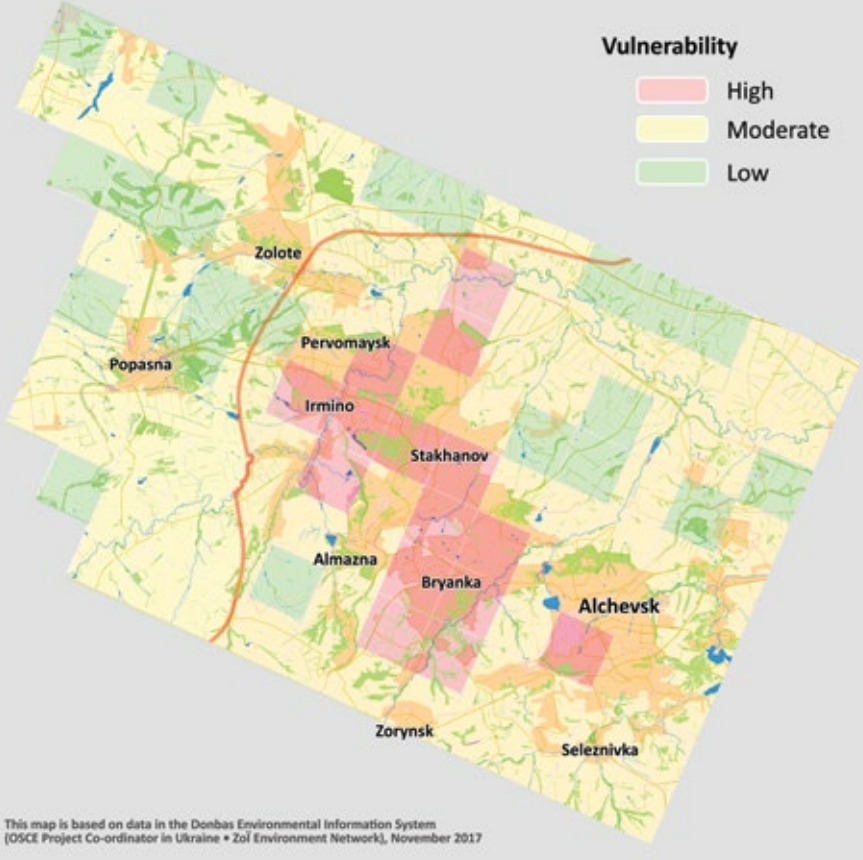
* As of 1 November 2017.

Flooding levels of the Pervomaisk group of coal mines in the Luhansk Oblast*



157,1 Land surface above sea level, meters
-228,0 Mine water above sea level, meters
-401,0 Mine bottom above sea level, meters
Mine water layer
Approximate data
Mine shaft
Koper

Vulnerability evaluation of the underground aquifers of the Stakhanov – Pervomaisk mining and residential agglomeration



The flooding of a large number of formerly operational coal mines has the potential to spread polluting processes to territories beyond the immediate vicinity of the mines in question[51]. To establish, however, a comprehensive risk evaluation of the situation requires additional study, employing in-depth monitoring and assessment of the hydrogeological situation in order to accurately project potential threats. Any actions taken to prevent adverse outcomes require coordination between parties on both sides of the contact line.

Sources: O. Ulytskyi, V. Yermakov Research Institute for Environmental Safety and Management, State Environmental Academy of Postgraduate Education, Ministry of Ecology and Natural Resources of Ukraine[52], amended.

Colliery gases – primarily methane and radioactive radon – pose an additional hazard. These rise to the surface with the flooding of mine facilities, potentially accumulating in the basements of buildings and mine spoil tips and heightening the risk of explosion, a risk that is only exacerbated during periods of armed conflict[53]. Radon gas presents a further hazard at ground water intakes[54].

CONCLUSIONS

- As a result of repeated power outages and suspended operations at a number of coal mining facilities in the Donbas during the armed conflict, recently updated information currently identifies more than 35 mines in the region which have been flooded entirely or are in the process of being flooded. An additional 70 mines are undergoing the process of liquidation, several of which will also eventually be flooded.

- CHD estimates that during the period of conflict, annual water drainage from the mines of the Donbas has decreased from 800 million to 450 million cubic meters. Given the scale and nature of the current process of mine flooding occurring in eastern Ukraine, in time, polluted mine water can be expected to affect the quality of the ground aquifers on both sides of the contact line, potentially expanding across the Russian border. The establishment of the specific scale and expansion routes of this phenomenon will require additional investigation.

- If current scope of water drainage is disrupted, hazards will be posed by non-operative mines employed as storage for hazardous and radioactive waste, including facilities at Oleksandr-Zakhid, Vyhlehirsk, Kalinin, and Yunyi Komunar.

- Mine flooding can be expected to affect the ground water levels and the geological stability of the land, resulting in land subsidence and rendering non-operational city, village, and industrial facilities and elements of municipal infrastructure (including the regional water supply system). No reliable quantitative predictions of this impact have yet become available.

Water supply, water disposal, and waste removal challenges

With the onset of armed conflict there have been systematic disruptions to the power supply, water supply, water drainage, and waste removal systems in the affected regions. Reports of damaged municipal sewage and water supply networks have emerged from the majority of communities located along the contact line, resulting in "optimal conditions" for accidental polluting of the water supply.

In 2016, a discharge of effluents into the environment was the result of the overfilling of the Bakhmut Agrarian Union sediment ponds – an incident directly attributable to the prevention of the performance of schedule maintenance at the ponds. Also in 2016, damage to the treatment facility in the town of Dokuchaievsk in the Donetsk region impeded disinfection of the town's effluents, leading to environmental pollution. Fires were reported at water supply chlorine storage facilities at the Donetsk Filtering Station, Verkhniokalmiuska Filtering Station, and others.

According to available data, in 2014-2017, operational disruptions were reported at several major regional water supply facilities, including the Siverskyi Donets–Donbas Canal; the Donetsk, Verkhniokalmiuska, Mariupolska, Yenakiievska, Horlivska, Slovianska, and Zakhidna Filtering Stations; the Pivdenno-Donbaskyi, Dryhyi Donetskyi, Aidarskyi, Molodohvardiyskyi, and the Kondrashivskyi Water Lines, and other facilities.

Challenges to the reliable and secure operation of the regional water supply system were studied and included in the informational support provided both to the Minsk Negotiation Process Trilateral Contact Group[55] in 2015-2016, and again in response to a request from UNICEF in 2017[56].

The Trilateral Contact Group study makes specific mention of: the high level of vulnerability of the community water supply in the context of armed conflict (the study also included the population centers of Mariupol, Krasnoarmiisk, and Volnovakha); and the heightened emergency hazard (e.g., flooding of Kramatorsk) in the event of an emergency shutdown at pumping stations near the contact line[57]. To reduce the potential risk of an incident occurring, chlorine (liquefied gas) in the water treatment and water preparation systems has been replaced in part with the less hazardous option of calcium hypochlorite and on-site electrolytic hypochlorite production cells[58].

Shared, interconnected elements of the regional water supply that span the contact line allowed the supply to remain generally operational during hostilities[59], a result that was possible due to significant participation from humanitarian organizations, including international organizations[60].

Yet another challenge is that posed to the emergency response capability, which is often impeded by an inability to coordinate a ceasefire, a condition necessary to ensure timely access by repair crews to impacted areas and facilities. The State-run MTOT Programme[61] envisages urgent measures covering capital repairs, reconstruction, and restoration of water supply and sewage, pump stations, and treatment facilities, as well as research examining the potential for diversification of water supply sources and poten-

tial system modernization. The Donetsk Regional Administration has announced its own plans to reconstruct and build new treatment facilities in fourteen communities in the Siverskyi Donets basin over the next three years[62]. In the long-term perspective, a full-scale modernization of the outdated and chronically underfunded regional water supply system is recommended[63].

The general deterioration of the housing-and-utility services and environmental efforts in the conflict area (see below) have also impacted the waste management system, primarily in communities along the contact line. Damage to and a deficit of reliable utility company vehicles, the hazard of traveling through the conflict area, and a general shortage of funding have given rise to periodic difficulties with household waste collection and removal to landfills, a problem that was particularly acute during the early stages of the conflict. Fire-fighting at household waste landfills near the contact line have proven to be a challenge[64]. The overall situation is further complicated by the large number of buildings and structures that have been destroyed during hostilities, and the inability to adequately remove the wreckage. The challenges here lie in the need to demine destroyed objects and clear the territory of unexploded munitions, and to identify additional areas suitable to this type of waste disposal.

The State MTOT Programme[65] envisages urgent measures to construct new landfills for solid household waste in Kramatorsk and the Popasna District of the Luhansk Oblast, as well as the reconstruction of the solid household waste landfill located in the town of Kreminna in the Luhansk Oblast.

The Luhansk Oblast Environmental Protection Programme for 2016-2018 includes measures to design and complete the construction of a solid household waste landfill in the village of Osynove in the Novopskovsk District[66]. The Donetsk Regional Administration announced that a pre-conflict programme to construct inter-district (regional) landfills in Kramatorsk, Pokrovsk, Kurakhovo, and Mariupol would also resume. It further announced plans to construct transfer stations with sorting elements in the towns of Toretsk, Bakhmut, Sloviansk, Konstantynivka, and Lyman using regional budgetary funds for the project.

The Oblast also plans to upgrade equipment for rural areas, including arranging for separate waste collection, resolving the issue of adequate disposal of spent light bulbs and medical and biological waste, and attracting investment for deep waste processing[67].

CONCLUSIONS

- During the conflict, multiple disruptions have been reported in the operation of both regional water supply and water disposal systems and facilities, and incidents of the accidental discharge of pollutants into bodies of water.

- On the whole, with support from the international community (specifically, under the coordination mechanism of humanitarian response (WASH Cluster), the regional water supply system can be sustained in operational mode. Yet, online maintenance and necessary major future system upgrades are problematic due to ongoing hostilities.

- The conflict has challenged solid household waste management services, especially in communities along the contact line. The lack of adequate disposal services of traditional household wastes is exacerbated by the uncollected wreckage of military equipment, buildings, structures, and infrastructural elements, whose disposal requires additional capacity, and is logistically impossible without a prior demining of the territory and clearing of unexploded munitions.

- High-priority measures to expand solid household waste disposal capacities are outlined in the State MTOT Programme and are to be reflected in regional budgets. It will be necessary in the future to upgrade the regional waste management system, drawing on pre-conflict domestic as well as foreign experience.

Impact on land resources, ecosystems, flora and fauna

The movement of heavy military equipment in combat maneuvers or military exercises, construction of fortifications, explosions, and combustion of munitions all contribute to the disturbance of topsoil, reducing its fertility and disrupting the natural landscape. According to estimates prepared by Environment-People-Law[68], an explosion of 15,500 shells in a 225-square-kilometer territory near Savur-Mohyla in the Shakhtar district of the Donetsk region dislodged, at minimum, 91,400 cubic meters of soil. The profitable stewardship of land damaged during hostilities is challenged by the need to re-cultivate polluted and damaged soil. These territories also require demining and disposal of undetonated munitions.

The conflict in eastern Ukraine has deprived large areas of forest and wind break strips. According to ForestWatch, in 2014 alone, 479 hectares of the region's forests were completely destroyed[69].

The biggest risk to forests in the region is that posed by forest fires sparked by the explosion of munitions or arson related to conflict tactics (see box). Fires caused by the hostilities wrought the worst damage on the forests along the contact line. Significant tracts of forest suffered damage from the movement of military machinery and the explosions of munitions. Shell splinters damage the bark, branches, tops of trees, and soil, weakening forests or killing them outright. Mechanical damage to root systems leads to the deaths of individual trees and the loss of entire forests[70].

Significant damage to forests is also caused by illegal tree felling to obtain wood for the construction of temporary fortifications and for use as firewood. These practices will serve to critically decrease forestation in the Donetsk and Luhansk regions and hamper the field-protective, soil-protective, water-protective, and recreational functions of the forests.

In territory beyond Ukrainian government control and along the contact line, the operation of forestry facilities and emergency services is often challenging or impossible. On both sides of the 15-kilometer zone along the contact line forest fire protection services were suspended shortly following the onset of hostilities. The armed conflicted resulted in numerous deaths and injuries to fire observers working in watchtowers, and firefighters injured or killed traveling to emergency sites and fighting fires in areas and facilities littered with exploding munitions. Paramilitary groups often refused entry to fire engines traveling to sites of fires, even "requisitioning" some fire engines owned by the forest service. Among the regions of Ukraine most vulnerable to fire, the suspension of forest protection services in eastern Ukraine during the initial stages of the conflict resulted in a significant increase in the number, spread, and intensity of natural fires[71].

Additionally, forestry measures along the entire contact line are logistically impossible without a complete cessation of hostilities and demining of the region's forest lands, and their interruption has further resulted in a significant decrease in reforestation efforts in the area, falling from 5,634 reforested hectares in 2013 to 857 hectares in 2015 and 1,665 hectares in 2016 (the largest volumes of reforestation are recorded in the Luhansk region)[72].

The State MTOT Programme[73] envisages measures to restore forests through replanting efforts and by facilitating processes of natural reforestation, including reforestation in the areas destroyed by shelling (burnt areas); forestation of eroded land in the Luhansk region; cultivating planting material for reforestation and forestation; surface pest extermination in stands of pine woods; maintaining fire-guard and fire-chemical stations; extinguishing active forest fires; and forest fire safety arrangements.

Remote analysis of the data on vegetation fires in Eastern Ukraine

Vegetation fires are common in Ukraine. National forest services record between 4,000-6,000 forest fires annually, affecting up to 6,000-7,000 hectares, with the occurrence of grass fires being tens and hundreds of times higher. According to satellite imagery, 2010 saw 300,000 grass fires, mainly due to the intentional burning of agricultural crop residue left in fields. Many of these fires triggered forest fires.

Southern and south-eastern regions of Ukraine comprise those areas most vulnerable to fire in Ukraine. The number of reported fires is traditionally higher than in the country's central and northern regions. Out of the two conflict-affected regions, the Luhansk region is characterized by larger areas of pine forests located on the Siverskyi Donets pine-forest terraces, a location of frequent forest fires. The Donetsk region is dominated by ravine deciduous oak forests, where fires seldom occur.

One aspect of the conflict's affect on the regional environment is a heightened risk of fire danger and an increase in forest fires when compared to statistical norms. Reasons contributing to these increases in both incidence and loss of vegetation in the conflict area include:

- hostilities related to the transport and use of munitions;
- large-scale displacement of the civilian population fleeing areas of hostilities;
- large-scale movement of troops and their stationing, and subsequent failure to observe fire safety requirements in natural terrains;
- disruption of forest fire protection services.

According to representatives of the Donetsk and Luhansk Regional Forestry and Hunting Administrations, fire statistics are currently maintained only in safe remote areas; thus, the only method for estimating the number of fires in the military conflict area is through the analysis of satellite imagery. The number of fires is well registered by a special spectral radiometer, MODIS, which filters out most cases of vegetation fires from

other possible sources of infrared emission (industrial pipes and smokestacks, burning landfills, burning houses, shell salvos and munitions explosions).

It should also, however, be noted that a large number of low- and medium-intensity ground forest fires are not reflected in the satellite data because tree crowns block the signal. Therefore, the number of registered ground forest fires is consistently lower than actual numbers of occurrences (precise estimations of ground forest fires are possible only during on-site inspections).

On the whole, in 2014 MODIS registered 12,518 vegetation fires in the Donetsk and Luhansk regions, including 405 forest and 12,113 grass fires. Out of these, 4,867 were located in the hostilities zone.

Analysis of fire frequency demonstrates that the highest incidence of fires in 2014 was observed in the Donetsk region (0.30 fires per square kilometer), and in the conflict area (0.303; in areas experiencing the most intense

Average fire density per administrative region of Ukraine and Russia within and outside of the conflict area during 2014 vegetation period

This map is based on data in the Donbas Environmental Information System (OSCE Project Co-ordinator in Ukraine • Zoï Environment Network), November 2017

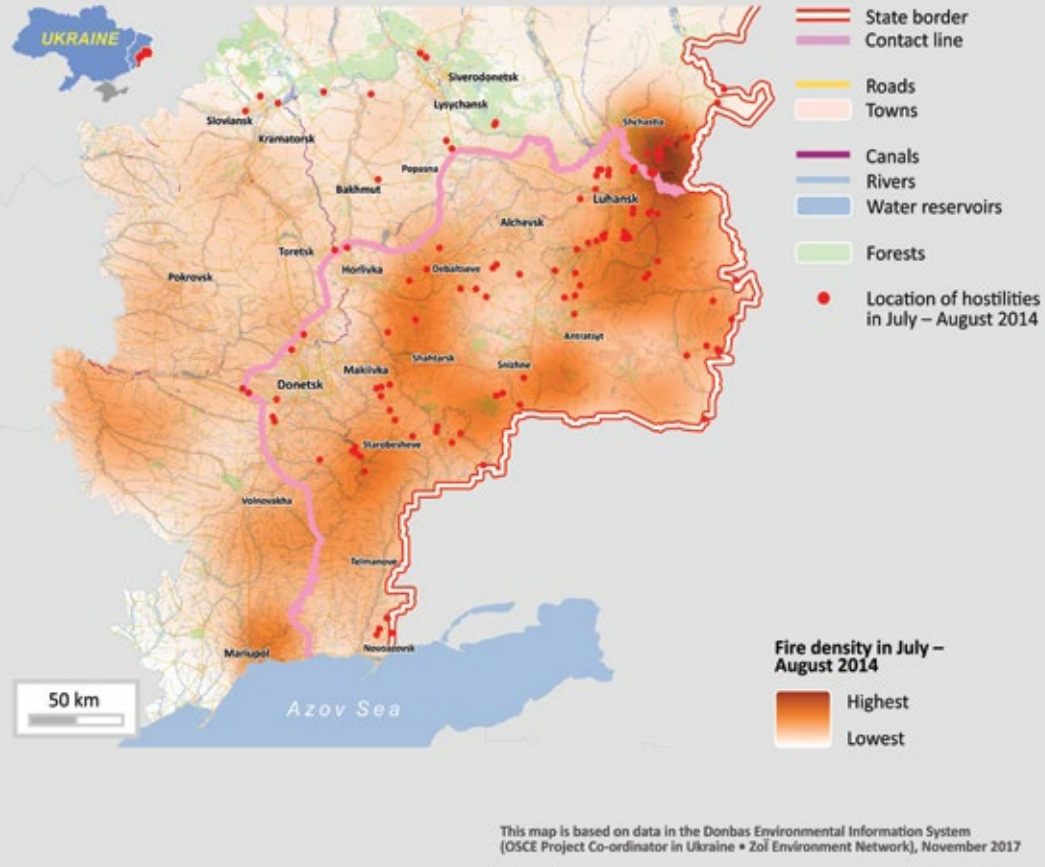
hostilities, the number of fires per square kilometer reached 93).

On average, vegetation fire density in 2014 in the conflict region exceeded that in neighboring regions of Ukraine and Russia located in the same natural zone and characterized by similar meteorological and social-economic conditions by a factor of 1.5-2[74]. Factoring in the potential for unrecorded ground fires, this difference is even greater, demonstrating unambiguously that armed hostilities significantly increased the number of fires and resulted in direct environmental damage.

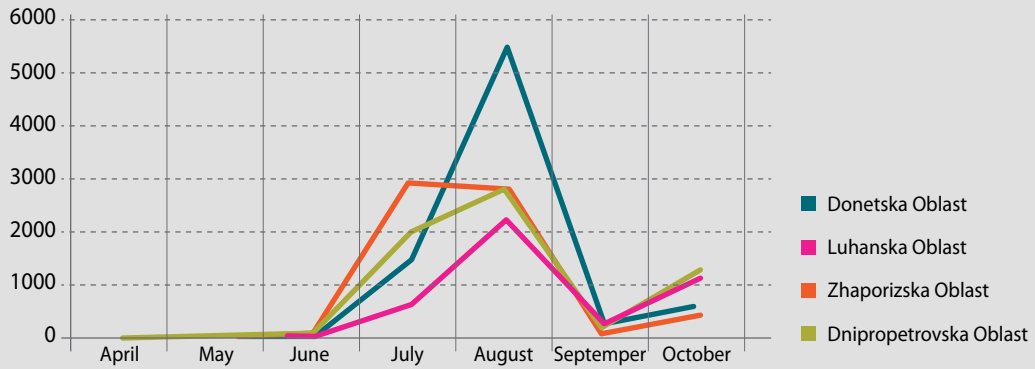
The greatest number of vegetation fires in the conflict area occurred in August 2014 (fires recorded to the South and East of the Mariupol – Donetsk – Horlivka – Shchastia line, where most armed clashes took place[75]). In neighboring regions, fire incidence peaked in July-August.

Additionally, the number of grass fires in the Donetsk region was twice as high as in neighboring regions. In the Luhansk, Zaporizhia, and Dnipropetrovsk regions, the incidence of grass

Fire density according to MODIS satellite data, July – August 2014



Seasonal variations in fire intensity in regions of eastern Ukraine, 2014



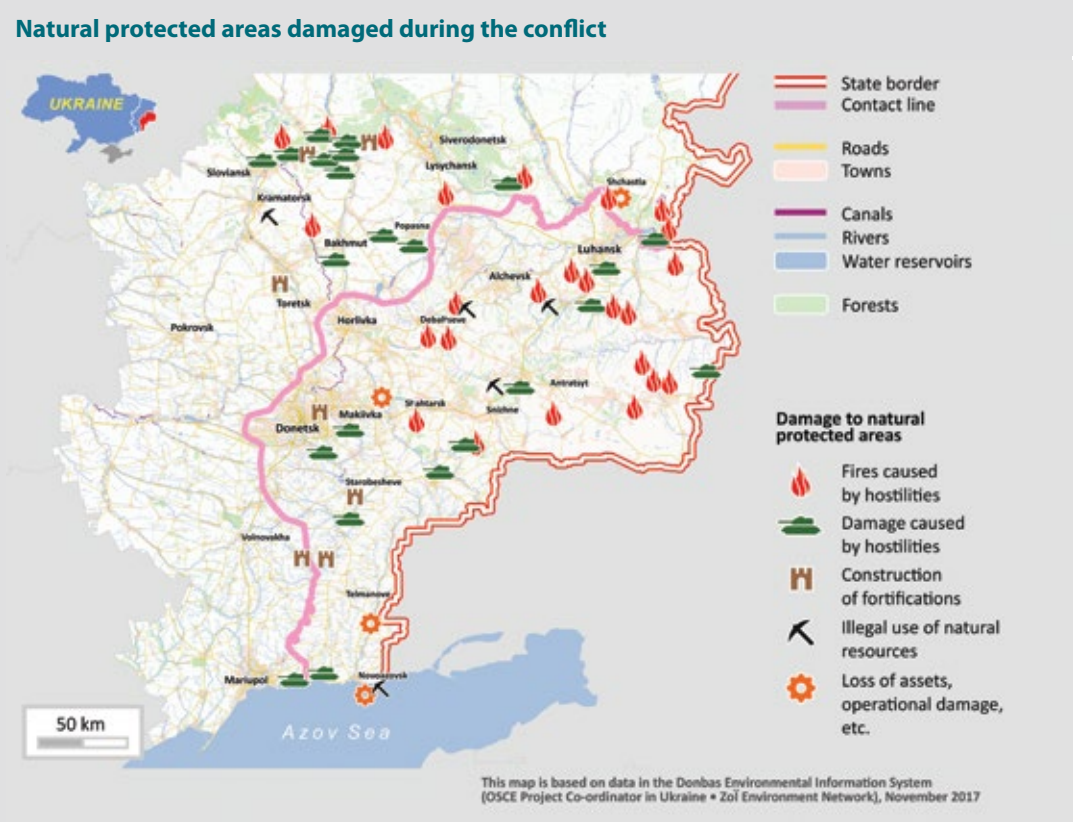
fires was comparable, which may be attributed to a less intense engagement in hostilities in the Luhansk region when compared to Donetsk.

According to expert assessments of the situation[76], areas of pine forest affected by fire may reach as high as 20,000 hectares, or roughly 22% of all the region's pine forests. Significant damage was reported in some areas of the floodplain oak forests. In 10-15% of those areas, up to 30-50% of trees have been decrowned and trunks have experienced splintering. In the EPL assessment, more than 80% of fires in the conflict region in June-September 2014 occurred in the steppe, forests, and agricultural lands[77]. In the Ministry of Ecology and Natural Resources of Ukraine estimates, fires affected 17% of the forests and 24% of the steppes in the conflict area[78]. However, reliable estimates of the areas covered by fires require additional data (including high-resolution satellite images) and more thorough studies, which have yet to be undertaken.

Source: S. Zibtsev, V. Bogomolov, Eastern European Fire Monitoring Center, National University of Life and Environmental Sciences of Ukraine[79]; amended.

There are 135 natural reserves in the conflict area, accounting for one third of the entire nature reserves of eastern Ukraine. One hundred twenty-four species of plants are included in the Red Book of Endangered Species of Ukraine, with 36 species in the European Red List[80].

The hostilities in the Donetsk and Luhansk regions polluted the lands and disturbed the terrain of the natural protected areas. Multiple nature reserves have suffered from the construction of fortifications, forest cutting, and forest and steppe fires. On the whole, the conflict in eastern Ukraine has affected about 60 nature reserve sites[81]. The operation of natural protected areas is further disrupted by the absence of personnel, suspended funding, and the lack of security on the territories of the Luhansk nature reserves at the Khomutov Steppe, Kalmius Reserve, Triokhizbenka Steppe, and the Donets Flood Plain [i.e., the Prydontsovska Zaplava Reserve][82]. Administrative documentation and equipment were lost at the Donets Range [Donetskiy Kryazh], Zuivskyi, and Kleban-Byk regional landscape parks[83].



Sources: D. Averin 2017; EPL; Donbas Environmental Information System (OSCE Project Co-ordinator in Ukraine).

The funding and operation of the Meotida Nature Park Protection Service in the Donetsk Region was suspended during 2015, although it has now been partially restored[84].

According to the Ukrainian Helsinki Human Rights Union, deterioration in protection efficiency of nature complexes on territories controlled by the Government of Ukraine is also due to insufficient interaction between environmental institutions (Environmental Departments, Environmental Inspectorates, Nature Reserve Territories Directorates) and the Armed Forces of Ukraine[85].

The effects of hostilities and the destruction of nature reserves and other ecosystems leads to unpredictable changes in biological diversity. Ungulate animals and birds have left the area along the contact line[86]. Devastation of animal and bird habitats, as well as mass poaching, result in reductions to their populations, including the populations of rare species (e.g., the curly pelican, which used Meotida as a nesting habitat, and the largest colony of black-headed tarrocks in Europe which has disappeared from the National Park)[87]. Conversely, new species of the region's wildlife, including mammals (jackal), fish (common sunfish), insects (Asian Lady Beetle), and other species, have begun flourishing. Due to the inability to harvest crops along the contact line, the population of rodents is on the

rise. A high density of foxes has been recorded in Shakhtarsk and Amvrosiivka Districts and near Mariupol; wolf attacks on domestic animals have been reported in the conflict area; and the number of stray dogs has increased substantially. Furthermore, the region has witnessed a growth in the number of non-indigenous species of plants, e.g., sandbur grass (Cenchrus tribuloides), ragweed, Heracleum sosnowskyi, and others[88].

Given that ongoing requirements for the stewardship of the nature reserves and biological monitoring on the whole have been only partially fulfilled, information on today's condition of flora, fauna, and natural communities in eastern Ukraine, reliable quantitative data in particular, remains fragmentary at best.

CONCLUSIONS

- Combat maneuvers or military exercises, the construction of fortifications, explosions and combustion of munitions disturb the topsoil. Utilization of the lands damaged by the hostilities will be challenged by a need for their re-cultivation, demining, and disposal of undetonated munitions.
- Due to forest fires, mechanical damage, and illegal forest cutting related to the ongoing conflict in eastern Ukraine, large areas of forests and wind-break strips have been lost. This will critically decrease forestation in the Donetsk and Luhansk regions and reduce field protective, soil-protective, water-protective, and recreational functions of the forests. Due to hostilities, in 2014, the region's average density of forest and grass fires was 1.5-2 times higher than that recorded in neighboring regions of Russia and Ukraine. Current exact estimates of vegetation fire areas in the conflict area are unavailable.
- The conflict in eastern Ukraine has affected about 60 natural reserves in the Donetsk and Luhansk regions. Currently, their protection and rehabilitation are challenged by an absence of personnel, the suspension of funding and area protection, and insufficient interaction between environmental institutions and the Armed Forces of Ukraine.
- The region has been experiencing changes in biological diversity, including the disappearance of some species, as well as uncontrolled dispersion and growth in population of other species, including those that threaten the sanitary and epidemiological conditions of the territory and its agriculture.
- Given that the needs of the nature reserves and biological monitoring on the whole are only partially met, information on the current condition of flora, fauna, and natural communities in eastern Ukraine, reliable quantitative data in particular, remains only fragmentary.

Decreased environmental protection activities in the conflict area

The outbreak of hostilities paralyzed much of the environmental activity ordinarily taking place in eastern Ukraine. Environmental protection agencies and organizations were forced to move or surrender large areas of their premises, equipment, vehicles, and other resources[89].

In a number of cases, paper and electronic archives were lost, including multiannual environmental observation data. State, agency, and industrial monitoring network stations discontinued operations, including all activity at pre-conflict automated stations measuring air quality[90].

Significantly, the services of a substantial number of qualified personnel were lost, as workers either chose to remain with their organizations but at alternative locations, or moved away from the conflict area. Ukrainian Parliamentary Legislation #44 from 2014 "On Temporary Measures during the Anti-Terrorist Operation Period" suspended scheduled and ad-hoc audits of industrial facilities in the region (with the exception of high-risk companies)[91]. Due to the conflict, centralized funding of a number of environmental protection enterprises was discontinued, including the administration of protected areas (see above).

In the 2015 analysis and Reconstruction Programme[92], the World Bank, the European Commission, and the United Nations noted that investment in high-priority environmental rehabilitation measures in the Donbas, estimated at 30 million USD (with an additional 40 million USD estimated in order to restore water supply and sanitation), would only be possible after the full-scale restoration of the environmental protection system in eastern Ukraine.

The impact from the initial disabling of the environmental protection system in the conflict area continues to be felt today. Some lost archival information has yet to be restored, portions of the territory are not covered by environmental monitoring, and operations conducted under conditions of non-transparency prevent access to reliable information on the nature of the damage to facilities. Atmospheric air control stations belonging to the Donetsk Regional Hydrometeorological Center in Donetsk, Makiivka, Horlivka, Yenakiieve, and Toretsk are currently non-operational, as are stations of the Luhansk Hydrometeorological Center in Luhansk and Alchevsk. 11 of 25 observation stations in the Donetsk region are currently in operation, and 4 of 11 in the Luhansk region. In addition, surface water quality monitoring stations of the Donetsk and Luhansk Regional Hydrometeorological Centers and Siverskyi Donets Basin Administration of Water Resources located along the contact line and in territories not controlled by the Ukrainian government are non-operational. Out of 39 Siverskyi Donets Basin Administration of Water Resources stations in the Donetsk region, 20 are operational, while 6 of 24 in the Luhansk Region remain operational.

In the Donetsk and Luhansk regions, the operation of the State Environmental Inspectorates remains problematic due to extant financial and logistical issues. In the past two years, the inspectorates were not provided with sufficient fuel, oils, and lubricants, and have undergone staff reductions with subsequent diminishment of agency activities. According to the Ukrainian Helsinki Human Rights Union[93], by 2017, the average number of monthly protocols on en-

vironmental violations was 35, compared to an earlier average of 80. The majority of recently generated protocols relate to violations of forest fire safety regulations, fishing regulations, and waste management regulations.

According to the Ukrainian Helsinki Human Rights Union[94], environmental agencies have pursued insufficient interaction with Armed Forces and National Guard administration. As evidence, the Foundation reports a complete absence of any official disciplinary, administrative, or criminal actions for non-compliance with environmental protection measures in the conflict area being forwarded by divisions subordinate to the Ministry of Defense during the entire period of armed conflict. The National Guard of Ukraine Central Administration reported to the organization that national guard servicemen were not prosecuted for non-compliance with environmental protection measures in the conflict area in the Donetsk and Luhansk regions during 2014-2016.

Funding for environmental protection activities was slashed at the beginning of the conflict and is now beginning to recover slowly. Not accounting for inflation, in 2016, capital and operational expenditures for environmental protection in the government-controlled territories accounted for 78% of the average environmental protection expenditures in the entire territory of the Donetsk and Luhansk regions during the period from 2009 to 2013 (including 96% in government-controlled territory of the Donetsk region and 45% of the Luhansk region)[95]. Untimely and incomplete funding for nature reserves' operations jeopardizes the very existence of conservation areas, which were particularly affected by the conflict.

In a positive outcome, exclusive of inflation, environmental protection expenditures in government-controlled territories were increased by 150% overall in 2016 compared to 2014 (178% in the Donetsk region and 86% in the Luhansk Region)[96]. The Special Environmental Fund of the Donetsk Region held reserves of 650 million UAH at the end of 2016 compared to 235 million at the beginning of the year, a result that has prompted a restart of a gradual restoration of the observation system. Six automatic air quality control stations have been procured in the Donetsk Region — in Mariupol, Kurakhovo, Mykolaivka, Kramatorsk, and Bakhmut. Drones are scheduled to be procured for monitoring forests and spotting illegal forest cutting[97]. At present, the environmental priorities of the Donetsk Region (also see previous sections) include construction and reconstruction of the water treatment facilities, improvement of waste management, protection of the forests and nature reserves, environmental awareness-raising campaigns, and, in future, renewable power generation[98]. The State MTOT Programme[99] envisages a broad range of actions to analyze and monitor the environment in the conflict area, respond to the direct environmental impact resulting from the conflict, manage waste, restore forests and natural protected sites, and step up protection of the Siverskyi Donets River basin.

Yet, these recent, positive developments must be considered in the broader context of a lack of a full-fledged, systemic, and long-term approach to environmental protection – an outcome possible only following a comprehensive analysis of the environmental situation and the

environmental protection needs of the entirety of government-controlled territory subjected to conflict (as provided for, specifically, in international and national recovery programs[100]).

In the future it will be necessary to ensure coordination of regional priorities and guarantee essential and practical approaches to address the environmental problems of eastern Ukraine. The monitoring and protection of water and air resources, waste management, development of the natural protected area network, and other strategic issues of environmental protection and sustainable development must be reflected in a cogent, and coordinated, national policy.

CONCLUSIONS

- The onset of armed conflict virtually paralyzed many aspects of environmental protection in eastern Ukraine. The impact of the initial disabling of the environmental protection system in the conflict area is felt even today. Some lost archival information has not been restored, part of the territory is not covered by environmental monitoring, there is a shortage of specialists, and financial and logistical support issues persist. Adequate interaction between environmental protection officials and the military is reported to be lacking. Funding of environmental protection activities is being restored slowly. Audits of economic entities in the conflict area are banned.
- At the same time, growing environmental expenditures in government-controlled territories has allowed for the gradual restoration of the environmental protection system. Specific actions on restoration of the monitoring, water supply, and sanitation systems, waste management, forest protection, and development of the network of natural protected areas have been included in the plans and implemented by the regional administrations and under the State MTOT Programme.
- Despite recent positive changes, there is no systemic, long-term approach, which requires a comprehensive analysis of the environmental situation and environmental protection needs in the conflict area, as well as their coordination with the strategic areas of national and international policy in the sphere of environmental protection and sustainable development.

Environmental consequences outside the conflict area

The armed conflict in eastern Ukraine affects not only the region, but also the entire country, its surroundings, and the global community.

Uncontrolled grass and forest fires in the conflict area release substantial amounts of carbon into the atmosphere from a combination of vegetation, steppe mat, and forest floor fires.

According to preliminary estimates, the conflict may have caused an equivalent of between 400 and 600 thousand tonnes of carbon in the CO_2 equivalent[101] to be released into the atmosphere. Over the same time period, by 2016, carbon dioxide emissions from stationary sources in government-controlled territories had decreased by 10 million tonnes compared to 2014 levels, and by over 30 million tonnes compared to the entire territory of the Donetsk and Luhansk regions in 2013[102]. The atmospheric air and the ozone layer are also affected by jet aviation and multiple rocket launch systems employed during the conflict.

It has been noted that the damage inflicted upon and disruption to operations of Donbas industrial facilities, including uncontrolled flooding of the coal mines, poses a pollution hazard to the drainage basin of the Siverskyi Donets transboundary river, transboundary ground waters, and the water basin.

Reduced coal production in government-controlled territories and the increased reliance on nuclear power in the country's power generation (from 25% to 37% between 2013 and 2015)[103] may raise the risk of accidents due to intensified NPP operation[104]. If "dirty" Donbas coal is replaced with imported coal, characterized by an even higher content of sulfur and other pollutants[105], increases in the amounts of pollutant emissions in the areas of Ukraine's TPPs are inevitable.

The continuing need for military training ranges increases the burden on the territory, specifically on the nature reserves outside the conflict area[106]. Lastly, repeated accidents at munitions depots outside the armed conflict area (Kharkiv and Vinnytsia regions) pose a significant hazard for both the civilian population and the environment of Ukraine.

CONCLUSIONS

- Armed hostilities may potentially alter Ukraine's contribution to global greenhouse gas emissions (including through increased emissions resulting from wildfires, and decreases due to a decline in industrial production).
- Physical damage and disrupted operations at regional industrial facilities poses a potential pollution hazard in both transboundary waters and the Sea of Azov.
- Reduced coal production in the region combined with further growth in the dependence on NPP-generated electricity in Ukraine increases the risk of accidents, whereas the replacement of Donbas coal with imported coal may increase pollutant emissions in other regions of the country.
- The need for military training ranges increases the burden on nature reserves outside the conflict area. Repeated accidents at munitions depots outside the conflict area pose heightened environmental and civilian hazards.

PRIORITIES FOR REDUCING ECOLOGICAL HAZARDS AND IMPROVING THE ENVIRONMENT IN EASTERN UKRAINE

The following recommendations are primarily intended for the government authorities of Ukraine (including regional and local authorities and their subordinate organizations). However, implementation in most cases will be more efficient with the involvement of research and non-governmental organizations, including members of the international community interested in resolving the environmental problems in the Donbas[107].

Draft recommendations prepared under this project[108] were discussed with government authorities at an OSCE Project Co-ordinator in Ukraine round-table on September 4, 2017.

Their revision, provided below, takes into account the comments, proposals, and additional conclusions based on the analysis of environmental issues in eastern Ukraine obtained during this study, as well as proposals from other publications and processes on environmental issues and future areas of environmental rehabilitation of eastern Ukraine[109].

The recommendations are subdivided into four categories:

(1) "Yesterday" – actions required as a foundation for addressing broader issues, and whose implementation should already have begun or is to begin presently;

(2) "Today" – actions required for the reduction of environmental risk, and whose implementation is required in the near future;

(3) "Tomorrow" – actions required for the restoration of environmental activities in the area, and which are to be included in mid-term governmental action planning;

(4) "The Day After Tomorrow" – actions advisable (and required) to be taken in the more distant future, which, however, needs to be prepared already now.

The first two categories are elaborated in greater detail, while the third is presented at the level of general priorities, meaning that its content will require a fully open process of articulating national and local priorities and resources. The fourth category is outlined on a more general, strategic level.

(1) Yesterday: Information and analysis

Although the volume of information on environmental issues in the conflict area in eastern Ukraine has rapidly increased, uncertainty and differences in the interpretation of data related to this information have arisen. Examples may include an assessment of the immediate effects of the hostilities on the condition of the environment, environmental hazards posed by industrial facilities in the conflict area, or environmental issues related to mine flooding. If the nature of most issues today is clear in principle, their scale and especially their specific attributes and impact continue to stir debate due to a shortage of information and methodological uncertainty. A pressing need exists to systematize the available information and identify remaining data gaps, establishing facts on the environmental situation and sources of environmental hazards located within the conflict area in order to formulate a cogent basis for further action. Apart from organizing the available data, compiling a collection of the missing information and analytical work requires obtaining data from certain sources to which access is still often restricted.

1.1. Systematize the available data about the environmental situation and about the sources of environmental hazard within the conflict area, and arrange broad dissemination of the respective data and access to them in order to enable decision-making.

Establish a large-scale, comprehensive inspection and assessment of the environmental status of the conflict territory in general, and of specific areas of particular environmental, sanitary-epidemiological, and economic interest[110].

Systematize and analyze available series of regular observations on a broad range of indicators to obtain a comprehensive picture of changes (or the absence thereof)[111].

Establish a dedicated center at the Minecology for the collection, analysis, and regular publication of information on the environmental situation in the conflict area; establish a mechanism for interagency exchange of information and data analysis[112].

Regularly publish relevant information on the environmental condition of the conflict area on the Minecology website[113].

Non-governmental organizations should regularly collect and publish data on the environmental issues facing eastern Ukraine (including the establishment of a joint NGO portal, and engaging in outreach to mass media, local authorities, and the general public)[114], maintain public control over the operation of the environmental protection services and agencies located within the conflict area.

1.2. Take inventory of the gaps in information about the environmental situation and sources of environmental hazards in the conflict area, and organize targeted studies to fill those gaps.

Systematically inspect the soil and bottom sediment composition in the conflict area.

Restore and intensify regular environmental monitoring of all environments in the conflict area, including systematic use of remote sensing data, comparison of the current environmental condition with historical data (for instance, with respect to ground-water quality)[115].

Investigate (including both high-resolution satellite imagery and field activities) the condition of forest and other natural vegetation, field-protecting windbreak strips, damage from forest and grass fires, soil degradation, and conditions of key animal and plant species within the nature reserves[116].

Perform a forward-looking assessment of the impact of mine flooding that addresses environmental conditions, hazardous geomorphological processes in communities, the quality of ground and surface waters, and transboundary impact[117].

Assess the radiological situation in the conflict area[118].

Arrange for operational inspections of the impacted territories using organizations' and agencies' mobile laboratories[119]. Provide the local authorities and population with the equipment for express analysis of the environmental situation in the conflict area[120].

Fill gaps in statistical reports by conducting additional statistical research and soliciting expert opinions (including the uncontrolled territories) and the disaggregation of retrospective statistical information for the purposes of data comparison.

1.3. Make arrangements for unimpeded access to other information about the state of the environment and natural resources in the Donetsk and Luhansk regions.

Ensure open access to the current and past data held by the central and local authorities on the condition of the air, surface and ground waters, soils, drinking water, and other pertinent information on the environmental situation in the conflict area[121].

Ensure open access to the results of studies on environmental issues in eastern Ukraine carried out by, or via request of, international organizations[122].

(2) Today: Reducing ecological hazards from major sources

The conflict in eastern Ukraine rages on, thus, there remains a risk related to the impact of hostilities at both natural sites and industrial and municipal infrastructure facilities that pose an increased environmental hazard while playing a critical role in the livelihood of the region's population. In order to effectively plan and implement urgent measures aimed at reducing the hazard from major sources within the conflict area, it is necessary to maintain a continuously specified and updated assessment of this hazard. This assessment should further serve as the basis for the following: the regular planning and allocation of resources, including financial; for systematic risk management and mitigation, including the maintenance of sufficient means and resources to ensure timely response to potential accidents; and for the adoption of political measures within the framework of the negotiation process.

2.1. Regularly update the inventory of the industrial and municipal facilities that have become, or hold the potential to become, major sources of environmental hazard as a result of armed conflict.

Perform an environmental audit of man-made facilities and develop recommendations for the safe operation of said facilities[123]. Develop a detailed cadaster of industrial facilities, mines, and public utilities, employing satellite data, among other methods[124].

Take inventory of the power supply, water supply, sewage, and household waste management at infrastructure facilities where disruptions in operation may jeopardize civilian health and safety[125].

Develop additional local environmental monitoring programmes to support safe operation plans for individual enterprises[126].

Perform field studies and monitor the situation at specific mines to optimize both their operation and shutdown procedures[127].

Assess the environmental hazards posed by the transportation of chemicals in the conflict area with the aim of developing measures to prevent severe accidents (in line with the EU Seveso Difective)[128].

Take inventory of waste generation sites and propose recommendations on their use and/or elimination[129].

Analyze the safety of enterprises located within the territories not controlled by the Government of Ukraine[130].

2.2. Implement urgent measures to reduce the risk posed by the largest industrial and municipal sources of environmental hazard, including by establishing and ensuring sufficient means and resources to respond to emergencies in hazardous areas.

Increase the readiness and capacities for a timely response to emergencies[131], including at the sites of large industrial facilities[132].

Restrict the use of hazardous substances in the conflict area and transport them outside its boundaries; organize and arrange hazardous substance storage sites[133].

Reduce the use of active chlorine at public utilities and replace it with other agents[134].

Increase the ability to evacuate the population from areas of high hazard, provide the population with information on the availability of emergency shelters[135].

Ensure the operation of an early warning system for the population and local authorities in the event of industrial accidents in the conflict area[136].

Restore and stabilize water drainage from flooded mines in order to maintain ground water levels at safe depths [137].

Develop basin and territorial management schemes for the ground water level regime based on mine flooding impact predictions[138].

Determine priority investment to enhance the stability of the region's water supply system, restore damaged water supply system facilities, treat household and industrial effluents and to address the needs of other aspects of municipal infrastructure[139].

Conduct urgent measures to collect and eliminate building and structural refuse, and military and civil equipment destroyed in combat[140] and coordinate these efforts with actions to demine the territory and clear it of undetonated munitions.

Conduct strategic assessments of the entire range of planned measures to restore the Donbas[141].

2.3. Political measures to preclude hostilities near the sources of heightened environmental hazard, to enable international monitoring, and to take preventive measures in relation to high-hazard installations.

Opposing parties in the conflict must abide by a set of ceasefire measures and the subsequent withdrawal of heavy weaponry from the conflict area[142].

Opposing parties in the conflict must cease hostilities at sites of significant sources of environmental hazard[143].

Opposing parties in the conflict must refrain from placing military installations and staging positions near highly hazardous industrial facilities and other facilities required for the sustenance of the local population (including water supply); both sides must refrain from attacking these facilities[144].

Ensure conditions for the operation and maintenance of industrial enterprises and life-sustaining infrastructure facilities in the conflict area, pro-

vide quick and unobstructed access to them for maintenance and service personnel[145].

Hold regular discussions within the Minsk Negotiation Process Trilateral Contact Group or other negotiation mechanisms in order to coordinate risk management for major environmental hazard sources, including discussions on preventing adverse environmental and geological effects of coal mine flooding[146].

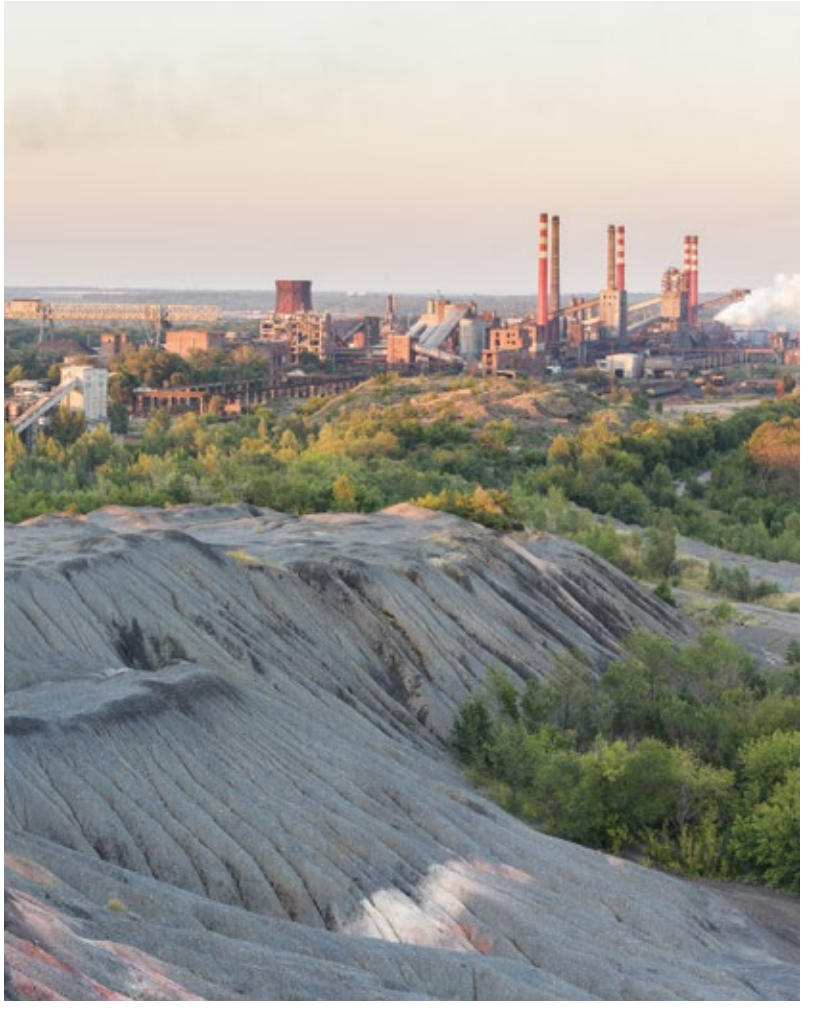
Employ information on the environmental situation and environmental hazard sources within the conflict area to maintain and develop the negotiation process[147].

Disseminate information on the environmental situation within the conflict area at the international and European levels (including within the frameworks of the UN and the EU) and employ international mechanisms to draw additional attention to environmental issues in the conflict area in eastern Ukraine[148].

(3) Tomorrow: Restoring environmental activities in the region

The heavily industrialized Donbas has long stood as one of the more environmentally stressed regions of Ukraine, accounting for a large share of emissions into the environment and waste in the country. Many areas in the Donetsk and Luhansk regions are heavily polluted by mining, metallurgy, chemical industry, and heavy machine building facilities.

Today, this baseline is exacerbated by conflict-related environmental issues. Yet the situation in the government-controlled territories allows for the resumption of activity by core state and local administration institutions, including those responsible for environmental protection. This step is necessitated both in order to restore environmental protection activities limited by the conflict, and to plan and implement any potential Donbas rehabilitation programmes.



3.1. Restore and enhance the organizational and legislative foundations of environmental protection.

Among other measures, it is necessary to restore the operation of the environmental protection system agencies and public utilities[149], and to enhance environmental protection legislation in keeping with environmental priorities evident in the conflict area and which reflect international and European experience[150].

3.2. Restore, expand, and automate pollution monitoring, control, and environmental reporting in the conflict area.

Among other measures[151], provide material support in order to restore, adapt, and modernize observation networks in all spheres, including pollution monitoring of water, air, natural soils, and agricultural lands, forests, flora and fauna, radiation background levels, drinking water, and geological environment (especially during mine liquidation and in the post-liquidation period), and to address the use of natural resources, and long-term monitoring of "delayed" conflict impact. Apply remote monitoring approaches (drones, space images) in difficult-to-access territories and monitor territories not under government control under the auspices of international organizations. Train personnel in modern analytical methods. Restore local authorities and operation of environmental control systems. Promote inter-agency monitoring and coordination in the conflict area and interaction with the monitoring programmes of line agencies, private business, and non-governmental and research organizations.

3.3. Restore and upgrade industrial and municipal waste management systems.

Among other measures, restore regular waste removal in communities[152] and conduct strategic planning addressing waste management in the region, taking into account its degeneration during the conflict and its need for reconstruction or new construction. Arrange for the safe storage of waste generated in the aftermath of the conflict and its use in production activities. In the future, modernize the waste management system in line with the decentralization of the state administration and local experience[153] in the implementation of modern technologies (waste separation and separate processing[154] and the withdrawal of useful components), the application of new organizational and economic models (including that of small business potential). Conduct systematic improvements in the quality of statistical data on household and industrial waste.

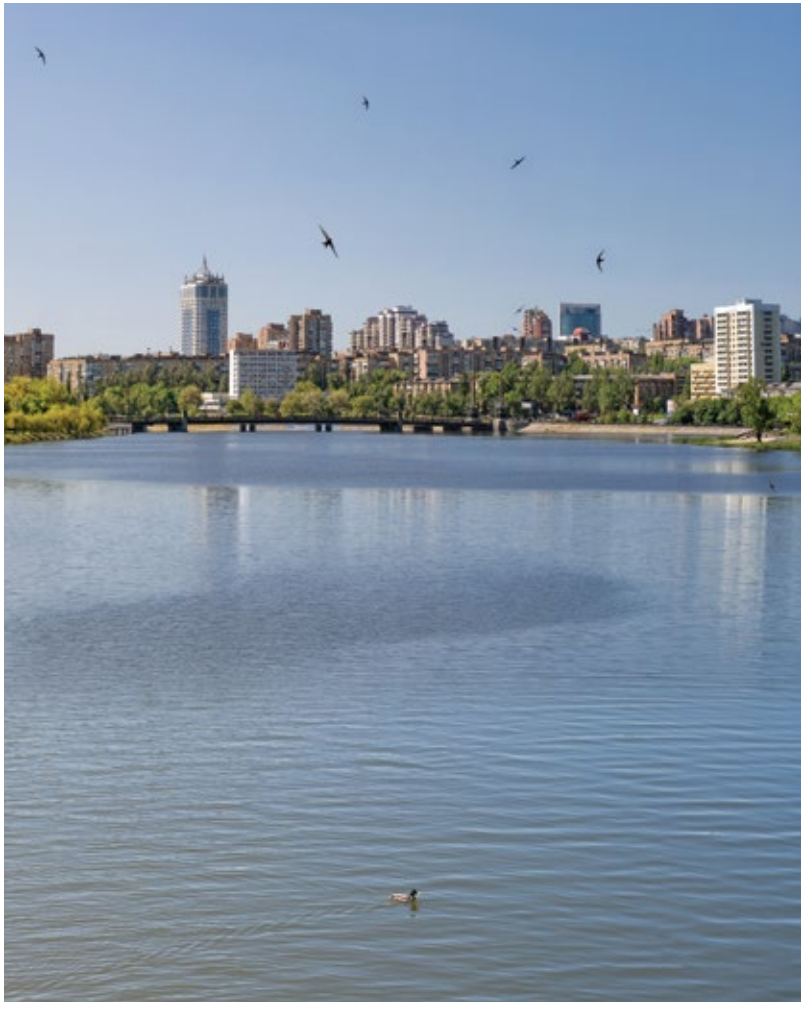
3.4. Modernize the use and protection of the region's surface waters based on the basin approach, restore and modernize water supply and waste water treatment systems.

Among other measures[155], conduct strategic planning of the use and protection of the region's water resources, taking into account sources of environmental hazard and based on the basin approach. Restore the water supply and sewage in the region and conduct strategic planning addressing its further development, taking into account the necessity of radical infrastructure modernization.

3.5. Ensure full management of natural protected areas, accounting for the necessity of rehabilitation of areas affected by hostilities.

Among other measures[156], ensure adequate funding for natural protected areas, taking into account the specific nature of their operation under conflict conditions; ensure that local administrations provide protected

areaswith vehicles, office equipment, and information materials, and conduct remote probing and recording of environmental conditions and their disturbance. Conduct employee training at natural protected areas on the specific requirements of working in conflict area. Conduct strategic planning of protected areas development in the region; conduct development and pursue approval of new projects for the maintenance of individual sites. Conduct territorial demining and clearing; restore nature reserves; and take actions aimed at the prevention of further damage. Develop mechanisms to engage communities (environmental, human rights, etc.) in the provision of assistance to protected areas and their employees; organize volunteer-based assistance to the most affected sites.



3.6. Restore other damaged lands, water bodies, forests and windbreak strips.

Among other measures[157], demine and clear remaining munitions from agricultural and other lands, forests, windbreak strips, watersides and bottom sediments in bodies of water. Implement urgent measures for bank protection and restoration of water protection areas. Implement measures to promote the chemical melioration of soils. Conduct forest restoration through planting and facilitation of natural restoration (reforestation in stands destroyed by shelling, forestation of eroded lands, cultivation of material for reforestation, forestation, and surface pest extermination in pine stands). Ensure forest protection from fires; maintain agency fire guard and fire-chemical stations; capacities to extinguish active forest fires, and make arrangements for forest fire safety.

3.7. Respond to the impact resulting from altered flow and deterioration in the quality of mine waters, modernize principles and practices of both operating and closing mines, and rehabilitate areas damaged by mining.

Among other measures[158], implement steps to protect against mine submergence and flooding in order to preclude the development of hazardous geological processes and eliminate or reduce their adverse impact on the territory within acceptable parameters. Diversify water supply sources. In the future, modernize principles and practices of mine operation, closure, and restoration, in a manner that conforms with international experience[159].

3.8. Expedite the introduction of principles and methods for reducing the environmental impact of defense activities into the field operations of Ukraine's Armed Forces and National Guard units deployed in the region.

Among other measures[160], step up cooperation between environmental protection agencies and the Department for Civil-Military Cooperation of the Armed Forces of Ukraine with the objective of ensuring that servicemen abide by environmental legislation when conducting non-combat related activities; systematically inform unit commanders about the presence of environmentally hazardous facilities and nature reserves in areas of their activities; inform commanders of legal requirements for the protection of nature reserves and hazardous facilities which includes the preparation of relevant reference and cartographic information; improve mechanisms for acquiring approval from the environmental protection agencies in the organization of temporary military training areas; and organize regular environmental awareness-raising activities and training for servicemen as part of military-patriotic campaigns[161]. Increase the number of AFU units involved in environmental issues[162].

3.9. Expand awareness-raising activities on environmental protection in the conflict area.

Among other measures[163], increase outreach activities regarding environmental and civil defense issues in the conflict area; prepare and disseminate special information formats available to the general public (leaflets, video information on the internet) on the environmental situation in the conflict area, sources of environmental hazards and rules of behavior in critical situations. Leverage NGO and mass media (including television) capabilities for the hosting of informational campaigns and disseminating environmental information; regularly publish information on the Minecology site.

(4) Day after Tomorrow: Environmental future of the Donbas

The future of the Donbas is uncertain, and mid-term prospects can be discussed only on the level of implementing specific political and economic scenarios. However, if events develop favorably, with the restoration of Ukraine's territorial integrity, the long-term perspective offers a unique opportunity for the reorganization and modernization of the region's economy.

Elements of modernization, in line with contemporary views on economic and environmental efficiencies, were already set up during the pre-conflict period, when the most advanced facilities (such as the Zasiadko Mine, DTEK and Metinvest facilities) began implementing new technological solutions and approaches.

On the whole, however, industry in the Donbas remains among the most energy-intensive in the world and presents opportunity for significant efficiency improvement in terms of energy consumption, pollutant emissions, the reduction of its "carbon footprint". If implemented, this potential for improvement may result in a competitive increase along with a cleaner environment, which would benefit the welfare of the regional civilian population.

Ensuring support for the main actors interested in the future development of the Donbas may serve as the basis for ensuring the necessary political will, technologies, and investment.

4.1. Develop a comprehensive concept for the economic restructuring of the Donbas on the basis of green economy and effective adaptation to climate change.

Among other measures[164], account for and apply the principles of a "green" economy[165], closed-cycle circular economy featuring the multiple turnover of products, efficient adaptation to climatic change[166], and regional development scenarios and strategies[167].

4.2. Hold broad discussions of the concept with central and regional authorities, local governments, and representatives of industry, businesses, and the public.

Among other reasons, in order to support and attract domestic and foreign long-term investment.

REFERENCES

Абибок Ю., 2017. «Сегодня у нас огромное количество научных открытий». Чем живет разделенный войной Национальный природный парк «Меотида»? // «ОстроВ», 27.07.2017

Аверін Д., 2017. Кабінетне дослідження «Визначення шкоди, завданої довкіллю на сході України» для Координатора проектів ОБСЄ України. Київ, 13.07.2017

Аверин Д., Подтуркин Д., 2015. Экологический капкан «республик» // «Пётр и Мазепа», 22.07.2015

Булатчик В., Аверин Д., 2017. На грани катастрофы: часть территорий Донбасса может стать непригодной для жизни в течение 5–10 лет // «ОстроВ», 26.05.2017

Бущенко А. (ред.), 2017. На межі виживання: знищення довкілля під час збройного конфлікту на сході України. Українська Гельсінська спілка з прав людини. Київ

Войціховська А., 2015. Дослідження ЕПЛ впливу військових дій на довкілля на сході України // Екологія. Право. Людина, № 23–24 (63–64)

Гетьман В., 2015. Війна і заповідні території // Асоціація природоохоронних територій України

Попов В., Соляков И., Щеголев Д. (ред.), 1971. Гидрогеология СССР. т. VI. Донбасс. Москва, «Недра»

ГУ ОПС в Донецкой области, 2009. Земля тревоги нашей. По материалам Докладов о состоянии окружающей природной среды в Донецкой области в 2007 – 2008 годах. Министерство охраны окружающей природной среды. Государственное управление охраны окружающей природной среды в Донецкой области. Донецк

Денисов Н., Аверин Д., Ющук А., Лоїк И., Юрцаба Я., 2017. Приоритеты снижения экологической опасности и оздоровления окружающей среды на востоке Украины. Предварительный вариант/Материалы для обсуждения для Координатора проектов ОБСЕ в Украине. Киев, 04.09.2017

Дурнев Д., 2017. Пора ли отступать с Донбасса: стало известно содержание секретного доклада // MKRU, 11.07.2017

Зибцев С., Богомолов В., 2015. Сравнительный анализ случаев растительных пожаров в зоне АТО и на прилегающих территориях на основе данных MODIS за период 1.04 – 31.10.2014. Региональный восточноевропейский центр мониторинга пожаров. Краткий отчет для Экологической сети «Зой». Киев, 29.03.2015

Кириллов Д., 2017б. Донбасс закрывает шахты // Радио «Свобода», 14.07.2017

Колгушева О., 2017. Сергій Натрус, директор департаменту екології та природних ресурсів Донецької ОДА (інтерв'ю) // Укрінформ, 19.04.2017

МТОТ , 2016. Державна цільова програма відновлення та розбудови миру в східних регіонах України, Міністерство з питань тимчасово окупованих територій та внутрішньо переміщених осіб України. Київ, 26.12.2016

Набиванец Ю., 2017. Оценка возможного влияния конфликта на востоке Украины на качество поверхностных вод. Информационный материал для Координатора проектов ОБСЕ в Украине. Украинский гидрометеорологический институт Государственной службы Украины по чрезвычайным ситуациям и Национальной академии наук Украины. Киев, октябрь 2017

Норенко К., 2015. Наслідки розривів снарядів на сході України: понівечена отруєна земля // Екологія. Право. Людина. № 23–24 (63–64)

«ОстроВ», 2016. В Донецкой области в непосредственной близости от проведения боевых действий горел полигон ТБО // «ОстроВ», 19.07.2016

«ОстроВ», 2017. В Луганской области построят полигон твердых бытовых отходов за 10 миллионов // «ОстроВ», 03.02.2017

СД БУВР, 2017. Звіт про польові дослідження для Координатора проектів ОБСЄ в Україні. Сіверсько-Донецьке Басейнове управління водних ресурсів. Слов'янськ, вересень 2017

Удалов І., 2017. Цикли техногенної трансформації геологічного середовища та створення системи екологічної безпеки Північно-Східного Донбасу. Дисертація на здобуття наукового ступеня доктора геологічних наук за спеціальністю 21.06.01 – екологічна безпека. Національна академія наук України, Державна установа «Інститут геохімії навколишнього середовища НАН України». Харків

Улицький О. , Єрмаков В., 2017. Аналіз поточної гідрогеологічної ситуації в умовах неконтрольованого затоплення гірничих виробок вугільних шахт та вплив цього процесу на формування якісного складу поверхневих та підземних вод в межах територій Донецької та Луганської областей. Інформаційний матеріал для Координатора проектів ОБСЄ в Україні. Науково-дослідний інститут екологічної безпеки і управління Державної екологічної академії післядипломної освіти та управління Міністерства екології та природних ресурсів України. Київ, жовтень 2017

Филиппова А., 2016. Река из отходов. Бахмутскому району угрожает экологическая катастрофа // «ОстроВ», 22.07.2016

Denisov N., Simonett O., Weir D., Averin D., 2015a. The Ukraine conflict's legacy of environmental damage and pollutants // Sustainable Security, April 2015

Denisov N., Simonett O., Weir D., Averin D., 2015b. Ukraine war leaves a long shadow of pollution, ill-health and ravaged industries // Ecologist, 24.05.2015

Denisov N., Weir D., Averin D., 2017. New data on Ukraine conflict's environmental risks supports calls for comprehensive assessment // Toxic Remnants of War Network, 13.03.2017

Environment and Security Initiative, 2017. Climate Change and Security in Eastern Europe. Republic of Belarus, Republic of Moldova, Ukraine. Regional assessment. Vienna

ENVSEC, Zoï, UNEP / GRID-Arendal, 2011. Coalland – Faces of Donetsk. Environment and Security Initiative, Zoï Environment Network and UNEP / GRID-Arendal. Geneva

Gazeta.UA, 2016. За час війни згоріли 37% заповідників Донбасу // Gazeta.UA, 8.11.2016

Gibbons-Neff T., 2017. Shelling around Ukrainian industrial facilities may trigger serious environmental consequences, report says. The Washington Post, March 2017

IBRD, EU, UN, 2015. Ukraine. Recovery and Peacebuilding Assessment. Analysis of crisis impacts and needs in eastern Ukraine. Volume II: full component reports. International Bank for Reconstruction and Development / The World Bank, Delegation of the European Union to Ukraine, United Nations – Ukraine. Kyiv, March 2015

Kahlweit C., 2016. Ukraine: Nach dem Krieg droht die Umweltkatastrophe // Süddeutsche Zeitung, 19.07.2016

Kaschka E., 2015. Final report analysis on the assessment of the water facilities of the industrial site «Karbonit» that is located both on controlled and temporarily not controlled by the government of Ukraine territory. November 2015

Kaschka E., 2016. Rehabilitation of Communal Infrastructure in East Ukraine. Assessment of Donetsk Filter Station, Krasnoarmeysk WTP, Hydraulic Structures at Karlovskoe Lake. Final Report. Federal Ministry for Economic Cooperation and Development, KfW, Posch+Partners. May 2016

Kravchenko O. (ed.), 2015. Military Conflict in Eastern Ukraine — Civilization Challenges to Humanity. ICO Environment – People – Law, Lviv

Meerschman E., Cockx L., Islam M.M., Meeuws F., M. Van Meirvenne, 2011. Geostatistical Assessment of the Impact of World War I on the Spatial Occurrence of Soil Heavy Metals // AMBIO (2011) 40

Nicole L., Ferraro F., 2017. SHA secondment to OCHA. Environmental advisory – Donbass region. Mission report: May 29 – July 21, 2017. 31.05.2017

OSCE SMM 2015. Access to water in conflict-affected areas of Donetsk and Luhansk regions. Organisation for Security and Co-operation in Europe, Special Monitoring Mission to Ukraine. September 2015

Peck Ph., 2009. Risk Assessment Considerations in the Donetsk Basin. Mine Closure and Spoil Dumps. Environment and Security Initiative, UNEP / GRID Arendal

Petry R., 2016. Gutachten zur Wiederaufnahme der Kohleförderung in der Ukraine. 2016 [zitiert nach Kahlweit 2016]

UNDP, 2016a. The Donetsk region development strategy until 2020. UNDP Recovery and Peacebuilding Programme. Kramatorsk

UNDP, 2016b. The Luhansk region development strategy until 2020. UNDP Recovery and Peacebuilding Programme. Severodonetsk

Yakovliev Ye., Chumachenko S., 2017. Ecological Threats in Donbas, Ukraine. Centre for Humanitarian Dialogue. Geneva

Zibtsev S., Zagorodniuk I., Averin D., Averin E., Bystrov P., Bogomolov V., 2015. Environmental threats of the conflict in the eastern Ukraine. Information note for the United Nations Environment Programme / Secretariat of the Environment and Security initiative. Kyiv

ZN.UA, 2016. Тымчук указал на угрозу масштабной экологической катастрофы в Донбассе // ZN.UA, 11.05.2016

Zwijnenburg W., 2017. Donbas: A Ticking Toxic Time Bomb. Open-source tracking and monitoring of environmental health risks of targeting industrial sites // Bellingcat, 30 March 2017

Notes

1. http://www.unenvironment.org/explore-topics/disasters-conflicts.
2. http://mediarnbo.org/.
3. https://www.humanitarianresponse.info/en/operations/ukraine/water-sanitation-and-hygiene.
4. The programme is not an analytical document but provides insight into government priorities.
5. Analysis is based on the description of the study found on the implementing organization's web-site www.pap.co.at: Risk Assessment of Voda Donbasu Water Supply Services in Donetsk Oblast of Ukraine.
6. IBRD, EU, UN, 2015.
7. Most of the EPL studies are summarized in the compilation – Kravchenko, 2015.
8. Denisov et al., 2015a, 2015b, 2017.
9. Kaschka 2015, 2016.
10. Petry 2016, Kahlweit C., 2016.
11. OSCE SMM, 2015.
12. МТОТ, 2016.
13. See http://komekolog.rada.gov.ua/news/main_news/74071.html.
14. Zwijnenburg, 2017.
15. Бущенко, 2017.
16. Nicole and Ferraro, 2017.
17. Risk Assessment of Voda Donbasu Water Supply Services in Donetsk Oblast of Ukraine: www.pap.co.at.
18. Аверін, 2017.
19. Kravchenko, 2015.
20. Yakovliev and Chumachenko, 2017.
21. For comparison purposes, CHD used the average regional background values (Yakovliev and Chumachenko, 2017) while EPL used measurements taken 4 meters from the edge of the shell crater (Kravchenko, 2015).
22. СД БУВР, 2017.
23. In other words, either the corresponding MACs had already been exceeded prior to the conflict, or had not been exceeded even in consideration of the additional conflict-based pollution.
24. Набиванець, 2017.
25. Baruim and strontium are extensively used in pyrotechnic compounds. Increased concentrations of barium were noted in studies by UN Environment in the locations of hostilities in Iraq and Palestine. More: http://www.unep.org/disastersandconflicts/.
26. Some differences between the 2008 and 2017 results may be explained by different locations of sampling points in the two studies: in 2008, samples were taken from the reservoir dams, whereas in 2017 they were taken from the shore. However, differences in the hydrodynamic mode alone hardly explain increases in metal concentrations by factors of several thousands.
27. Studies show that copper and lead concentrations in soils taken from locations of trench warfare conducted in Belgium and dating from World War I remain high even today (Meerschman et al., 2011).
28. ГУ ОПС в Донецькій області, 2009; ENVSEC, Zoï, UNEP / GRID-Arendal, 2011.
29. State Statistics Service of Ukraine http://www.ukrstat.gov.ua/.
30. State Statistics Service of Ukraine http://www.ukrstat.gov.ua/. The economic blockade and expropriation of companies in the territories not under Ukraine Government control are expected to further reduce statistical reporting by major enterprises in 2017.
31. Yakovliev and Chumachenko, 2017.
32. Denisov et al., 2017.
33. Аверін та Підтуркин, 2015.
34. Wikipedia https://uk.wikipedia.org/wiki/Екологічні_наслідки_війни_на_сході_України/.
35. Войціховська, 2015.
36. Thus, a recurrence of the well-documented failure in 2016 of the Bakhmut Agrarian Union sediment ponds was successfully avoided via the efforts of МТОТ (Булатчик, 2017).

37. Mononitrochlorobenzene, an obsolete pesticide, was removed from deposits at the Horlivka State-Owned Plant located in Ukraine-controlled territory (Колгушева О., 2017).

38. Nicole and Ferraro, 2017.

39. Although prominent reported exceptions do exist, e.g., the intentional destruction of the Donetsk airport and of coal mining infrastructure at Kyryllov in 2017.

40. The report draws attention to the risk potential for accidents during the transportation (including railroad transportation) of raw and other materials (Nicole and Ferraro, 2017).

41. ZN.UA, 2016.

42. Филиппова, 2016.

43. Wikipedia https://uk.wikipedia.org/wiki/Ядерний_вибух_у_Донецькій_області/.

44. Yakovliev and Chumachenko, 2017, Дурнев, 2017.

45. Кириллов, 2017а.

46. Дурнев, 2017, Кириллов, 2017а.

47. Other published data (Кириллов, 2017) maintain that currently approximately 80 mines are in uncontrolled waterlogging mode.

48. Кириллов, 2017б.

49. Попов и др., 1971, Удалов, 2017.

50. The total volume of the mine waters discharged into surface water bodies accounts for only 10%-15% of the Siverskyi Donets flow (a figure that decreased during the conflict due to reduced water drainage). Nonetheless, pollution with mine waters poses a particular hazard for low-water tributaries and underground aquifers providing fresh water supply and irrigation. The flooding of mines in Lugansk Oblast affects Svytlychanskyi; in the Donetsk Oblast, Volyntsivske, and Olhovastse are under threat; flooding of the Torezo-Sniezhanska group can result in the polluting of the Hrabyvske reservoir.

51. According to some estimates, mine flooding may potentially affect a territory measuring fifteen thousand square kilometers (Дурнев, 2017).

52. Улицький, Єрмаков, 2017.

53. Zibtsev et al., 2015.

54. Удалов, 2017.

55. Kaschka 2015, 2016.

56. Risk Assessment of Voda Donbasu Water Supply Services in Donetsk Oblast of Ukraine: www.pap.co.at.

57. Other researchers also noted that the potential failure of a dam in poor condition on the Nizhnyaya Krynka river poses a flood risk to the towns of Zuyevka, Troitsko-Khartsyzsk, and Zugres (Zibtsev et al., 2015).

58. Nicole and Ferraro, 2017.

59. Specifically, failure of the Siverskyi Donets – Donbas Canal would make long-term water supply to Mariupol impossible, due to the absence of sufficient backup sources.

60. A significant component of international coordination is implemented under a humanitarian response mechanism addressing water supply, water disposal, sanitation and hygiene (WASH Cluster).

61. MTOT, 2016.

62. Priority sites include Bakhmut, the village of Krasne, and the towns of Mykolaivka, Konstiantynivka, Ocheretyne, Vuhledar, Verkhniotoretske (Колгушева, 2017).

63. Kaschka, 2016.

64. «ОстроВ», 2016.

65. MTOT, 2016.

66. «ОстроВ», 2017.

67. Колгушева, 2017.

68. Норенко, 2015.

69. Zibtsev et al., 2015.

70. Zibtsev et al., 2015.

71. Zibtsev et al., 2015.

72. Аверін, 2017 and State Statistics Service of Ukraine http://www.ukrstat.gov.ua/. Comparison of the 2013 reforestation statistics in the Donetsk and Lugansk Regions and 2015-2016 statistics for territories controlled by the government of Ukraine is possible, since most forests are located

north of the Donetsk Region and in the flood plain of the Siverskyi Donets along the contact line. In high-risk districts, however, reforestation activities are not currently being undertaken.

73. MTOT, 2016.

74. The available estimates, claiming that the fire frequency in 2014 exceeded the 2010-2013 period by a factor of 2 to 15 (Kravchenko, 2015), cannot speak of the conflict effects, since 2014 was much dryer than the previous years; thus, the forest fire situation differed for natural reasons.

75. Additional analysis of fire localization relative to the active hostilities areas in 2014 is provided in Kravchenko, 2015.

76. According to the Lugansk Agroforestry Station specialists' data (Zibtsev et al., 2015).

77. Kravchenko 2015. Based on the MODIS radiometer data, the EPL analysis revealed 2,091 cases of vegetation fires in the conflict area (compared to 4,867 in this research). The resulting evaluation of a total area of 297,000 hectares affected by fires appears to have been severely overstated. Further, the reliability of evaluation of the fire-affected areas based on the MODIS data is inadequate.

78. Бущенко, 2017.

79. Зибцев, Богомолов, 2015, Denisov et al., 2015 a, b

80. Бущенко, 2017, Гетьман В., 2015.

81. According to the OSCE Project Coordinator in Ukraine Information System. The analysis of satellite data carried out by EPL showed that fire affected 37% of the Donetsk and Lugansk Regions' protected areas (Gazeta.UA, 2016).

82. Zibtsev et al., 2015.

83. Wikipedia https://uk.wikipedia.org/wiki/Екологічні_наслідки_війни_на_сході_України/.

84. Wikipedia https://uk.wikipedia.org/wiki/Меотида/; there are current plans to rehabilitate and develop the regional Kramatorskiy and Kleban-Byk parks at the expense of the Donetsk Regional Administration and under the State MTOT programme, (Kolhusheva, 2017, MTOT, 2016).

85. Бущенко, 2017.

86. Zibtsev et al., 2015.

87. Абибок, 2017.

88. Zibtsev et al., 2015.

89. Some nature reserves, having ended up on opposite sides of the contact line, have also lost part of their territories (Абибок, 2017).

90. The last of the automatic stations for air quality monitoring in the town of Shchastia were in operation until mid-November 2014.

91. "The agencies and officials legislatively authorized to effect state supervision (control) over economic activities, during the period and in the territory of the anti-terrorist operation, shall be prohibited from carrying out scheduled and ad-hoc audits of the entities which pursue their activities in the anti-terrorist operation zone, except for ad-hoc audits of the entities which, pursuant to the risk assessment criteria approved by the Cabinet of Ministers of Ukraine for the economic operation, are included among the high-risk entities". (Art 3. Moratorium on Carrying out Audits by Agencies and Officials Legislatively Authorized to Effect State Supervision (Control) over Economic Activities): zakon.rada.gov.ua.

92. IBRD, EU, UN, 2015.

93. Бущенко, 2017.

94. Бущенко, 2017.

95. State Statistics Service of Ukraine http://www.ukrstat.gov.ua/.

96. State Statistics Service of Ukraine http://www.ukrstat.gov.ua/.

97. Currently, there is a ban on using civil aircraft in the conflict area.

98. Колгушева, 2017.

99. MTOT, 2016.

100. IBRD, EU, UN, 2015 and MTOT, 2016.

101. Zibtsev et al., 2015.

102. State Statistics Service of Ukraine http://www.ukrstat.gov.ua/.

103. State Statistics Service of Ukraine http://www.ukrstat.gov.ua/.

104. It should be noted, however, that due to a general decrease in electricity generation in Ukraine (< 72% in 2015 of 2013 levels), actual electricity generation by NPPs thus far has increased only incrementally – by 5% over the same period (data, State Statistics Service of Ukraine).

105. The average lower calorific capacity of South African anthracite is 5,685 kcal/kg (Ukrainian 2,850-3,516 kcal/kg); sulfur content – 1.3% (Ukrainian 1.0%), ash – 21.8% (Ukrainian 15 – 20%).

106. EPL identifies specific examples in the Lviv, Ternopol, Odesa, Kherson, Cherkasy, Chernigiv Regions: http://epl.org.ua/environment/natsionalni-parky-i-zapovidnyky-vs-minoborony-pidsumky-2016-roku/.

107. "Environmental sector recovery implementation will need to be coordinated at three levels: The Ministry of Environment and Natural Resources at the central level; the government structure responsible for coordinating Donbas recovery efforts at the regional level; and the state (oblast) environmental protection administration and CSOs at the local level. Technical administrations at the oblast level... have highly qualified experts with the technical skills and experience to lead implementation of the proposed projects. It will be necessary to involve and capitalize on the professional skills of environmental NGOs that have played a critical role in monitoring and reporting on conflict-related environmental damages. To promote ownership and active involvement, it is important that local communities be involved in discussions and decision making on key issues, and be provided with job opportunities through environmental rehabilitation work to the extent possible (such as reforestation projects, waste cleanup operations, and so on). Finally, it will be important to collaborate with international organizations that can potentially provide specialized technical assistance and quality assurance oversight, and share experiences and lessons from relevant initiatives. In addition, international partners could provide project management support, especially given the reduced operational capacity of national institutions in the immediate post-conflict phase". (IBRD, EU, UN, 2015).

108. Denisov et al., 2017.

109. An agreement to integrate recommendations of a number of other processes and publications into this document was reached, specifically, at the coordination meeting under aegis of the Embassy of Canada in Ukraine on September 8, 2017. Since the format of a summary publication does not allow for presenting other organizations' proposals in detail and without changes, we recommend referring to the primary sources for acquaintance with the original language and details.

110. Element of the IBRD, EU, UN, 2015 programme, EPL recommendations (Kravchenko, 2015), Zoї (Denisov et al. 2015a, b), UHHRU (Бущенко, 2017). The MTOT 2016 programme envisages the development of a set of environmental maps for territory adversely affected by hostilities with identification of the degrees of environmental and man-made hazard.

111. Partly implemented in the OSCE Project Co-ordinator in Ukraine Information System.

112. EPL recommendations (Kravchenko, 2015). Currently, these functions are partly assigned to the Center for Donbas Environmental and Resource Restoration of the State Environmental Academy of Postgraduate Education of the Minecology. In pursuance of the protocol of the meeting on resolving challenging issues in the environmental sphere of the Donetsk and Luhansk regions chaired by the Vice Prime Minister of Ukraine of May 11, 2017, the MTOT Order 68 of June 16, 2017 established an interagency working group for the analysis of challenging issues in the environmental sphere, and the identification of approaches to resolving them on both government-controlled and uncontrolled territories of the Donetsk and Luhansk regions.

113. EPL recommendations (Kravchenko, 2015).

114. EPL recommendations (Kravchenko, 2015).

115. CHD (Yakovliev and Chumachenko, 2017). Element of the IBRD, EU, UN 2015 programme, specific measures are planned in the MTOT programme and by the regional administrations.

116. EPL (Kravchenko, 2015) and UHHRU (Бущенко, 2017) recommendations.

117. CHD recommendations (Yakovliev and Chumachenko, 2017).

118. CHD recommendations (Yakovliev and Chumachenko, 2017).

119. Mobile analytical laboratories are procured, specifically, by the Donetsk Regional Administration (Колгушева, 2017).

120. EPL recommendations (Kravchenko, 2015).

121. This recommendation has been implemented in part via an information system developed with support of the OSCE Project Co-ordinator in Ukraine. However, complete disclosure of the relevant data and unimpeded access to them require the involvement of various authorized state agencies and organizations.

122. Specifically, the report for the UN OCHA (Nicole and Ferraro, 2017) recommends a balanced dissemination of the conclusions presented therein. Accessibility of the results of individual international studies is summarized in the table of Chapter 1.

123. EPL recommendations (Kravchenko, 2015), Zoï (Denisov et al., 2015a, b, 2017). Envisaged by the MTOT, 2016 programme.

124. Recommendations of the report for the UN OCHA (Nicole and Ferraro, 2017).

125. In relation to water supply facilities, among other things, a research requested by UNICEF.

126. Recommendations of the report for the UN OCHA (Nicole and Ferraro, 2017).

127. CHD recommendations (Yakovliev and Chumachenko, 2017).

128. Recommendations of the report for the UN OCHA (Nicole and Ferraro, 2017).

129. Envisaged by the MTOT, 2016 programme.

130. Recommendations of the report for the UN OCHA (Nicole and Ferraro, 2017).

131. IBRD, EU, UN, 2015 programme element.

132. Recommendations of the report for the UN OCHA (Nicole and Ferraro, 2017).

133. EPL recommendations (Kravchenko, 2015).

134. UN OCHA, 2017 recommendations (Nicole and Ferraro, 2017), partially implemented.

135. EPL recommendations (Kravchenko, 2015).

136. Recommendations of the EPL (Kravchenko, 2015) and of the report for the UN OCHA (Nicole and Ferraro, 2017).

137. The MTOT 2016 programme envisages development of projects to restore water removal mine complexes, mine-water drainage, and water level reduction in submerged mines.

138. Удалов, 2017.

139. Content of the research for UNICEF, recommendations for the report for the Trilateral Contact Group Report (Kaschka, 2016) and CHD (Yakovliev and Chumachenko, 2017), and element of the IBRD, EU, UN, 2015 and MTOT, 2016 programmes.

140. IBRD, EU, UN, 2015 programme element. The MTOT, 2016 programme envisages development of recommendations on waste management and impact of the hostilities in line with the modern environmental standards.

141. IBRD, EU, UN, 2015 programme element.

142. OSCE SMM, 2015 recommendations.

143. Bellingcat recommendations (Zwijnenburg, 2017).

144. OSCE SMM, 2015 recommendations relative to facilities dedicated to sustenance of the local population.

145. OSCE SMM, 2015 recommendations relative to facilities dedicated to sustenance of the local population.

146. CHD recommendations on mine flooding (Yakovliev and Chumachenko, 2017), Zoï (Denisov et al., 2017).

147. EPL recommendations (Kravchenko, 2015), Zoï (Denisov et al., 2017).

148. EPL recommendations (Kravchenko, 2015), Bellingcat (Zwijnenburg, 2017), Zoï (Denisov et al., 2017).

149. IBRD, EU, UN, 2015 programme element.

150. Recommendations of the EPL (Kravchenko, 2015), UHHRU (Бущенко, 2017), and of the report for the UN OCHA (Nicole and Ferraro, 2017). EPL and UHHRU propose detailed recommendations on legislation improvement.

151. Recommendations of the EPL (Kravchenko, 2015), UHHRU (Бущенко, 2017), and of the report for the UN OCHA (Nicole and Ferraro, 2017), also see Удалов, 2017. Element of the IBRD, EU, UN 2015 and MTOT 2016 programmes (development of the environmental monitoring system on the regional, territorial, and facility level: building up observation stations for the atmospheric air, soils, and water, including a range of specific measures in the Donetsk region and in the Siverskyi Donets basin).

152. Element of the IBRD, EU, UN, 2015 and MTOT, 2016 programmes (landfill reconstruction and construction).

153. E.g., results of the European Commission technical assistance project "Capacity Building in Donetsk Oblast".

154. Колгушева, 2017.

155. Content of research requested by UNICEF, recommendations for reports to the Trilateral Contact Group Report (Kaschka, 2016) and UN OCHA (Nicole and Ferraro, 2017), and elements of the IBRD, EU, UN, 2015 and MTOT, 2016 programmes.

156. UHHRU recommendations (Бущенко, 2017), elements of the IBRD, EU, UN, 2015 and MTOT, 2016 programmes.

157. Element of the IBRD, EU, UN, 2015 and MTOT, 2016 programmes.

158. MTOT, 2016 programme element.

159. Peck, 2009; ENVSEC, Zoï, UNEP / GRID-Arendal, 2011.

160. UHHRU recommendations (Бущенко, 2017).

161. The MTOT 2016 programme envisages re-training, professional training, and internship on environmental issues for military service personnel and conflict area victims.

162. EPL recommendations (Kravchenko, 2015).

163. EPL (Kravchenko, 2015) and UHHRU (Бущенко, 2017) recommendations, MTOT, 2016 programme element.

164. Zoï recommendations (Denisov et al., 2017)

165. In the near future, renewable energy may become one of the new priorities of the environmental development of the Donetsk region (Колгушева, 2017).

166. Today, eastern Ukraine's agriculture and forestry readiness for expected climatic changes is relatively low; the Donetsk and Lugansk regions have no regional adaptation programmes, whereas farm businesses have low levels of awareness of required actions. In the future, it will become necessary to account for climatic changes in production development plans, review the composition of agricultural crops in favor of those more resistant to climatic changes, adapt land-utilization structure, develop irrigation, and improve agro-climatic monitoring and prediction. At the same time, there is a possibility of reducing the climatic impact of these industries, e.g., through restricted plowing, protection of multi-year pastures, and use of waste biomass to generate heat and electricity, thus making an additional contribution to the "greening" of the Donbas economy. See also "Environment and Security" Initiative 2017.

167. UNDP, 2016a, 2016b – examples of regional mid-term development strategies.