ARUP

Public Water Management Company Srbijavode

European Bank for Reconstruction and Development

Environmental and Social Impact Assessment, Climate Change Assessment and Technical Assessment for Pambukovica Dam in Serbia

Environment (Air Quality, Noise and Vibrations, Soil and Groundwater, Resources and Material Management, Waste and Wastewater), Cultural Heritage, Health and Safety, Landscape and Visual

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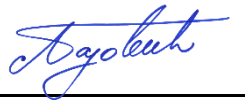
		Signature			
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Abbreviations

Abbreviation	Definition
AHP	Analytical Hierarchy Process
AoI	Area Of Interest
CESMP	Contractor's Environmental Management Plan
EBRD	European Bank for Reconstruction and Development
EC	European Community
EEC	European Economic Community
EIA	Environmental Impact Assessment
ELC	European Landscape Convention
EN	European Norm
EPRP	Emergency Preparedness and Response Plan
ESCP	Erosion and Sediment Control Plan
ESIA	Environmental and Social Impact Assesment
EU	European Union
ICOLD	International Commission on Large Dams
IFC	International Finance Corporation
LVIA	Landscape and Visual Impact Assessment
MAFWM	Ministry of Agriculture, Forestry and Water Management
OHSMP	Occupational Health and Safety Management Plan
PM	Particulate Matter
PPE	Personal Protective Equipment
PR	Performance Requirements
PUC	Public Utility Company
RAMS	Risk Assessment Method Statements
RMMP	Resource and Material Management Plan
RS	Republic of Serbia
RSA	Road Safety Audit
SRPS	Serbian Standard
SRRP	Site Restoration and Rehabilitation Plan
TMP	Traffic Management Plan
US FDSC	United States Federal Dam Safety Commission
VOC	Volatile Organic Compound
WMD	Water Management Directorate
ZTV	Zone of Theoretical Visibility
ZTV	Zone of Theoretical Visibility

1. Introduction

The European Bank for Reconstruction and Development (the "EBRD") is considering providing finance to the Republic of Serbia (the "Borrower", or the "Client"), represented by the Ministry of Finance to enable construction of a water resources reservoir near Pambukovica, Serbia. The Project will be implemented by the Public Water Management Company Srbijavode ("Srbijavode"), the national body responsible for water management, including water use and protection from pollution. Srbijavode is also responsible for management of risks associated with water bodies (such as flood risk). The Project would reduce flooding downstream through water retention in the reservoir and associated attenuation of high flows. Srbijavode operates under the Water Management Directorate (WMD), which in turn is an administrative authority of the Ministry of Agriculture, Forestry and Water Management (MAFWM). The Loan is expected to finance the construction of a new impoundment dam and reservoir infrastructure at Pambukovica including associated works such as upstream sediment traps and road realignment (vertical realignment over the reservoir).

TheEnvironmental Impact Assessment (EIA) study developed under Serbian legislation was prepared by the Energoprojekt - Hidroinženjering on behalf of Srbijavode and was subject to an Environmental and Social Gap Analysis, which indicated that a full Environmental and Social Impact Assessment (ESIA) in accordance with EBRD's Environmental and Social Performance Requirements[1] was required.

1.1 Purpose of this Chapter

ESIA Volume I Book 5 of the Environmental and Social Impact Assessment (ESIA) for the Pambukovica Dam Project, presents evaluation of the Project's potential impacts on environmental, health, safety, landscape, and visual receptors. It has been prepared in accordance with Serbian national legislation and the Environmental and Social Performance Requirements of the EBRD, particularly PR1 (Assessment and Management of Environmental and Social Risks and Impacts), PR3 (Resource Efficiency and Pollution Prevention and Control), PR4 (Health, Safety and Security), PR6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources), and PR8 (Cultural Heritage).

This volume builds upon the findings of the national Environmental Impact Assessment (EIA) and addresses the gaps identified between national legislative requirements and EBRD Performance Standards.

Book 5 covers the following areas:

- **Air Quality**: Assessment of emissions and dust generation during construction and operation, including mitigation measures to protect sensitive receptors.
- **Noise and Vibrations**: Evaluation of noise and vibration impacts from construction machinery, blasting, and transport activities, with a focus on nearby communities and ecological receptors.
- **Soil and Groundwater**: Analysis of potential contamination, erosion, and hydrological changes, including groundwater monitoring and erosion control strategies.
- **Resources and Material Management**: Review of material sourcing, transport, storage, and disposal, with emphasis on sustainable use and circular economy principles.
- **Waste and Wastewater**: Identification and management of hazardous and non-hazardous waste streams, wastewater treatment, and compliance with national and EBRD standards.

[1] EBRD (2019) Environmental and Social

(v. April 2019)

- **Cultural Heritage**: Assessment of impacts on cultural heritage, including chance find procedures and relocation of sensitive assets.
- **Health and Safety**: Evaluation of occupational and community health and safety risks during all project phases, including emergency preparedness and response planning.
- **Landscape and Visual**: Analysis of visual and landscape changes due to dam construction, reservoir formation, and associated infrastructure, supported by ZTV mapping and photomontages.

1.2 Legal and Policy Framework

Full list of relevant legislation and standards (Project Standards) is provided in the separate subchapters and **Book 1 Introduction.** Important considerations relevant for each topic are highlighted in individual chapters of this Book.

1.3 Methodology

Overarching ESIA methodology is presented in the **Book 1 Introduction.** Important considerations relevant for methodology of each topic are highlighted in individual chapters of this Book.

1.4 Assumptions and Limitations

Overarching ESIA assumptions and limitations are presented in the **Book 1 Introduction. Assumptions and limitations i**mportant for each topic are highlighted in individual chapters of this Book.

2. Air Quality

2.1 Introduction and Purpose

Managing air quality is a critical aspect of environmental protection during the construction and decommissioning phases of the Project. Various project activities, such as land clearing, excavation, material transportation, rock blasting, and the operation of construction machinery, are expected to result in temporary increases in dust and exhaust emissions. Key sources of air pollution include particulate matter (PM_{10} and $PM_{2.5)}$ from dust-generating activities and gaseous emissions (e.g., NOx, CO) from fuel-powered equipment. The analysis conducted in this chapter encompasses the activities planned for the dam, along with a high-level overview of those that will be executed for the irrigation system.

This chapter presents the key considerations for air quality management, focusing on identifying pollution sources, assessing their effects on air quality and nearby receptors, and implementing mitigation measures to minimize adverse impacts. While temporary air quality impacts are anticipated, appropriate control measures will help reduce emissions and ensure compliance with environmental standards. Negligible impacts are expected during the pre-construction and operational phase.

2.2 Legislation and Standards

Air quality-related EU legislation is extensive, particularly as it also addresses emissions into the air and sets quality standards for internal combustion engines. The governing Directive is Directive 2008/50/EC on ambient air quality and cleaner air for Europe, which establishes the need to reduce pollution to levels that minimize harmful effects on human health, with particular attention to sensitive populations and the environment. The Directive also aims to improve the monitoring and assessment of air quality, including the deposition of pollutants, and provide information to the public. Specifically, it sets limit values for key pollutants such as PM_{10}, $PM_{2.5}$, nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), which should not be exceeded in order to protect human health and the environment.

EBRD Performance Requirements

- EBRD PR 1: Assessment and Management of Environmental and Social Risks and Impacts / This requirement emphasizes the need to identify, assess, and manage potential air quality risks during the Environmental and Social Impact Assessment (ESIA) process. This includes evaluating the impact of emissions from construction activities.
- EBRD PR 3: Resource Efficiency and Pollution Prevention and Control / This performance requirement focuses on a project-level approach to pollution prevention and control, including the minimization of air emissions. It builds on the mitigation hierarchy, which prioritizes addressing environmental damage at its source, and applies the "polluter pays" principle. The project-related risks and impacts associated with resource use, waste generation, and emissions must be assessed in the context of the project location and local environmental conditions, including the proximity to sensitive receptors such as residential areas, agricultural lands, and biodiversity zones.
- EBRD PR 4: Health, Safety and Security / This requirement addresses the potential health risks posed by air pollution, particularly for sensitive groups, including workers and local populations. Given the proximity of the construction site to residential areas in Ub, it is crucial to assess and mitigate risks related to air quality, such as dust exposure and respiratory diseases.

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

2.3 Methodology

An impact assessment has been conducted based on available documents, including the Environmental Impact Assessment (EIA), Project for a Building Permit, and Spatial Plans, as well as the characteristics of the project and the study area. The assessment relied on a review of secondary data sources, including project documentation, publicly available air quality data, and applicable legislation and standards relevant to air pollution and emissions.

In this assessment receptor identification was conducted to determine potential exposure to air pollutants, with a focus on sensitive receptors such as residential areas, schools, healthcare facilities and protected habitats and species. Given the project location, the closest receptors are situated at a distance where significant impacts are not expected; however, temporary increases in dust and pollutant levels may occur during intensive construction activities. This chapter will assess the significance of the impacts related to air quality, considering both the magnitude of the impact (negligible, minor, moderate, and major) and the vulnerability of receptors (low, medium, and high). This assessment will adhere to the methodology outlined in **Book 1 Introduction**. The findings of the impact assessment will serve as a basis for defining mitigation measures and identifying any residual negative impacts where full mitigation is not feasible.

2.4 Assumptions and limitations

Assumptions and limitations presented in the **Book 1 Introduction** are relevant for this topic.

Air Quality specific assumption and/or limitations:

- Lack of readily available baseline ambient air quality data at the project site.
- Data from the nearest monitoring station used as a reference.

2.5 Baseline

This chapter will present the data captured in previous stages of the Project and publicly available official data. No baseline air quality measurements have been conducted at the project site to date.

The EIA study reviewed local and regional sources of air pollution and concluded that local sources have a limited impact due to the low population density, the absence of industrial facilities, and low traffic intensity in the vicinity of the future dam site. The primary regional source of pollution was identified as the 'Kolubara' Mining Basin, specifically the 'Tamnava - West Field' open-pit mine, located approximately 25 km northeast of the project area. No air quality measurements were carried out on-site; instead, data from the nearest monitoring station in Valjevo were considered, showing high concentrations of PM_{10} and benzo(a)pyrene. However, it was assessed that pollutant concentrations at the dam site are expected to be significantly lower due to the low population density and the absence of major emission sources in the immediate surroundings. Based on these findings, the EIA concluded that air quality monitoring is not required, as no significant or long-term negative impacts on air quality are anticipated. However, it has been noted that, if necessary, the competent environmental protection inspector may require measurements, in which case the pollutants to be monitored and the sampling locations would be determined accordingly.

The Environmental Protection Agency of the Republic of Serbia (in the following text: the Agency) conducts systematic air quality measurements within the national monitoring network. Based on data collected from all monitoring stations in the national network, as well as data gathered and processed from local air quality measurement results within local government networks, the Agency prepares the Annual Report on the State of Air Quality in the Republic of Serbia. The nearest monitoring station where air quality is continuously monitored is located in Valjevo, approximately 15 km south of the dam site. However, these measurements cannot be considered fully representative of the area around the future dam and reservoir, nor can they be a reliable reference for air quality at the specific location, as significantly lower levels of pollutants are expected here, especially due to the low population density, absence of industrial facilities, and low traffic intensity.

Therefore, to ensure a more accurate assessment of baseline conditions, ambient air quality monitoring should be conducted during the pre-construction phase in the vicinity of potential sensitive receptors (for detailed information about receptor see Chapter 2.6 Receptors and Area of Influence). While negligible impacts on air quality are expected in this phase—since it primarily involves preparatory activities such as site surveys, geotechnical investigations, and logistical planning—this monitoring will provide reliable site-specific data on key air pollutants, including particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides (NOx), sulfur dioxide (SO_2), and carbon monoxide (CO). The results will serve as a reference for assessing potential impacts during construction and evaluating the effectiveness of mitigation measures.

Given the distance of the nearest monitoring station, the following section presents data on wind patterns and precipitation for the territory of the Ub municipality, obtained from the Meteoblue website[2].

Based on the defined wind rose (see Figure 1 - Wind rose (source https://www.meteoblue.com)), it can be concluded that the most frequent winds in the Ub area come from the east-southeast, west, southeast, and west-northwest. In general, it can be stated that winds in this area do not represent a significant or frequent climatic phenomenon, particularly not those of higher intensity.

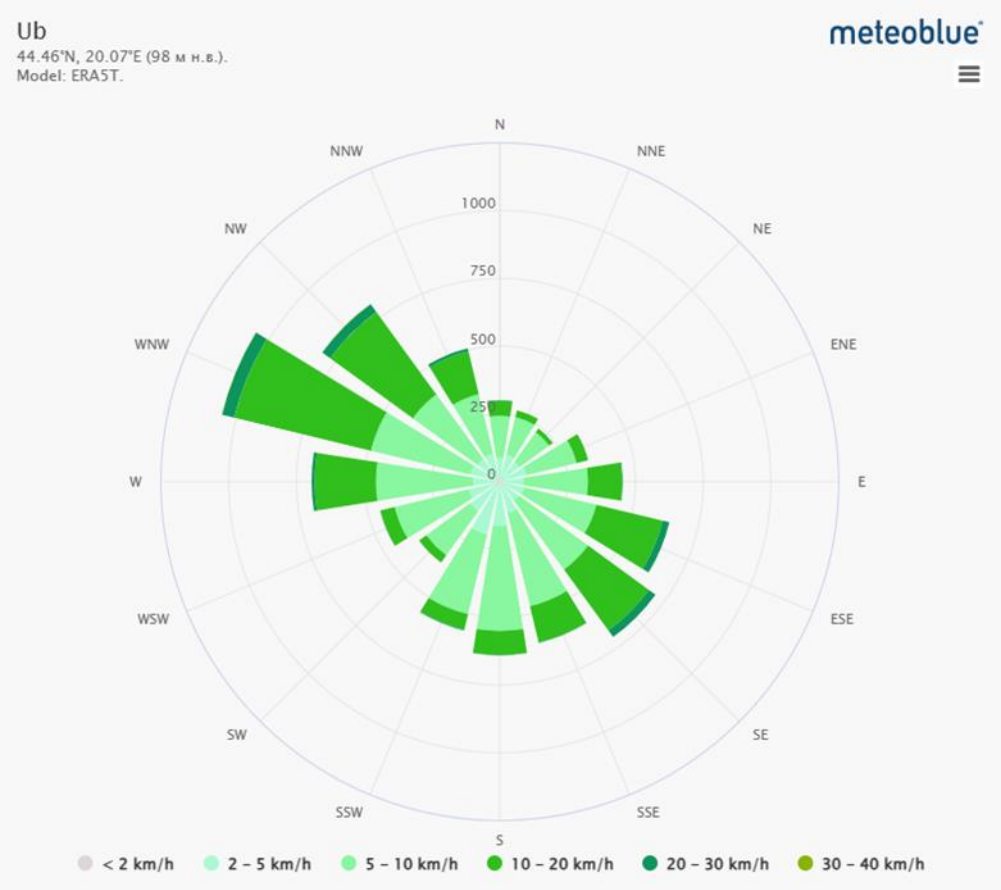

Figure 1 - Wind rose (source https://www.meteoblue.com)

This characteristic of the climatic conditions in the Ub area, with predominantly weak winds and no significant frequent strong winds, is favourable for minimising the spread of dust and pollutant particles from the construction site, thereby reducing the potential impact on air quality in the surrounding area.

The following diagram presents the average monthly rainfall recorded at the Ub station for the period 1958–2023.

[2] https://www.meteoblue.com/sr/vreme/nedeljna/beograd

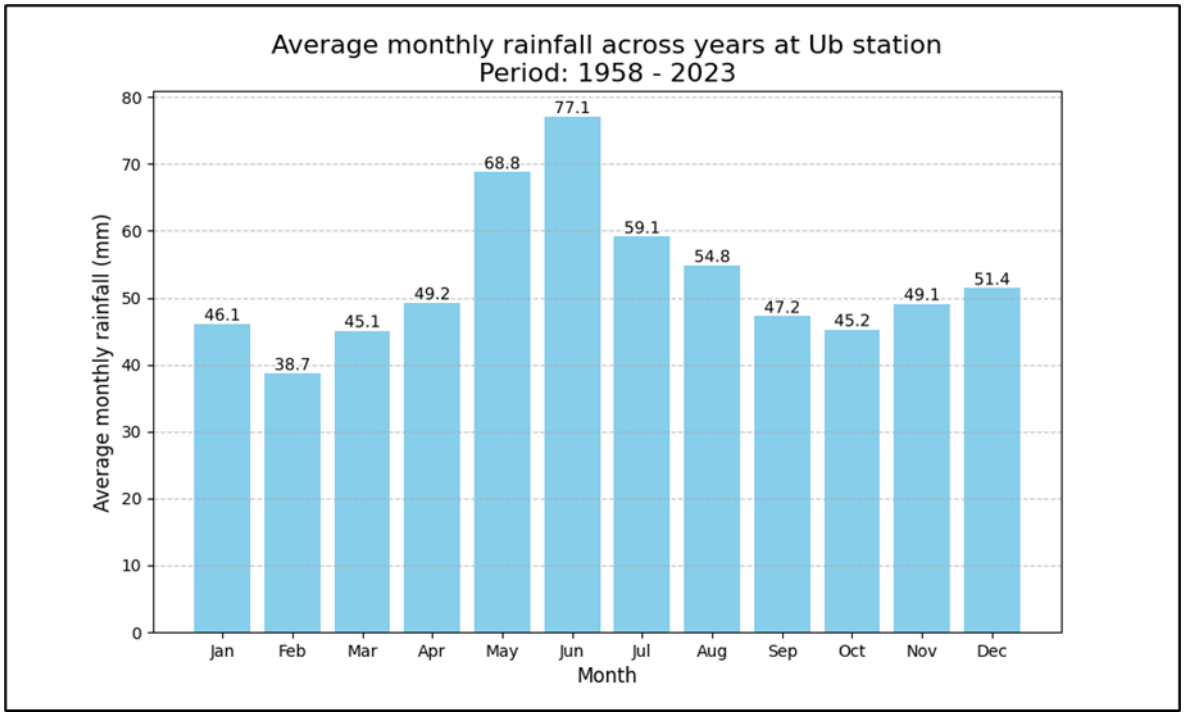

Figure 2 - Average monthly rainfall

Conclusion based on the diagram:

- The highest average monthly precipitation occurs in late spring and early summer, indicating a distinct rainy season.
- The driest period is observed in winter, while precipitation levels remain relatively stable throughout the rest of the year, with a slight increase during the colder months.
- Summer months generally receive significant rainfall, with early summer experiencing the highest values, followed by a gradual decline toward late summer.

Precipitation can have a dual impact on air quality at the dam construction site. On one hand, rain or snow can reduce dust levels by moistening the ground and preventing the dispersion of particles, which is particularly important in areas where excavation and material transport take place. On the other hand, precipitation can cause soil erosion, releasing fine particles that may later become airborne when the ground dries. Additionally, adverse weather conditions can deteriorate access roads, creating mud and complicating transport, which may lead to increased fuel consumption and higher emissions from construction vehicles and machinery. Understanding and monitoring these impacts will allow for more effective air quality protection planning during construction, which is important for minimizing negative environmental effects.

The location of the future dam is within the scope of the Detailed Regulation Plan "Pambukovica Dam on the Ub River" (Official Gazette of the Municipality of Ub, No. 30/16), which states that air quality in the municipality has been largely preserved.

Vegetation is represented in the form of agricultural land, forested areas, and vegetation in the floodplain of the river. Agricultural land consists of meadows, arable land, and boundary vegetation in contact with the arable areas.

Currently, the environment of the Ub municipality is subject to significant pressures from the exploitation of lignite coal, minerals, and non-metallic raw materials. However, negative impacts outside this zone have been minimized to the lowest possible extent. Local sources of air pollution mainly include individual heating systems, traffic, agriculture, waste disposal sites, and temporary borrow pits. These are mostly relatively small sources of pollution, but they are important for local air quality.

In the immediate vicinity of the future reservoir, there are very few residential buildings, so the use of individual heating systems does not have a significant impact on air quality. There are no industrial facilities nearby. The existing transport network is very underutilised, so no significant impact on air quality is expected from this source.

For the purposes of the project, the proposed construction materials are coarse aggregate (with a specific granulometric composition) from the Cucuge quarry and sandy material from the "Kopovi Ub" company's disposal site. These material extraction sites are located approximately 5 km from the construction site, within the territory of the Ub municipality. Also, material storage sites for excavated material will be located up to 1.5 km from the dam profile (For more detailed information, please refer to the Chapter Resources and Material Management).

2.6 Receptors and Area of Influence

The construction of the dam may lead to increased dust levels and emissions of air pollutants such as particulate matter (PM), nitrogen oxides (NOx), and sulphur oxides (SOx). These pollutants can adversely affect sensitive receptors, including crops, habitats and species within the area of influence. Dust deposition on crops could inhibit photosynthesis, reduce growth rates, and potentially lower yields.

The area of influence encompasses the zone immediately surrounding the construction site, borrow pits, quarries, and material storage sites, where the most significant impacts will occur.

The area of influence around the dam construction site would generally extend up to 250 m from the main area of construction, i.e. the border of the dam itself. At the borrow pit locations, the impact zone would likely extend 500 m from the drilling, blasting and material loading area.

The area of influence around the quarries is expected to extend approximately 50 m, while for material storage sites for excavated material, it is estimated to be around 200 m.

Along roads used to transport materials, the impact zone extends from 50 to 100 m on either side of the road, where truck dust and exhaust emissions can affect air quality. Additionally, the construction zone along the relocated section of State Road IB No. 21 is expected to have an air quality impact extending up to 200 m from construction activities.

Receptors related to air quality include:

- Crops (agricultural areas that may be affected by dust deposition);
- Residential areas – Households along the access roads in Raduša, Slatina, and Pambukovica. A particular focus is placed on sensitive receptors within these areas, including individuals with respiratory conditions, children, and the elderly, provided that the project’s air quality impacts could significantly affect their living conditions.
- Habitats and species (sensitive receptors include protected species from terrestrial fauna, such as amphibians, reptiles, bats, and birds. For further details, refer to the biodiversity section).

Additionally, the assessment has considered the presence of educational, healthcare, and elderly care facilities within the potentially affected area. It has been identified that the Pambukovica Health Center and the Primary School in Pambukovica are located along the regional road Ub–Koceljeva, which is proposed for transporting machinery to the construction site. The proximity of these facilities to the transportation route may increase exposure to dust and emissions generated by vehicles. Therefore, appropriate mitigation measures should be implemented to minimize potential impacts on these sensitive receptors.

The following map (Figure 3 - Expected Area of Influence in terms of Air Quality) illustrates the project’s area of influence on air quality during the second phase too, specifically the construction of the irrigation system, which includes both the primary and secondary distribution networks along with associated installations.

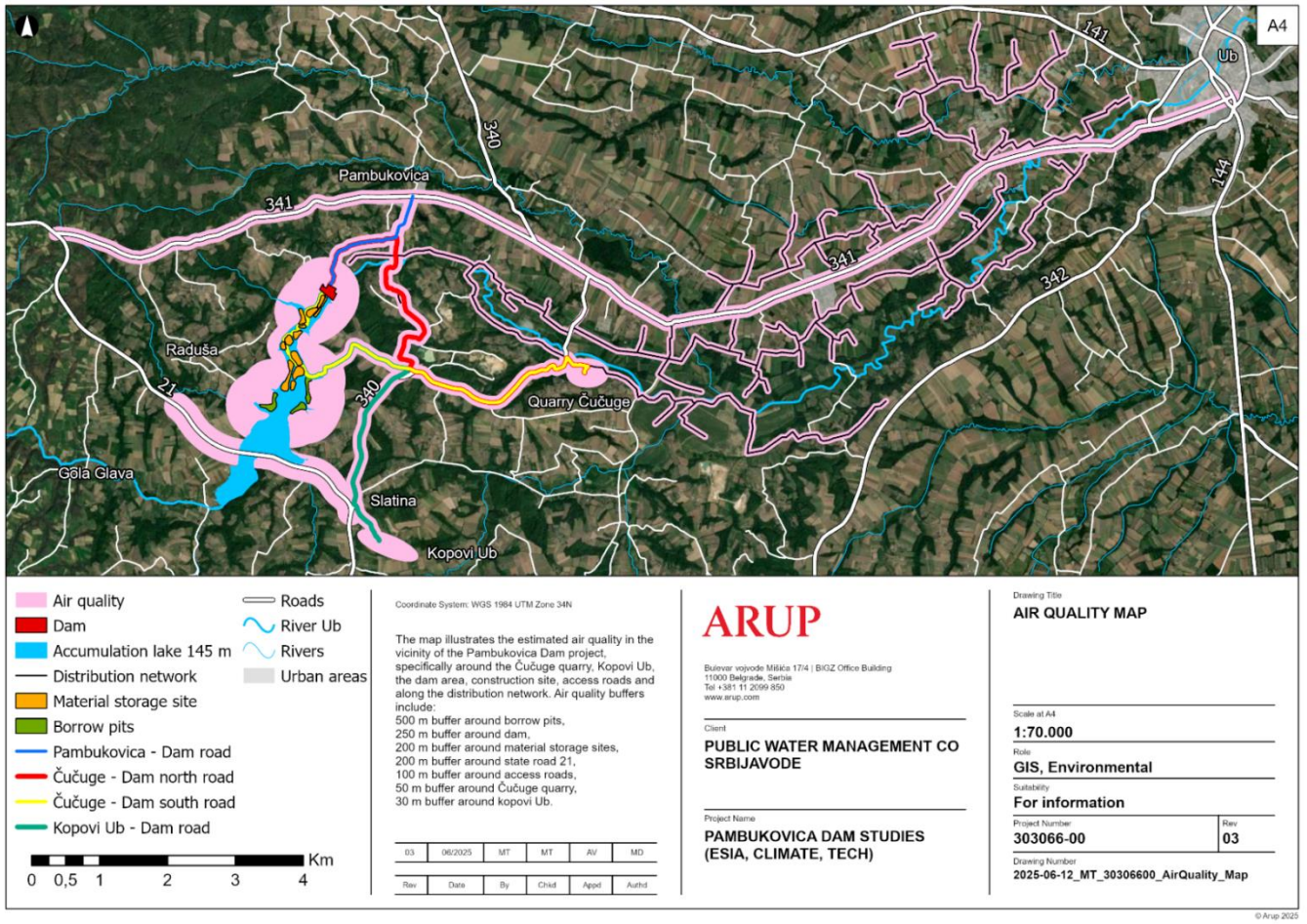

Figure 3 - Expected Area of Influence in terms of Air Quality

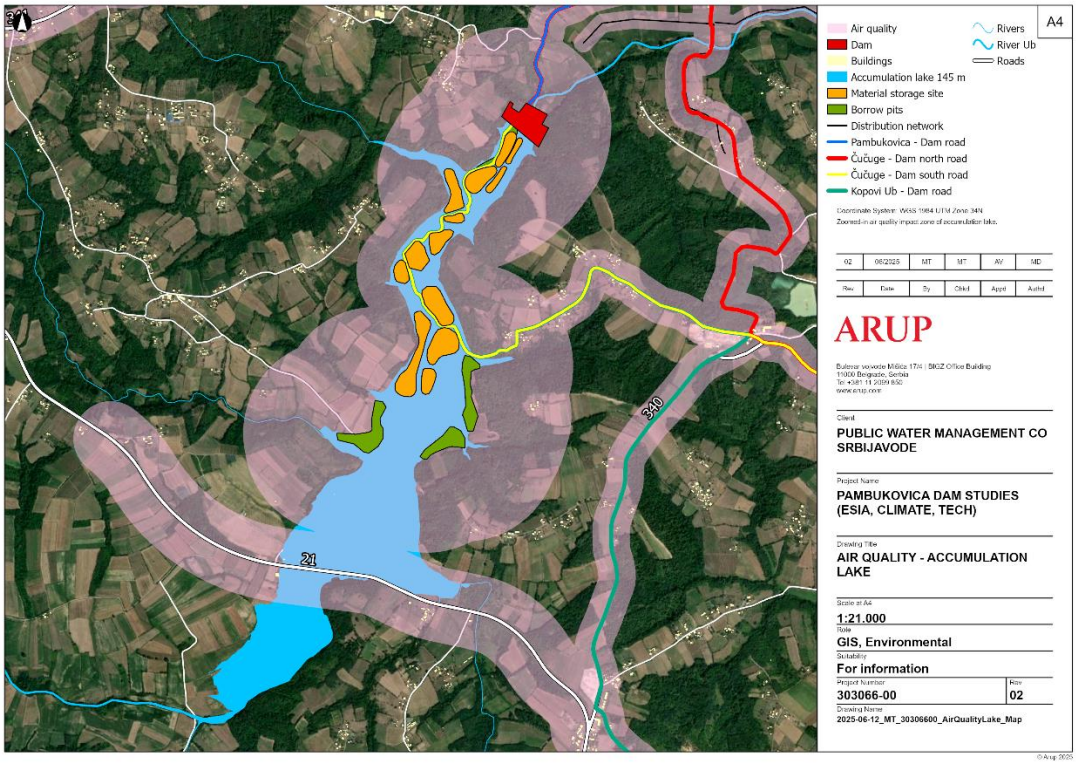

Figure 4 - Expected Area of Influence on Air Quality around Accumulation

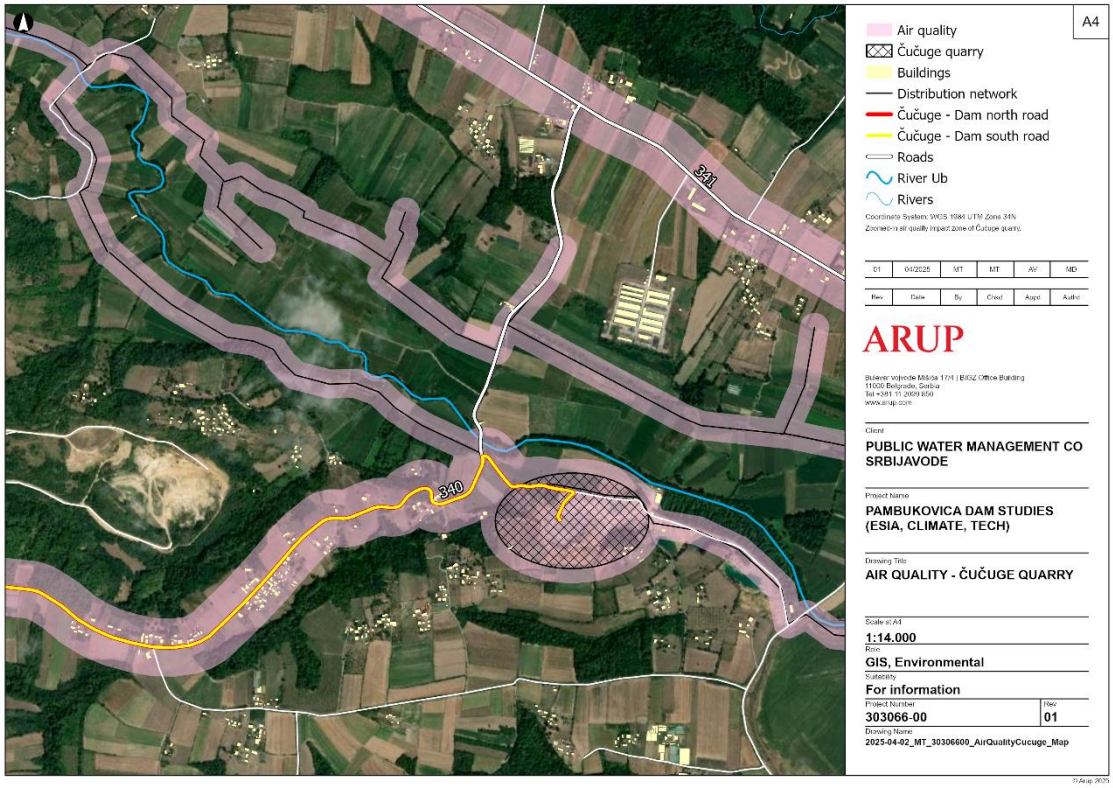

Figure 5 - Expected Area of Influence on Air Quality around Cucuge quarry

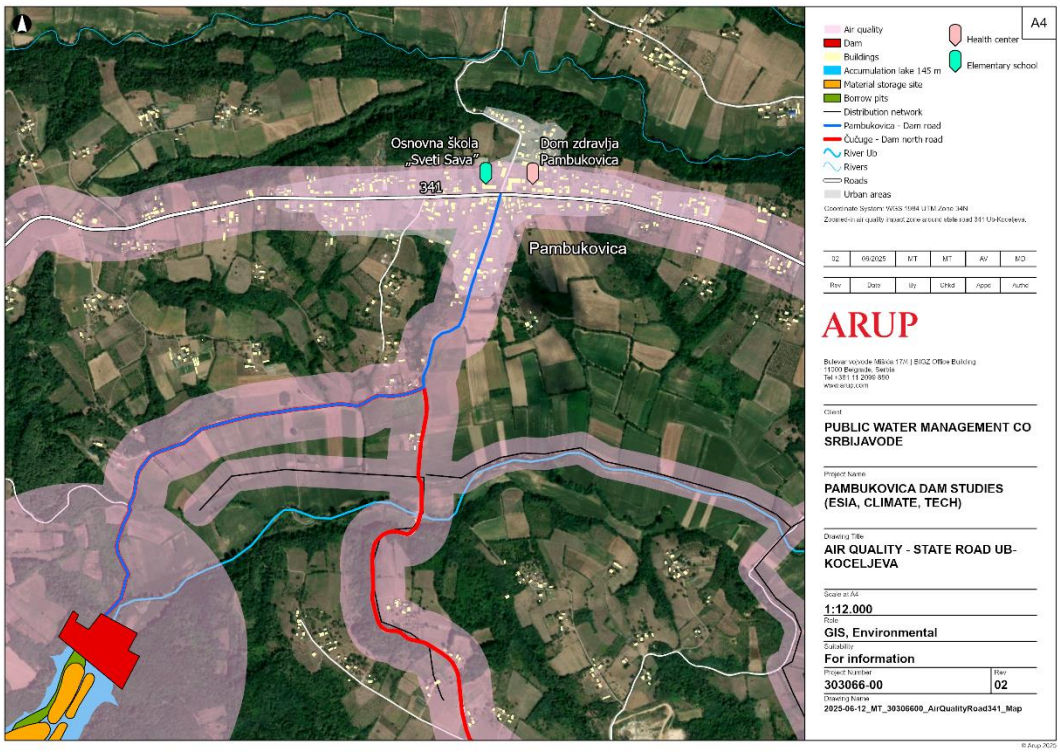

Figure 6 - Expected Area of Influence on Air Quality near Sensitive Receptors in Pambukovica

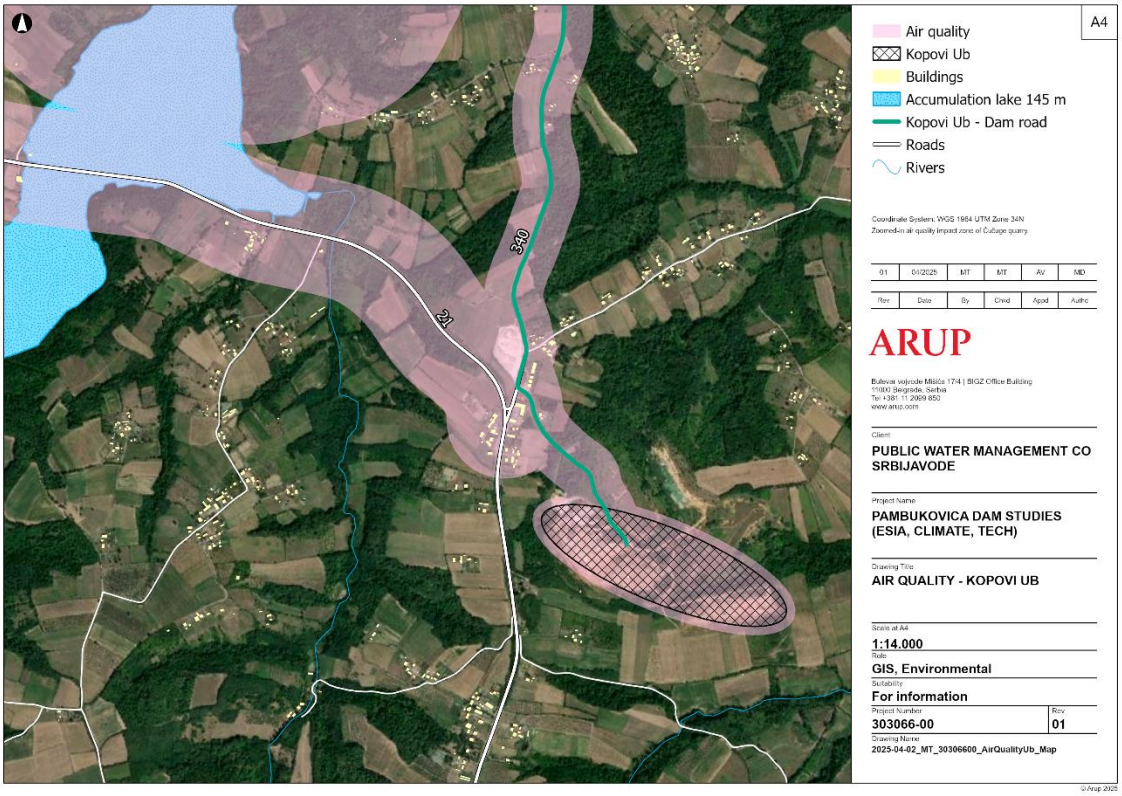

Figure 7 - Expected Area of Influence on Air Quality around Kopovi "Ub"

2.7 Project Activities and Identification of Impacts

Air quality impacts are expected to occur during the construction, and decommissioning phases of the Project. Negligible impacts are expected during the pre-construction and operation phase.

Activities within the Project that may lead to impacts on air quality are:

- Land clearing: May cause increased dust emissions, especially in dry conditions,
- Excavation: Dust and particulate matter (PM_{10} and $PM_{2.5}$) will be released from digging and drilling activities,
- Transportation: Increased dust and exhaust emissions from transporting materials, especially on unpaved roads,
- Rock blasting: Can release dust and small particles into the air,
- Machinery operation: Equipment like bulldozers and excavators will emit exhaust gases (e.g., NOx, CO) and dust.
- Demolition activities and material transportation off-site: Dust and emissions will be generated during the removal of structures and the transport of demolition waste

Impacts Identification

- Increased levels of air pollution due to increase of dust from construction works, excavations, operation of machinery, machine movement, potential blasting and operation of the quarry, as well as demolition activities and transportation of demolition waste off-site;
- Increased levels of air pollution due to emissions from machinery used for construction works, truck movement during material transport, potential operation of batch plant, and demolition activities.

2.8 Impact Assessment and Mitigation

2.8.1 Pre-construction

During the pre-construction phase, negligible impacts on air quality are expected, as this phase primarily involves preparatory activities such as site surveys, geotechnical investigations, and logistical planning. These activities do not include large-scale land clearing, excavation, or material transport, which are the primary sources of dust and emissions during later project phases.

However, to ensure an accurate assessment of baseline conditions, ambient air quality monitoring will be conducted prior to construction. This monitoring will provide reliable site-specific data on key air pollutants, including particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides (NOx), sulfur dioxide (SO_2), and carbon monoxide (CO). The results will serve as a reference for evaluating potential impacts during construction and the effectiveness of mitigation measures.

Activities during the preconstruction stage are not expected to result in a significant increase in dust generation or emissions, as no machinery will be utilized, and no extensive earthworks will be executed. As a result, the impacts are categorized as indirect, local, and temporary, resulting in a negligible magnitude. Given the presence of sensitive receptors in the area, which are considered to have a medium level of vulnerability from a conservative perspective, the significance of the impacts of increase in dust generation and increase in emissions is deemed negligible.

This description applies specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 1.

2.8.2 Construction

The construction phase is expected to involve extensive earthworks, including land clearing, the operation of heavy machinery, material transportation, and rock blasting. These activities are anticipated to generate significant amounts of dust and emissions. Machinery such as excavators, bulldozers, and trucks, which are powered by internal combustion engines, are expected to emit exhaust gases including nitrogen oxides (NOx), sulphur dioxide (SO_2), carbon monoxide (CO), and volatile organic compounds (VOCs).

Blasting activities, although localised, are likely to contribute to increased particulate matter (PM) and gaseous emissions. Air quality impacts are assumed to be most pronounced within the immediate vicinity of material extraction sites, particularly within an estimated 500-metre radius, where localised dust and emissions are expected to be higher.

Additionally, construction traffic, including heavy trucks and equipment operating along transport roads, is likely to result in dust generation and exhaust emissions from combustion engines, potentially affecting air quality within a certain distance on either side of the roads.

Concrete works and the construction of embankments are also expected to contribute to localised air quality impacts due to the operation of machinery and the movement of materials.

The impact on air quality during the construction of the irrigation system will primarily be associated with dust generation and emissions from construction machinery and transport vehicles. However, due to the phased execution of works and the dispersed nature of activities, these impacts will be localised and temporary, with the possibility of implementing mitigation measures to reduce dust and gas emissions (e.g., surface watering, optimization of transport routes).

The impact of increase in dust generation will be direct, localised, and short-term; therefore, its magnitude is considered moderate. Given that sensitive receptors are present in the area and their vulnerability is assessed as medium from a conservative standpoint, the significance of the impact is regarded as moderate.

Furthermore, the impact of increase in emissions will be direct, localised, and short-term, leading us to conclude that its magnitude will be minor. Given the presence of sensitive receptors in the area and a conservative assessment of their vulnerability as medium, we determine that the significance of the impact is moderate.

These descriptions apply specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 1.

Mitigation measures will include, but are not limited to:

- use newer generation vehicles with installed system for emission reduction;
- ensure regular maintenance of machinery;
- optimized traffic management to reduce congestion and emissions (reduction of speed, traffic management to avoid congestion and road overloading, avoid idling the machine as much as possible, etc.);
- application of dust suppression techniques, such as water spraying, particularly near blasting sites, material loading areas, and along transport routes;
- covering materials during transport and while they are stockpiled at the construction site to minimize dust dispersion.
- effective communication among personnel on-site to ensure the proper implementation of mitigation measures.
- regular dust monitoring surveys (PM_{10} and $PM_{2.5}$) will be conducted in proximity to sensitive receptors.

2.8.3 Operation

In contrast to the construction phase, this stage is characterized by activities that do not generate significant dust or emissions. As a result, the impact will be indirect, local, and temporary, leading to a negligible magnitude. While sensitive receptors may experience medium sensitivity to emissions and dust generation, they are not expected to be significantly affected by the Project in this stage. Consequently, the overall impact is considered negligible, and no mitigation measures are required.

This description applies specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 1.

2.8.4 Decommissioning

The decommissioning phase will involve the demolition and dismantling of infrastructure and the removal of materials. Similar to the construction phase, dust and emissions will be generated during demolition activities and transportation of materials off-site.

Considering the demolition activities and the transportation of demolition waste off-site, the impact of increase in dust generation will be direct, localised, and temporary and therefore, its magnitude is considered moderate. Given that sensitive receptors are present in the area and their vulnerability is assessed as medium from a conservative standpoint, the significance of the impact is regarded as moderate.

Increase in emissions: The decommissioning phase will involve significant machinery usage and truck movement for material transportation. Consequently, this impact is direct, localised, and temporary, leading us to conclude that its magnitude will be minor. Given the presence of sensitive receptors in the area and a conservative assessment of their vulnerability medium, we determine that the significance of the impact is minor.

These descriptions apply specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 1.

Since the impacts are similar to those during the construction phase, similar mitigation measures will be applied, such as:

- Use newer generation vehicles with installed systems for emission reduction.
- Ensure regular maintenance of machinery.
- Optimized traffic management to reduce congestion and emissions (reduction of speed, traffic management to avoid congestion and road overloading, avoid idling the machine as much as possible, etc.).
- Application of dust suppression techniques, such as water spraying, particularly near demolition activities, material loading areas, and along transport routes.
- Covering demolition waste during transport to minimize dust dispersion.
- Covering the demolition site with a shade cloth to prevent the dispersion of dust.

All the mitigation measures outlined in this chapter will be detailed in the CESMP (Contractor's Environmental Management Plan). Additionally, measures related to traffic management to reduce air quality impacts will be included in the TMP (Traffic Management Plan).

Table 1 - Impact Assessment Table – Air Quality

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Air Quality	Increased levels of air pollution due to emissions Pre-construction and operations Non-sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica, habitats and species within area of influence	Negligible	Low	Negligible	Not required	Negligible
Air Quality	Increased levels of air pollution due to emissions Pre-construction and operations Sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Habitats and species (sensitive receptors -protected species from terrestrial fauna, such as amphibians, reptiles, bats, and birds. For further details, refer to the Book 4 – Biodiversity Impact Assessment).	Negligible	Medium	Negligible	Not required	Negligible
Air Quality	Increased levels of air pollution due to emissions Construction and decommissioning Non-sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica, habitats and species within area of influence	Minor	Low	Negligible	Not required	Negligible

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Air Quality	Increased levels of air pollution due to emissions Construction and decommissioning Sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Habitats and species (sensitive receptors -protected species from terrestrial fauna, such as amphibians, reptiles, bats, and birds. For further details, refer to the Book 4 – Biodiversity Impact Assessment).	Minor	Medium	Minor	Use newer generation vehicles with installed system for emission reduction, Avoid idling the machine as much as possible, Ensure regular maintenance of machinery	Negligible
Air Quality	Increased levels of air pollution due to increase of dust Construction and decommissioning Non-sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica, crops within area of influence, habitats and species within area of influence	Moderate	Low	Minor	Water-spraying of roads and dusty materials stockpiles, Introduce speed limit for vehicles on site and access roads, Covering materials during transport and while they are stockpiled at the construction site	Minor
Air Quality	Increased levels of air pollution due to increase of dust Construction Sensitive receptors	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly);	Moderate	Medium	Moderate	Water-spraying of roads and dusty materials stockpiles, Introduce speed limit for vehicles on	Minor

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
		Pambukovica Health Center and the Primary School in Pambukovica: Habitats and species (sensitive receptors -protected species from terrestrial fauna, such as amphibians, reptiles, bats, and birds. For further details, refer to the biodiversity section).				site and access roads, Covering materials during transport and while they are stockpiled at the construction site Regular dust monitoring surveys (PM_{10}, $PM_{2.5}$).	
Air Quality	Increased levels of air pollution due to increase of dust Decommissioning Sensitive receptors	Habitats and species (sensitive receptors -protected species from terrestrial fauna, such as amphibians, reptiles, bats, and birds. For further details, refer to the biodiversity section).	Moderate	Medium	Moderate	Application of dust suppression techniques, such as water spraying, particularly near demolition activities, material loading areas, and along transport routes; Covering demolition waste during transport to minimize dust dispersion. Covering the demolition site with a shade cloth to prevent the dispersion of dust.	Minor

Table 2 - Mitigation and Monitoring – Air Quality

Type of Impact	Potential Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Air Quality	Increased levels of air pollution due to increase of dust. Pre-construction	Sensitive receptors	A preconstruction ambient air quality monitoring will be conducted to establish baseline air quality conditions, measuring key pollutants (PM_{10}, $PM_{2.5}$, NOx, SO_2, CO).	Before construction activities begin. Monitoring will be conducted for a period of at least one month, covering representative weather conditions.
Air Quality	Increased levels of air pollution due to increase of dust Increased levels of air pollution due to emissions Construction and decommissioning	Settlements along access road in Radusa, crops within area of influence, habitats and species within area of influence	Regular air monitoring surveys (PM_{10}, $PM_{2.5}$, NOx, SO_2, CO) will be conducted in proximity to sensitive receptors.	Ongoing monitoring on a regular basis (monthly) during construction/decommissioning activities.
			Visual monitoring. Develop and implement CESMP, which includes detailed dust and emission control and mitigation measures. Develop and implement TMP, which includes detailed dust and emission control and mitigation measures.	During construction and decommissioning activities/daily/beginning of activities on site

3. Noise and Vibrations

3.1 Introduction and Purpose

Effective noise and vibration management is essential to minimizing disturbances to local communities and reducing environmental impacts during the construction and decommissioning phases of the Project. Temporary increases in noise and vibration levels are expected due to excavation works, material transportation, and road construction and maintenance. Key sources include heavy machinery operation, blasting activities, and increased traffic from trucks and other construction vehicles. The analysis conducted in this chapter encompasses the activities planned for the dam, along with a high-level overview of those that will be executed for the irrigation system.

This chapter outlines the approach to identifying noise and vibration sources, assessing their potential effects on nearby settlements and sensitive receptors, and implementing mitigation measures to minimize disturbances. While some noise and vibration impacts are inevitable, proper planning and the application of best practices will help reduce negative effects and ensure compliance with regulatory standards. Negligible impacts are expected during the operational phase.

3.2 Legislation and Standards

EU legislation

The Environmental Noise Directive (Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002. relating to the assessment and management of environmental noise - Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise) is the main EU law to identify noise pollution levels and act on them. It focuses on four action areas:

- determining exposure to environmental noise and assessing its health effects at single dwelling level,
- ensuring that information on environmental noise and its effects is made available to the public,
- preventing and reducing environmental noise,
- preserving environmental noise quality in areas where it is good.

EBRD Performance Requirements

- EBRD PR1: Assessment and Management of Environmental and Social Impacts and Issue;
- EBRD PR 3: Resource Efficiency and Pollution Prevention and Control;
- EBRD PR 4: Health, Safety and Security.

National legislation

- Environmental Noise Protection Law ("Official Gazette Republic of Serbia", No. 96/2021),
- Regulation on noise indicators, limit values, methods for assessing noise indicators, disturbance and adverse effects of noise in the environment ("Official Gazette Republic of Serbia", No. 75/2010),
- Regulation on permitted environmental noise levels ("Official Gazette Republic of Serbia", No. 54/92, 72/2010-95,96,97),
- Regulation on noise measurement methods, content and scope of noise measurement report ("Official Gazette Republic of Serbia", No. 72/2010),

- Regulation on the conditions to be met by a professional noise measurement organization, as well as documentation submitted with the request for obtaining a noise measurement permission ("Official Gazette Republic of Serbia", No. 72/2010),
- Regulation on the content and methods of making strategic noise maps and the way they are presented to the public ("Official Gazette Republic of Serbia", No. 80/2010),
- Regulation on the methodology for the determination of acoustic zones ("Official Gazette Republic of Serbia", No. 72/2010),
- Regulation on the methodology for the determination of acoustic zones ("Official Gazette Republic of Serbia", No. 72/2010).

Article 4 of the Environmental Noise Protection Law ("Official Gazette of the Republic of Serbia", No. 96/2021) defines a noise source as: *A noise source is any emitter of unwanted or harmful sound resulting from human activities: any device, working tool, means of transportation, installation of equipment, technological process, electroacoustic and acoustic device, as well as a device used for performing industrial, craft, production, service, and similar activities that generates constant or occasional noise, both movable and stationary objects that under certain circumstances generate sound, and also open and closed spaces for sports, play, dance, performances, concerts, music listening, etc., as well as hospitality establishments, garages, parking spaces, etc.*

In accordance with Article 18 of the Environmental Noise Protection Law ("Official Gazette of the Republic of Serbia", No. 96/2021), the legal entity that owns or uses the noise source is obligated to conduct the initial noise measurement at the location before putting the noise source into operation and to obtain a noise measurement report from an authorized professional organization.

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

3.3 Methodology

An impact assessment has been conducted based on available documents, including the Environmental Impact Assessment (EIA), Project for a Building Permit, and Spatial Plans, as well as the characteristics of the project and the study area. The assessment relied on a review of secondary data sources, including project documentation, publicly available noise and vibration data, and applicable legislation and standards relevant to environmental noise and vibration limits.

In this assessment receptor identification was conducted to determine potential exposure to noise and vibration, with a focus on sensitive receptors such as residential areas, schools, healthcare facilities and protected habitats and species. Given the project location, the closest receptors are situated at a distance where significant impacts are not expected; however, temporary increases in noise and vibration levels may occur during intensive construction activities. This chapter will assess the significance of the impacts related to noise and vibrations, considering both the magnitude of the impact (negligible, minor, moderate, and major) and the vulnerability of receptors (low, medium, and high). This assessment will adhere to the methodology outlined in **Book 1 - Introduction**. The findings of the impact assessment will serve as a basis for defining mitigation measures and identifying any residual negative impacts where full mitigation is not feasible.

3.4 Assumptions and limitations

Assumptions and limitations presented in the Book 1 Introduction are relevant for this topic.

Noise and Vibrations specific assumption and/or limitations:

- Lack of baseline noise and vibration measurements at the Project location. No official data is available for the Project location.

- Assumptions have been made based on general environmental conditions and information available in the Environmental Impact Assessment (EIA) study.

3.5 Baseline

This chapter will present the data captured in previous stages of the Project and publicly available official data. Noise and vibration measurements have not been carried out at the future dam site for the purposes of the Project and the assessment of the baseline environmental conditions.

The Environmental Impact Assessment (EIA) study has addressed the issue of noise and its potential impact on the environment and public health. Existing noise levels, sources of noise, and possible impacts during the construction and operation of the dam have been analysed. It has been concluded that the current noise levels in the project area mainly originated from natural sources and occasional human activities, with the dominant sources being local traffic and agricultural machinery. Noise levels in this area generally do not exceed thresholds that could cause significant negative effects on the population.

Regarding noise during construction, the EIA has assessed that noise generated by construction machinery will be intermittent and localised, and given the distance of residential buildings, it is not expected to have a significant negative impact on public health. The EIA has also stated that traffic noise from material transport will not significantly contribute to overall noise levels, as residential settlements are located outside the main transport routes designated for material transport.

The EIA has further considered that there are no sensitive receptors in the immediate vicinity and that noise impacts will be local, reversible, and temporary. Based on this, the study has concluded that noise level monitoring is not foreseen. However, it has been noted that, if necessary, the competent environmental protection inspector may require measurements, in which case measurement locations and methodologies for monitoring noise levels would be determined.

According to Article 18 of the Environmental Noise Protection Law, the legal entity that owns or operates a noise source is obligated to conduct an initial noise measurement at the location before putting the noise source into operation and to obtain a noise measurement report from an authorized professional organization. Given that construction machinery and activities within the Project represent noise sources in accordance with Article 4 of the same law, there is a regulatory obligation to conduct initial noise measurements before the commencement of works.

Within the territory of the Republic of Serbia, noise levels in the environment are regulated through systematic measurements conducted by local government units. The Serbian Environmental Protection Agency consolidates the results of these measurements in its Environmental State Reports. According to the 2023 Report, no noise measurements have been performed within the Municipality of Ub.

For the purposes of this Project, the Detailed regulation plans for the "Pambukovica Dam on the Ub River" ("Official Gazette of the Municipality of Ub", No. 30/16) and the Detailed regulation plan for the dam and multipurpose reservoir "Pambukovica" on the Ub River, within the territory of the City of Valjevo ("Official Gazette of the City of Valjevo", No. 4/17) have been defined. The areas covered by these Plans include the following public-use areas:

- the area designated for the dam and multipurpose reservoir,
- the protective greenbelt of special purpose and
- transport surfaces.

The area within the Project's scope is characterized by a rural environment, predominantly consisting of agricultural land, dispersed and sparsely populated settlements, with no industrial facilities present. Consequently, it is assumed that there are no elevated noise levels arising from anthropogenic impacts or industrial installations.

Residential buildings to the north and east are situated at distances greater than 500 m, while the nearest residential buildings to the west are located approximately 363 m away. In assessing the potential noise impact on the population, this distance must be taken into account, given that noise levels tend to decrease with distance from the noise source.

With regard to vibrations, no baseline vibration measurements have been conducted for the purposes of this Project. However, given the rural character of the area and the absence of industrial facilities or heavy traffic, it is assumed that existing vibration levels are low.

The main potential sources of vibrations under current conditions are limited to occasional local road traffic, primarily agricultural machinery, and potentially construction equipment associated with the development of rural infrastructure. The existing road network in the area is not characterised by high traffic volumes or frequent passage of heavy vehicles that could lead to elevated environmental vibration levels.

3.6 Receptors and Area of Influence

The area of influence (AoI) for noise and vibrations around the dam construction site would generally extend up to 250 m from the main area of construction (i.e. the border of the dam itself). Furthermore, it would extend between 300 and 500 m from the borrow pits. This is where the highest levels of noise from heavy machinery, blasting, and loading material will take place. Around the quarries, the AoI is expected to extend approximately 50 m, while for material storage sites for excavated material, it is estimated to be around 200 m.

Along roads used for material transport, the AoI for noise and vibrations extends from 50 to 100 m on either side of the road. Lastly, the construction zone along the relocated section of State Road IB No. 21 is expected to have a noise and vibration impact extending up to 200 m from construction activities.

Receptors affected by noise and vibration levels include:

- Residential areas - Households along the access roads in Raduša, Slatina, and Pambukovica. A particular focus is placed on sensitive receptors within these areas, including individuals with respiratory conditions, children, and the elderly, as increased noise and vibration levels may significantly affect their living conditions;
- Habitats and species (sensitive receptors include protected species from terrestrial fauna (such as amphibians, reptiles, bats and birds) and aquatic fauna (such as fish and aquatic macroinvertebrates). For further details, refer to the **Book 4 – Biodiversity Impact Assessment**).

As previously mentioned in the Air Quality chapter, the assessment has also considered the presence of educational, healthcare, and elderly care facilities within the potentially affected area. The Pambukovica Health Center and the Primary School in Pambukovica are located along the regional road Ub–Koceljeva, which is proposed for transporting machinery to the construction site. The proximity of these facilities to the transportation route may result in increased exposure to noise levels. Therefore, appropriate mitigation measures should be implemented to minimize potential impacts on these sensitive receptors.

The installation of supply and irrigation pipes within the dam's irrigation zone generally does not produce high noise and vibration levels compared to other construction activities, such as excavation of foundation pits, blasting, or the operation of heavy machinery for site preparation. The works related to pipe installation mainly involve trench excavation (using excavators and bulldozers), welding and joining of pipes, and backfilling of trenches, which may result in short-term and moderate noise and vibration levels. The intensity of noise and vibrations depends on the type of machinery used and the duration of the works. The area of influence (AoI) for noise and vibrations around the pipe installation site is estimated to be approximately 30 m.

As the works progress gradually along the pipeline route, the source of noise and vibrations is constantly shifting, meaning that individual receptors will only be exposed to temporary and limited impacts. If the

works are carried out near residential areas, temporarily elevated noise levels may affect the comfort of residents; however, values that could cause serious health effects are not expected.

Noise and vibrations may have a transient effect on wildlife, but due to the gradual progression of the works and the fact that these activities generate lower noise and vibration levels than, for example, blasting or quarry operations, no long-term negative effects are anticipated.

The following map (Figure 8) illustrates the project's area of influence on noise and vibration levels during both project phases.

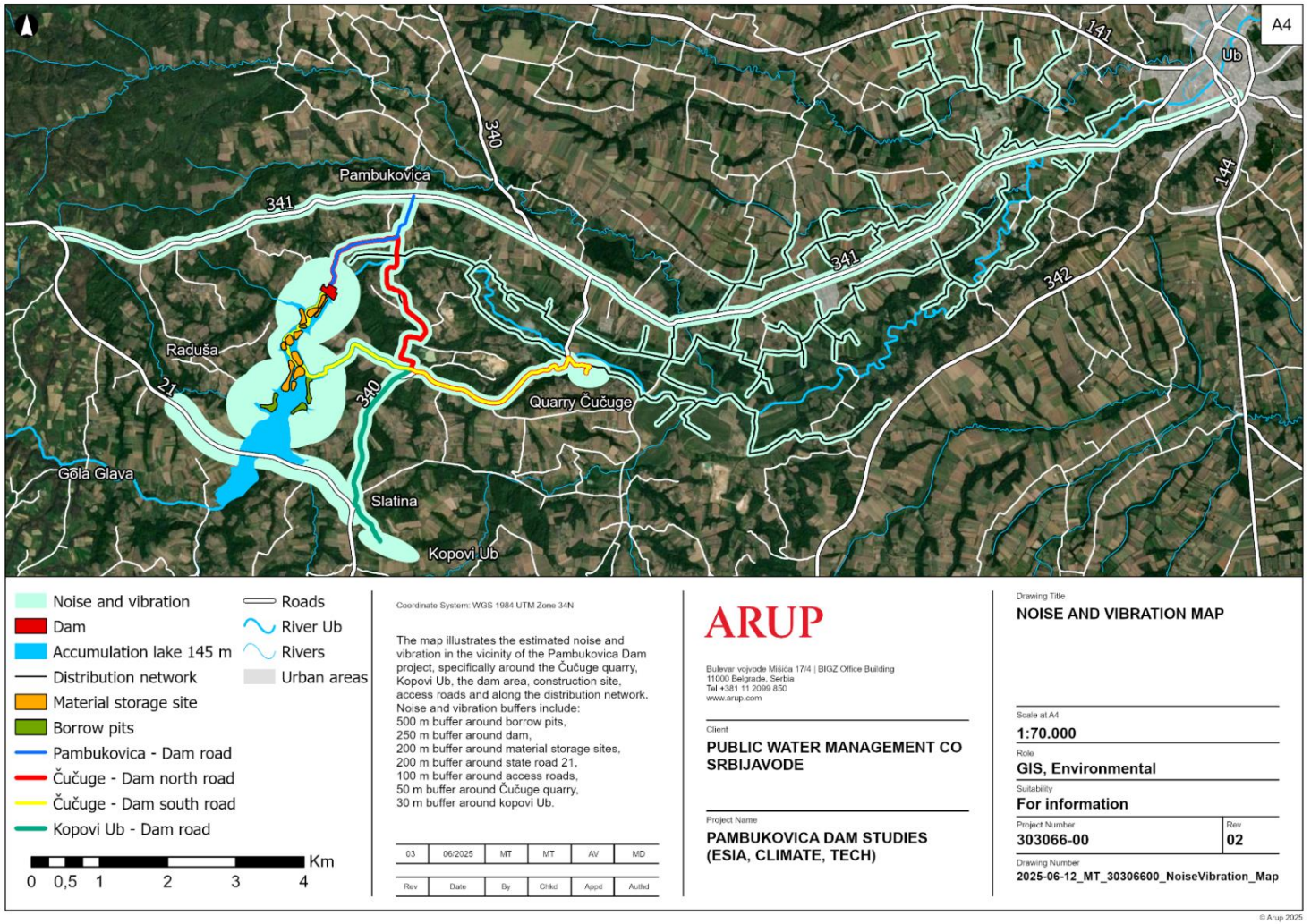

Figure 8 - Expected Area of Influence in terms of Noise and Vibrations

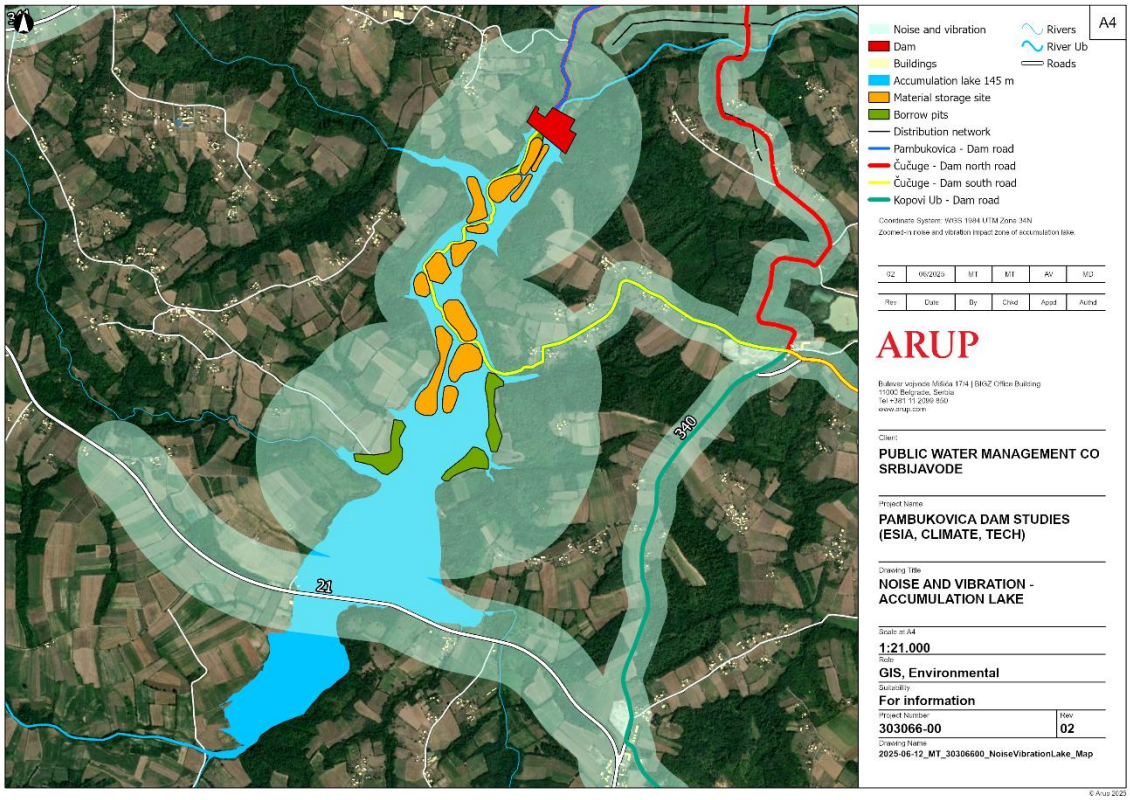

Figure 9 - Expected Area of Influence on Noise and vibrations around Accumulation

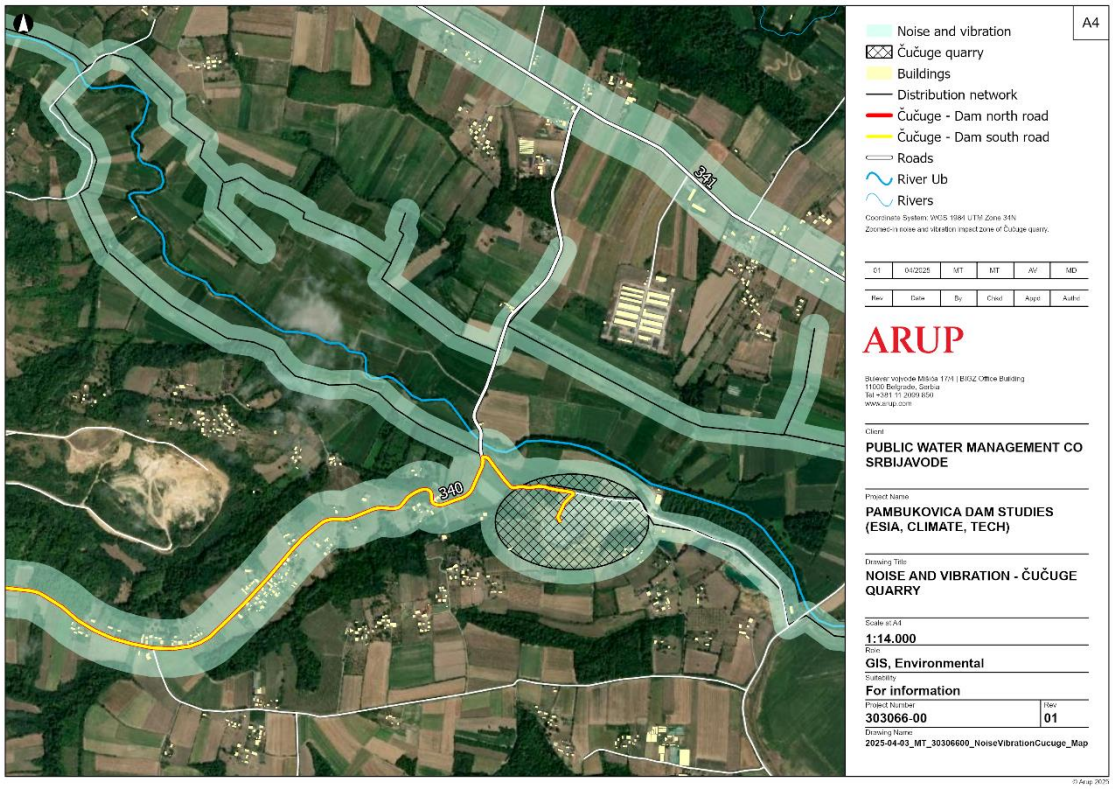

Figure 10 - Expected Area of Influence on Noise and vibrations around Quarry

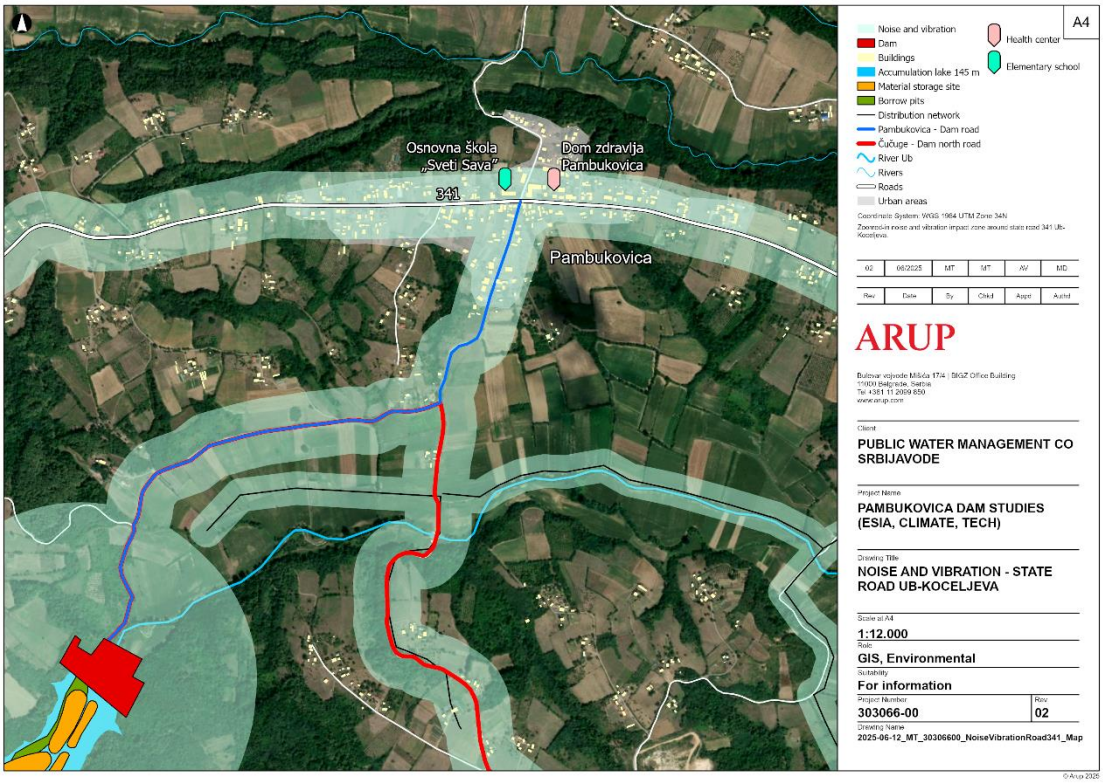

Figure 11 - Expected Area of Influence on Noise and vibrations around State road Ub – Koceljeva

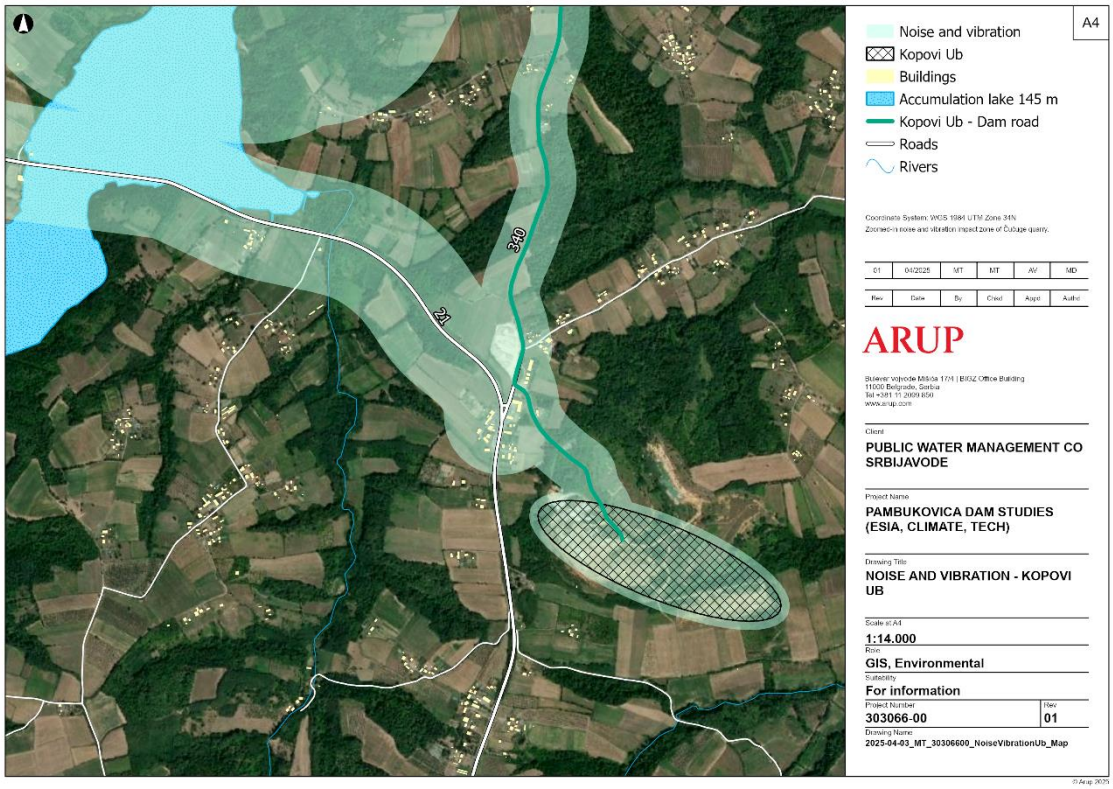

Figure 12 - Expected Area of Influence on Noise and vibrations around Kopovi Ub

3.7 Project Activities and Identification of Impacts

An increased level of noise and vibration is expected only temporarily during the execution of works, both at the borrow pits and at the location of the future dam. Regarding the pre-construction and operation phase, negligible impact on noise and vibration levels are expected, while impacts during the decommissioning phase are expected to be similar to that during the construction phase.

Activities within the Project that may lead to increased noise levels and vibration include:

- excavation works (involves heavy machinery such as excavators, bulldozers, and blasting operations for rock excavation),
- transportation of materials (increased traffic from trucks and other vehicles transporting materials from borrow pits and quarry to the construction site),
- construction and maintenance of access roads,
- demolition activities (involving heavy machinery such as excavators, bulldozers, and the dismantling of structures during the decommissioning phase),
- blasting activities.

Impact Identification

- Increased noise level due to excavation works, material transportation, and road construction/maintenance, and demolition activities;
- Increased vibration level from heavy machinery operation, blasting activities, and material transport.

3.8 Impact Assessment and Mitigation

3.8.1 Pre-construction

During the pre-construction phase, negligible impacts on noise and vibration are expected, as this phase primarily involves preparatory activities such as site surveys, geotechnical investigations, and logistical planning. These activities do not include large-scale land clearing, excavation, or heavy machinery operation, which are the primary sources of significant noise during later project phases. The impacts of noise and vibrations are categorized as indirect, local, and temporary, resulting in a negligible magnitude. Considering the presence of sensitive receptors in the area, which are assessed to have a high level of vulnerability from a conservative standpoint, the significance of the impacts associated with increased noise and vibrations levels are regarded as negligible. This description applies specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 3 - Impact Assessment Table – Noise and Vibrations.

However, to ensure an accurate assessment of baseline conditions and in compliance with relevant regulations, noise monitoring will be conducted prior to construction. According to Article 4 of the Environmental Noise Protection Law ("Official Gazette of the Republic of Serbia", No. 96/2021), a noise source is defined as any emitter of unwanted or harmful sound resulting from human activities, including machinery, vehicles, and construction operations. Additionally, Article 18 of the same law mandates that the legal entity responsible for the noise source must conduct initial noise measurements before the noise source is put into operation.

Noise monitoring will be carried out in order to gather site-specific data on existing noise levels, which will provide a reference for assessing potential impacts during the construction phase and the effectiveness of

mitigation measures. This monitoring will include measurements at representative locations around the project site and near potential sensitive receptors to capture typical noise conditions in the area.

3.8.2 Construction

During the construction phase, noise and vibrations will inevitably be generated by the operation of construction machinery. This noise is an unavoidable by product of the construction activities and is of a temporary nature. However, at the time of preparing this ESIA, precise data on the machinery to be used for the dam construction and the irrigation system are not yet available.

The noise levels described in the following section for machinery operation and blasting activities are based on values outlined in the existing Environmental Impact Assessment (EIA) for the project. These values represent typical, assumed noise levels for such activities and are commonly used for similar construction and mining operations.

Construction and transport machinery involved in the dam construction will generate noise levels ranging from 70 dB(A) to 90 dB(A), depending on factors like the type of equipment, engine load, road surface quality, technical condition, operating methods, speed, and vehicle age. The noise impact will be most pronounced at the construction site and its immediate vicinity, with effects being temporary in nature.

The highest levels of noise and vibration are expected during blasting and drilling operations. For instance, noise levels during rock drilling are estimated to range from 100 dB(A) to 120 dB(A), while during blasting, levels may exceed 130 dB(A), depending on the amount of explosive used and the type of explosive applied.

As noise levels decrease with distance from the source and are absorbed by the surrounding terrain, it is expected that at distances greater than 100 m from the construction activities, noise levels will reduce and blend into the ambient noise levels of the surrounding area.

Consequently, impacts on noise levels are direct, localised, and short-term, leading us to conclude that its magnitude will be moderate. Given the presence of sensitive receptors in the area and a conservative assessment of their vulnerability as high, we assess that the significance of the impact on noise is major.

In terms of vibration impacts, these are categorized as direct, localised, and short-term and therefore its magnitude is moderate. Given that vulnerability of the receptors for vibrations will be high, the significance of the potential impact on vibration is regarded as moderate.

These descriptions apply specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 3 - Impact Assessment Table – Noise and Vibrations.

Given that the primary receptors for noise and vibration impacts are residential areas (households along the access road in Raduša, Slatina and Pambukovica, with a particular focus on sensitive receptors such as individuals with respiratory conditions, children, and the elderly), as well as habitats and species, the mitigation measures will focus on minimizing disturbance to both local communities and wildlife.

Mitigation measures will include, but are not limited to:

- ensuring regular maintenance of equipment,
- optimized traffic management through regulation of vehicle speed, implementation of traffic control measures to prevent road congestion and overloading, and reduction of unnecessary engine idling,
- limiting construction activities to daytime hours to minimize disturbance to habitats and species within area of influence,
- installing temporary mobile noise barriers or screens near sensitive receptors during execution the intensive construction works in the close proximity of the receptors, where necessary,

- work scheduling (limit high-noise activities, particularly blasting and drilling, to specific hours during the day to minimize disturbance to wildlife during critical times),
- minimize blasting frequency and intensity (reduce the frequency and intensity of blasting activities where possible and use controlled detonation techniques to minimize noise and vibration),
- undertake a vibration risk assessment for the construction works including equipment transport, identifying all potential sensitive receptors and defining and implementing a hierarchy of mitigation measures, encompassing design considerations (such as avoiding high vibration processes), source-based mitigation, as well as on-site and off-site mitigation. Based on the risk assessment:
  - establish safe distances between blasting areas and sensitive structures/receptors.
  - Undertake a detailed pre-condition survey of all sensitive buildings by a qualified, independent surveyor to visually identify all existing signs of exterior or interior damage, cracks (including size, type and direction) and settlement before the construction takes place. The assessment should include a written record and photographs of the existing situation. Surveys should be witnessed by the building/asset owner.
  - During construction, condition surveys will be undertaken at least bi-monthly, and following the construction activities that generate a high level of vibration at specific location.
  - If required, crack gauges will be installed to enhance monitoring and construction methodologies will be refined to reduce vibration levels.
  - Condition surveys will be undertaken post construction, to identify any damage that needs to be repaired by the Contractor, in consultation with the affected people. The Contractor will be responsible for the repair of such damage.

3.8.3 Operation

In contrast to the construction phase, this stage is characterized by activities that do not generate significant noise or vibrations. As a result, the impact will be indirect, local, and temporary, leading to a negligible magnitude. While sensitive receptors may experience medium sensitivity to noise and high sensitivity to vibrations, they are not expected to be significantly affected by the Project in this stage. Consequently, the overall impact is considered negligible, and no mitigation measures are required.

3.8.4 Decommissioning

During the decommissioning phase, noise is expected to be generated by the demolition and dismantling of infrastructure and material removal. The potential impact of noise and vibrations is assumed to be similar to that during the construction phase, with the most significant effects occurring at the dam itself and in its immediate vicinity.

Considering the demolition activities and the transportation of demolition waste off-site, impacts on noise levels will be direct, localised, and temporary; therefore, its magnitude is considered moderate. Given that sensitive receptors are present in the area and their vulnerability is assessed as high from a conservative standpoint, the significance of the impact is regarded as major.

Lastly, the effects on vibrations will be direct, localised, and temporary, allowing us to assess that their magnitude will be moderate. Considering the presence of sensitive receptors in the area, which have been evaluated as having medium vulnerability, we conclude that the significance of the impact is moderate.

These descriptions apply specifically to the most vulnerable receptors, rather than to every individual receptor. Additional details of impact assessment can be found in Table 3 - Impact Assessment Table – Noise and Vibrations.

Mitigation measures will include, but are not limited to:

- Ensuring regular maintenance of equipment
- Optimized traffic management through regulation of vehicle speed, implementation of traffic control measures, and reduction of unnecessary engine idling, particularly for material transport during decommissioning.
- Limiting demolition activities to daytime hours to minimize disturbance to habitats and species within the area of influence.
- Installing temporary mobile noise barriers or screens near sensitive receptors where necessary, particularly during intensive demolition activities.
- Work scheduling to limit high-noise activities, such as heavy demolition operations, to specific hours during the day to minimize disturbance to wildlife during critical times.
- Using controlled demolition techniques (e.g., non-explosive demolition methods where feasible) to reduce noise and vibration levels.

All the mitigation measures outlined in this chapter will be detailed in the CESMP (Contractor's Environmental Management Plan). Additionally, measures related to traffic management to reduce air quality impacts will be included in the TMP (Traffic Management Plan).

Table 3 - Impact Assessment Table – Noise and Vibrations

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Noise	Increase in noise levels Preconstruction and operations Non sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica Habitats and species within area of influence	Negligible	Low	Negligible	None required.	Negligible
Noise	Increase in noise levels Preconstruction and operations Sensitive receptors	Settlements along access road in Radusa (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica: Habitats and species (sensitive receptors include protected species from terrestrial fauna (such as amphibians, reptiles, bats and birds) and aquatic fauna (such as fish and aquatic macroinvertebrates).	Negligible	Medium	Negligible	None required.	Negligible
Vibrations	Increase in vibration levels	Settlements along access road in Radusa, Habitats and species within area of influence	Negligible	Low	Negligible	None required.	Negligible

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
	Preconstruction and operations Non sensitive receptors						
Vibrations	Increase in vibration levels Preconstruction and operations Sensitive receptors	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:); Habitats and species (sensitive receptors include protected species from terrestrial fauna (such as amphibians, reptiles, bats and birds) and aquatic fauna (such as fish and aquatic macroinvertebrates).	Negligible	Medium	Negligible	None required.	Negligible
Noise	Increase in noise levels Construction and decommissioning Non sensitive receptors	Settlements along access road in Radusa, Slatina and Pambukovica Habitats and species within area of influence	Moderate	Low	Minor	Construction limited to daytime, Ensure regular equipment maintenance and turn off vehicles when not in use, Optimised traffic management (speed regulation, congestion prevention, reducing engine idling), Scheduled high-noise activities, Reduced blasting frequency and intensity.	Negligible

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Noise	Increase in noise levels Construction and decommissioning Sensitive receptors	Settlements along access road in Radusa (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica: Habitats and species (sensitive receptors include protected species from terrestrial fauna (such as amphibians, reptiles, bats and birds) and aquatic fauna (such as fish and aquatic macroinvertebrates).	Moderate	Medium	Moderate	Noise barriers near sensitive areas, Construction limited to daytime, Ensure regular equipment maintenance and turn off vehicles when not in use, Optimised traffic management (speed regulation, congestion prevention, reducing engine idling), Scheduled high-noise activities, Reduced blasting frequency and intensity	Minor
Vibrations	Increase in vibration levels Construction and decommissioning Non sensitive receptors	Settlements along access road in Radusa, Habitats and species within area of influence	Moderate	Low	Minor	Ensure regular equipment maintenance Schedule blasting and heavy excavation during periods of lowest sensitivity. Reduce blasting frequency and intensity and use controlled detonation techniques to limit ground vibrations. Undertake a vibration risk assessment for the construction works including equipment transport, identifying all potential sensitive receptors and defining and implementing a hierarchy of mitigation measures, encompassing design considerations (such as avoiding high vibration processes), source-based	Negligible

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						mitigation, as well as on-site and off-site mitigation Undertake a detailed pre-condition survey of all sensitive buildings by a qualified, independent surveyor to visually identify all existing signs of exterior or interior damage, cracks (including size, type and direction) and settlement before the construction takes place. The assessment should include a written record and photographs of the existing situation. Surveys should be witnessed by the building/asset owner. During construction, condition surveys will be undertaken at least bi-monthly, and following the construction activities that generate a high level of vibration at specific location. If required, crack gauges will be installed to enhance monitoring and construction methodologies will be refined to reduce vibration levels. Conduct post construction surveys in consultation with affected people to identify any damage. Contractor to repair all identified damage.	
Vibrations	Increase in vibration levels Construction and decommissioning Sensitive receptors	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly);	Moderate	Medium	Moderate	Limit construction activities to daytime Ensure regular equipment maintenance Schedule blasting and heavy excavation during periods of lowest sensitivity. Use pre-split blasting and delay sequencing to reduce vibration impact.	Minor

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
		Pambukovica Health Center and the Primary School in Pambukovica:); Habitats and species (sensitive receptors include protected species from terrestrial fauna (such as amphibians, reptiles, bats and birds) and aquatic fauna (such as fish and aquatic macroinvertebrates).				Establish safe distances between blasting areas and sensitive structures/receptors. Contractor to carry out vibration risk assessment, including equipment transport. Identify all sensitive receptors and define hierarchy of mitigation measures, incorporating design considerations (e.g. avoiding high-vibration processes), source-based measures, and both on-site and off-site mitigation based on the Risk Assessment. Undertake a detailed pre-condition survey of all sensitive buildings by a qualified, independent surveyor to visually identify all existing signs of exterior or interior damage, cracks (including size, type and direction) and settlement before the construction takes place. The assessment should include a written record and photographs of the existing situation. Surveys should be witnessed by the building/asset owner. During construction, condition surveys will be undertaken at least bi-monthly, and following the construction activities that generate a high level of vibration at specific location. If required, crack gauges will be installed to enhance monitoring and construction methodologies will be refined to reduce vibration levels. Contractor to undertake post-construction condition surveys in consultation with affected people to identify any damage.	

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						Ensure the Contractor repairs all identified damage.	

Table 4 - Mitigation and Monitoring – Noise and Vibrations

Type of Impact	Potential Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Noise	Increase in noise levels Pre-construction	Sensitive receptors: Settlements along access road in Radusa and Habitats and species within area of influence	Conduct noise measurement in accordance with Article 18 of the Environmental Noise Protection Law ("Official Gazette of the Republic of Serbia", No. 96/2021) before putting the noise source into operation, and obtain a noise measurement report from an authorized professional organization. (See chapter 2.2)	Before construction activities
Noise	Increase in noise levels Construction and decommissioning	Settlements along access road in Radusa Habitats and species within area of influence	Regular noise monitoring surveys will be conducted at representative locations and times (in proximity to sensitive receptors).	Ongoing monitoring on a regular basis (monthly) during construction/decommissioning activities.
			In case of complaints regarding elevated noise and vibration levels, monitoring shall be conducted by an accredited laboratory, Develop and implement CESMP, which includes detailed noise and vibrations control and mitigation measures. Develop and implement TMP, which includes specific measures to minimize noise from traffic and transport activities.	During construction and decommissioning/daily, evening and night/during activities on site
Vibration	Property damage Construction and decommissioning	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as	Carry out vibration risk assessment, including equipment transport. Identify all sensitive receptors and define hierarchy of mitigation measures, incorporating design considerations (e.g. avoiding high-vibration processes), source-based	Before start of construction.

Type of Impact	Potential Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
		individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:); Cultural Heritage sites (where required)	measures, and both on-site and off-site mitigation based on the Risk Assessment.c	
Vibration	Property damage Construction and decommissioning	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:); Cultural Heritage sites (where required)	Undertake a detailed pre-condition survey of all sensitive buildings by a qualified, independent surveyor to visually identify all existing signs of exterior or interior damage, cracks (including size, type and direction) and settlement before the construction takes place. The assessment should include a written record and photographs of the existing situation. Surveys should be witnessed by the building/asset owner.	Before start of construction.
Vibration	Property damage Construction and decommissioning	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:); Cultural Heritage sites (where required)	During construction, condition surveys will be undertaken at least bi-monthly, and following the construction activities that generate a high level of vibration at specific location.	During construction / bi-monthly
Vibration	Property damage Construction and decommissioning	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:);	If required, crack gauges will be installed to enhance monitoring and construction methodologies will be refined to reduce vibration levels.	During construction / continuous

Type of Impact	Potential Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
		Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:); Cultural Heritage sites (where required)		
Vibration	Property damage Construction and decommissioning	Settlements along access road in Radusa Slatina and Pambukovica (sensitive receptors such as individuals with respiratory conditions, children, and the elderly); Pambukovica Health Center and the Primary School in Pambukovica:); Cultural Heritage sites (where required)	Contractor to undertake post-construction condition surveys in consultation with affected people to identify any damage.	After completion of construction activities

4. Soil and Groundwater

4.1 Introduction and Purpose

Effective management of soil and groundwater is essential to minimizing environmental impacts and ensuring the long-term sustainability of the Project. Various construction activities, including earthworks, material disposal, equipment operation, and groundwater use, have the potential to affect soil stability, groundwater levels, and overall environmental quality. The analysis conducted in this chapter encompasses the activities planned for the dam, along with a high-level overview of those that will be executed for the irrigation system.

This chapter outlines the key considerations for soil and groundwater protection during the construction, operation, and decommissioning phases of the Project. It emphasizes risk mitigation measures, including erosion control, pollution prevention, and sustainable water use, to prevent contamination and degradation. While some negative impacts are anticipated, the Project is also expected to contribute positively by improving soil moisture and fertility in newly formed coastal areas and enhancing agricultural productivity through irrigation.

4.2 Legislation and Standards

EU legislation

- Directive 2004/35/EC on protection of soil,
- Directive 2006/11/EC on dangerous substances,
- Directive 2006/118/EC on the protection of groundwater against pollution and deterioration.

EBRD requirements performance

- EBRD PR1: Assessment and Management of Environmental and Social Impacts and Issues,
- EBRD PR3: Resource Efficiency and Pollution Prevention and Control,
- EBRD PR4: Community Health, Safety, and Security,
- EBRD PR6: Biodiversity Conservation and Sustainable Management of Living Natural Resources,
- EBRD PR10: Information Disclosure and Stakeholder Engagement.

National legislation

- Soil Protection Law („Official Gazette of the RS“, No. 112/2015),
- Regulation on the limit values of pollutant, harmful and hazardous substances in the soil („Official Gazette of the RS“, No. 30/2018 and 64/2019),
- Regulation on discharge limits of pollutants in water bodies and deadlines for compliance („Official Gazette of the RS“, No. 67/2011, 48/2012 and 1/2016),
- Water Law („Official Gazette of the RS“, No. 30/2010, 93/2012, 101/2016, 95/2018),
- Regulation on the limit values of pollutants in surface and groundwater and sediment and deadlines for achieving them („Official Gazette of the RS“, No. 50/2012).
- In the Republic of Serbia, water use is regulated by the Water Law ("Official Gazette of the RS", Nos. 30/10, 93/12, 101/16, 95/18, and 95/18 – other law). According to Article 67, general water use refers to

the use of water without prior treatment, i.e., without the use of special devices (pumps, water-lifting mechanisms, etc.) or the construction of water facilities. General water use is permitted for the following purposes: drinking, livestock watering within households, sanitary and hygiene needs, recreation (including bathing), fire extinguishing, and navigation.

Article 68 stipulates that any water use that does not fall under general water use is considered special water use. The right to special water use is acquired through a water permit, and if such use is based on a concession, it must comply with the agreement governing the concession.

According to Article 72, groundwater of potable quality and water from public sources may only be used for supplying the population with drinking water, sanitary and hygiene needs, livestock watering, industries requiring high-quality water (such as the food and pharmaceutical industries), and small-scale consumers (below 1 l/s). Water designated for drinking purposes under the water management plan cannot be used for other purposes, except for fire extinguishing, nor in a manner that could adversely affect its quantity and properties.

At the time of writing, it remains uncertain whether water will be sourced from groundwater. However, should the need arise, and in accordance with the provisions of the Water Law, if the project proponent intends to drill a well at the dam and reservoir site to utilize groundwater for worker camp supply, concrete batching, tanker rinsing, road wetting, or any other construction-related activity, the following steps must be undertaken:

- Verify the status of groundwater at the site – If the groundwater in the area is of potable quality and designated under the water management plan for public water supply, its use for other purposes may be restricted or prohibited.
- Obtain a water permit – Since the use of groundwater for construction-related purposes does not fall under general water use but rather special water use, the project proponent must obtain a water permit in accordance with Article 68 of the Water Law.
- Comply with the conditions set out in the water act – Before commencing well drilling, it is necessary to secure the relevant water act (water conditions, water consent, water permit) from the competent authority, which will define the manner, scope, and conditions of water use.
- Ensure that groundwater use does not compromise public water supply – If groundwater in the area has been designated for drinking purposes under the water management plan, its use for construction-related activities may be prohibited unless specifically approved by the competent authority under special conditions.

The Regulation on the Manner and Procedure of Managing Construction and Demolition Waste ("Official Gazette of RS", No. 93/2023) thoroughly regulates the handling of waste generated during construction works. According to Article 7, the investor is required to develop a Waste Management Plan, which includes an assessment of the volume of excavated soil generated by construction activities and the method of its disposal. The Plan must be submitted as part of the construction permit application and adhered to throughout the project's duration.

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

4.3 Methodology

An impact assessment has been conducted based on available documents, including the Environmental Impact Assessment (EIA), Project for a Building Permit, and Spatial Plans, as well as the characteristics of the project and the study area. The assessment relied on a review of secondary data sources, including project documentation, publicly available geological and hydrogeological data, and applicable legislation and standards relevant to soil and groundwater protection.

This chapter will assess the significance of the impacts related to soil and groundwater, taking into account both the magnitude of the impact (negligible, minor, moderate, and major) and the vulnerability of receptors

(low, medium, and high). This assessment will adhere to the methodology outlined in **Book 1 - Introduction**. The findings of the impact assessment will serve as a basis for defining mitigation measures and identifying any residual negative impacts where full mitigation is not feasible.

4.4 Assumptions and limitations

Assumptions and limitations presented in the Book 1 Introduction are relevant for this topic.

Soil and groundwater specific assumption and/or limitations:

- Limitation in precise definition of soil and groundwater contamination risks due to the variable composition of potential contaminants from construction activities, which depends on specific equipment, materials, and management practices.
- Assessment of groundwater flow changes is based on general hydrogeological principles and existing documentation.
- Long-term impacts of dam removal on soil and groundwater during the decommissioning phase are uncertain, as the decommissioning strategy has not yet been fully defined.

4.5 Baseline

According to the Detailed Regulation Plan for "Pambukovica Dam on the Ub River" ("Official Gazette of the Municipality of Ub", No. 30/16), the area covered by the Plan is predominantly undeveloped and primarily used for agriculture. Vegetation in this area consists of agricultural land, forested areas, and green spaces within the floodplain of the Ub River.

The primary function of the dam and reservoir is to protect downstream areas from flooding, which will be achieved through dam management – by discharging the reservoir to the required level in accordance with flood wave forecasts.

The water accumulated in this area will be used for enhancing low flows to ensure ecological flow, and when water levels permit, it will also be used for irrigation. The area designated for the dam and reservoir covers approximately 116,69 ha.

The Ub River, with its riparian zone in a natural or near-natural state, serves as an ecological corridor of regional significance. Landscape elements within the cultural landscape (such as green belts, tree clusters, individual trees, meadows, hedgerows, and similar features) within the Plan boundaries function as local ecological corridors of the ecological network. In line with these considerations and the requirements of the Institute for Nature Conservation of Serbia, a riparian vegetation protective belt 10 m wide is planned along the proposed reservoir to maintain the continuity of the Ub river's ecological corridor. This belt must consist of dense, multilayered native vegetation to fully serve its intended protective function. The protective vegetation belt is planned to cover an area of approximately 12 ha.

The reservoir, which will be created by constructing the dam, will extend upstream from the dam profile for approximately 4 km at the normal retention level, covering an area of approximately 129 ha (12.900.000 m²).

The following section provides an overview of the pedological characteristics of the project site, based on data from the Environmental Impact Assessment (EIA).

In terms of pedological characteristics, most of the catchment area consists of eroded parapodzolic formations, which account for over 90% of the catchment. In the left flank zone of the future Pambukovica dam, pseudogley soil is predominant, while the area of the future reservoir, specifically the middle and lower stretches of the Ub River, is composed of alluvial-deluvial sedimentary formations.

The waterlogged alluvial sediments in the area are heavy clay soils with very poor physical properties and extremely low biological activity. These soils are primarily used for meadows and arable farming.

Parapodzolic soils are widespread in the left flank zone of the future Pambukovica dam. Regarding their physical properties, their structure is notably poor, with compacted lower layers that are highly impermeable to water and lack adequate air circulation. These characteristics result in very low soil productivity and uneven yields, underscoring the need for serious ameliorative (anti-erosion) measures.

The pedological units within the study area are presented in Table 5 - Pedological units in the exploration area

Table 5 - Pedological units in the exploration area

Soil Type	Area (km^2)	Percentage (%)
Loamy alluvial deposit	0,03	0,02
Alluvial-deluvial deposit	4,72	3,98
Eroded parapodzolic soil	108,52	91,60
Parapodzol (pseudogley)	5,17	4,37
Skeletal parapodzolic soil	0,04	0,03

The catchment area of the Ub River, as marked on the pedological map, is shown in the following figure.

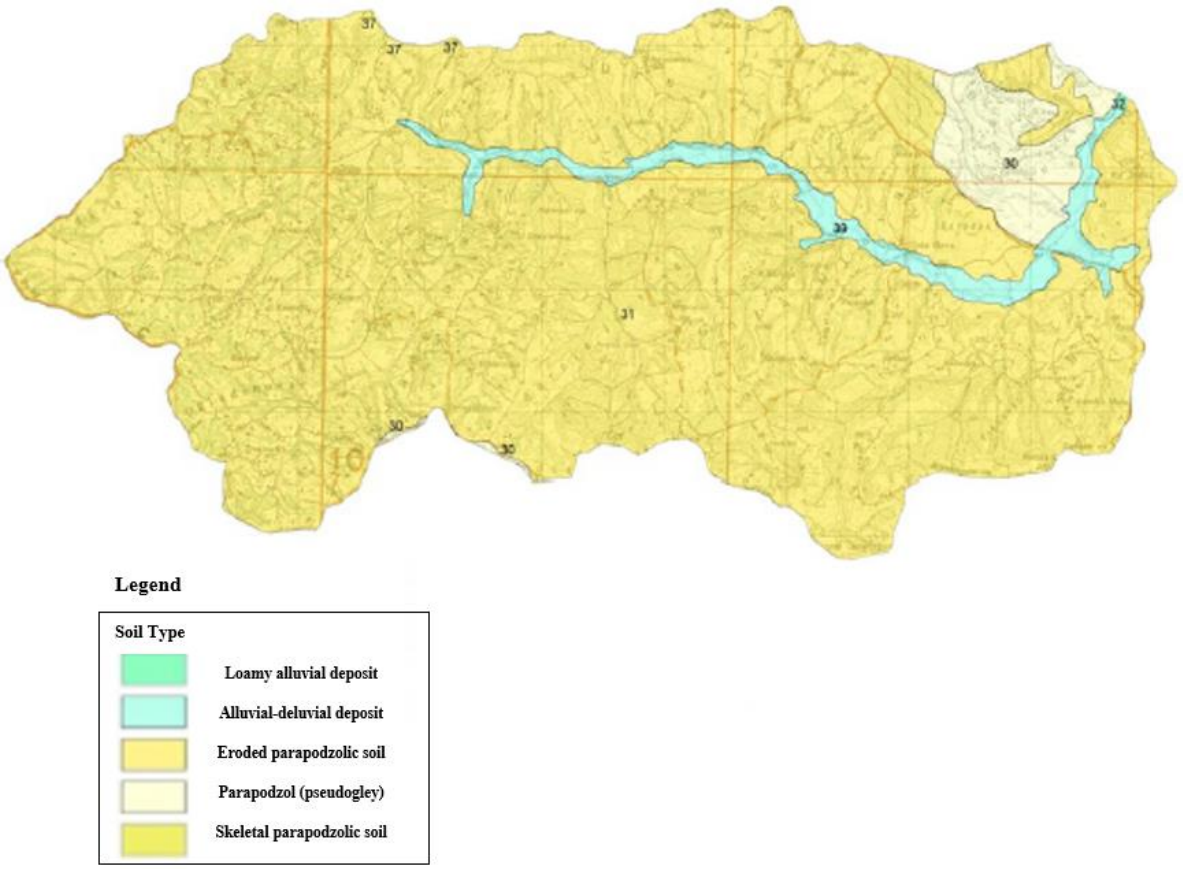

Figure 13 - The analysed Ub River basin marked on the pedological map

Data on vegetation cover, i.e., land use, were obtained using the CORINE Land Cover database, verified through digital orthophotos and field reconnaissance. The distribution of various land cover types in the catchment area of Pambukovica is presented in Table 6 below.

Table 6 - Land use in the catchment area of Pambukovica

Soil cover	Area (km^2)	Percentage (%)
Complex of cultivated parcels	34,7	29,30
Mixed forests	0,9	0,79
Mineral resource exploitation sites	0,0	0,01
Incomplete urban areas	0,6	0,51
Non-irrigated arable land	1,4	1,17
Pastures	1,2	1,03
Transitional area of forest and maquis	1,0	0,80
Predominantly agricultural land with larger areas of natural vegetation	39,6	33,40
Deciduous forests	39,1	32,98

In the analysed catchment area, most of the land is utilised for agricultural purposes. Forests and forest land account for approximately 33% of the catchment area. The forestation coefficient for the entire catchment is k_f = 0,35, while the erosion coefficient of the catchment is 0,30.

As stated in the EIA, detailed engineering-geological investigations were carried out in the area of the Pambukovica dam profile and associated structures. These investigations included studies of groundwater fluctuations and analyses of the chemical composition of both groundwater and surface water.

For the purpose of analysing groundwater level fluctuations, two piezometric installations were embedded in the drilled boreholes (PB-01 and PB-06) during the geological investigations. The primary goal of these installations was to determine the exact hypsometric position of the groundwater level in relation to the river channel. Additionally, a temporary water gauge was installed in the Ub River for this purpose. The monitoring process itself was very brief (a few days of observation) and, therefore, cannot fully represent the groundwater regime, which would require measurements over an entire hydrological cycle for complete definition. Despite this limitation, the installation of the piezometers proved to be effective, as determining the hypsometric position of the groundwater levels on the flanks of the dam profile allowed for conclusions to be drawn regarding the hydrogeological conditions in the future dam area.

In Table 7 and the diagram shown in Figure 14 - Diagram of groundwater and Ub River level fluctuations, the measurements taken from the piezometers and the Ub River are presented. The data shown represent the processed results in absolute elevations.

Table 7 - Measurement of groundwater level fluctuations and the Ub River

Date	PB-01 (mnm)	PB-06 (mnm)	River Ub (mnm)
12.04.2016.		-	127,1
13.04.2016.		-	127,09
14.04.2016.	148,39	-	127,14
15.04.2016.	147,54	128,4	127,63
16.04.2016.	147,44	128,3	127,23
17.04.2016.	147,29	128,15	127,19

Date	PB-01 (mnm)	PB-06 (mnm)	River Ub (mnm)
18.04.2016.	147,24	128,1	127,13
19.04.2016.	146,54	128,1	127,14
20.04.2016.	146,04	128,1	127,14
21.04.2016.	144,94	128,1	127,08
22.04.2016.	144,84	128,0	127,1
23.04.2016.	144,64	127,9	127,11

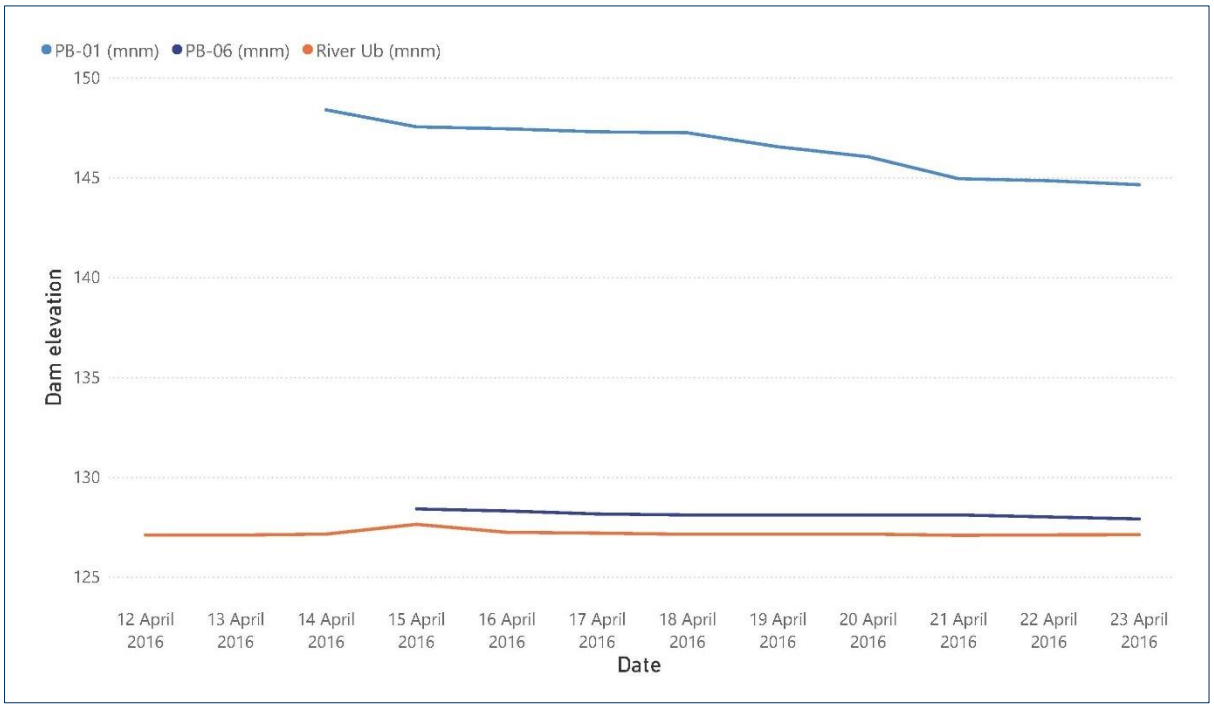

Figure 14 - Diagram of groundwater and Ub River level fluctuations

As can be seen from the diagram above, based on the measured levels, there is an asymmetry in the groundwater levels on the flanks of the dam profile. In the piezometer PB-01, which monitors the level along the left flank, the groundwater level fluctuates around 147-145 m a.s.l. while in piezometer PB-06 on the opposite bank, the level is recorded around 128 m a.s.l. These data indicate differences in hydrogeological conditions on each flank.

The high groundwater level on the left side of the profile suggests favorable hydrogeological conditions in terms of water retention for the dam profile. The average hydraulic gradient is 0,12. When also considering the data on the position of the water table during drilling in wells PB-02 and PB-03, located in the alluvial plain on the left bank, between piezometer PB-01 and the river, where the level is approximately equal to the river level, it can be concluded that there is no linear propagation of the hydraulic gradient. This leads to the conclusion that in the part of the left bank, in the zone above the alluvial plain, the hydraulic gradient value is even higher, at around 0,18. In contrast, in piezometer PB-06, the measured level is no more than 1 meter higher than the simultaneously recorded river water level. This level gives a hydraulic gradient of about 0,008, which is more than 15 times lower than the gradient on the left flank. This low value suggests an unfavourable hydrogeological situation regarding water retention, as there is effectively no saturation of the medium with groundwater in the hinterland of the right bank of the river flow.

Additionally, the diagram reveals different trends in the oscillation of groundwater levels on the flanks. Although the observation period is quite short, it is evident that in the left flank there is a trend of oscillation that, during this period, indicates a slight regression of the level without direct influence from the river flow. On the opposite side, the groundwater level is dictated by the river level, with no significant oscillations recorded.

To assess whether there is potentially aggressive action from groundwater and surface waters on concrete and reinforced concrete structures, chemical analyses of water samples from the piezometers and the river flow in the dam profile zone were performed. A total of three analyses were conducted, two from the piezometers and one from the river. The results of these analyses are presented in Table 8.

Table 8 - Results of water chemical analysis regarding aggressiveness to concrete structures

Sample	HCO_3	Aggressiveness content (concentration) on concrete structures (mg/l)			
		pH	$SO4^{2-}$	Mg	Ammonia
PB-01	549	7,86	20,8	7,3	<0,7
PB-06	572	7,53	20,0	8,8	<0,7
River Ub	546	7,85	21,2	8,2	<0,7

In the EIA, a monitoring program has been defined for tracking the quality and level of groundwater at two piezometers, one on the left and one on the right bank at the dam profile, in accordance with the Regulation on Limit Values of Pollutants, Harmful and Hazardous Substances in Soil ("Official Gazette of the RS," No. 30/18 and 64/19), Annex 2 – Remediation Values of Pollutants, Harmful and Hazardous Substances in the Aquifer Layer.

A detailed description of the engineering-geological and hydro-geological properties of the terrain, within the dam's embankment and reservoir area, is provided in the Geotechnical Conditions Report for the construction of the Pambukovica Dam with Reservoir on the Ub River, No. 22003-I-E1. The report synthesizes data from geological-geotechnical investigations conducted from 2016, up to and including the 2022 investigations.

During the investigation, periodic measurements of groundwater levels were carried out by the contractor in all previously completed boreholes and piezometers. The measured groundwater levels for the period from 20 April to 1 July 2022 in all new piezometers and boreholes, as well as in the older piezometer PB-6, were relatively consistent. The only value that significantly deviated was recorded in the older piezometer PB-1, located on the left flank.

The groundwater levels at PB-1 ranged from 147.1 to 148.02 m a.s.l., with an average of 147.5 m. These levels correspond to those recorded during the previous period of investigation (2016), when asymmetry in the groundwater levels in the embankment profile was observed, indicating the presence of differing hydrogeological conditions in the embankment flanks.

However, the new investigation results, particularly the levels in the boreholes drilled in the left flank, suggest the likely presence of two aquifers:

- the higher aquifer, measured at piezometer PB-1, and
- the lower aquifer, whose level correlates well with the river level.

The groundwater levels recorded in the remaining piezometers and boreholes (which were monitored until they became obstructed) ranged from 126.59 to 129.17 m a.s.l., with an average of 127.6 m. These values correspond to the river level of the Ub River, approximately 20 m lower than the aquifer level measured at piezometer PB-1.

In the *Geotechnical Conditions Report for the construction of the Pambukovica Dam with Reservoir on the Ub River (No. 22003-I-E1, Chapter 8)*, proposals for further investigative works and testing have been outlined based on the conclusions regarding the explored terrain. As part of these measures, a monitoring program has also been proposed. The recommended measures include:

- Engineering-geological, hydrogeological, and geotechnical mapping of all excavations for the dam and associated structures;
- Drilling of investigative boreholes for the installation of additional piezometers for groundwater monitoring and inclinometers (and/or excavations for geodetic benchmarks) to monitor the stability of slopes in the future dam area and reservoir slopes, accompanied by engineering-geological mapping of borehole cores;
- Mineralogical and petrological analyses of rock samples from borehole cores to verify and determine reference horizons and control the lithological profile;
- Geophysical logging in additional investigative boreholes, including caliper logging, temperature measurements, flowmeter testing, and borehole wall imaging;
- Drilling of investigative boreholes with continuous coring to assess the effectiveness of grouting works (reference boreholes before grouting and control boreholes after grouting), along with engineering-geological and geotechnical mapping of borehole cores;
- Hydrogeological testing in control and additional investigative boreholes to improve data accuracy and verify the success of grouting works;
- Hydrogeological instrumental survey of water occurrences in the field immediately downstream of the dam;
- Tracer dye tests for tracking underground water flows from additional investigative and control boreholes;
- Hydrogeological monitoring of groundwater levels in piezometers, conducted on a permanent (automated) basis;
- Continuous (automated) monitoring of river water levels, synchronized with groundwater level monitoring in piezometers, before, during, and after reservoir formation;
- Monitoring of reservoir water levels, synchronized with river level and groundwater level observations;
- Additional exploratory pits in the reservoir area within borrow zones of alluvial and terrace materials intended for use in the construction of dam support structures.

The document *D3.7 Karst Analysis – Geotechnical Investigations and Required Grouting Depth for Karst Geology* defines the following recommendations regarding the necessity, planned scope, and methodology of additional investigations:

- Six additional boreholes are planned to develop a more precise geological and hydrogeological model of the terrain, aiming for an accurate lithological characterisation of the area.
- Boreholes FB-1, FB-2, and FB-4 are located within the riverbed and dam excavation area and are proposed as a measure for engineering geological mapping before the commencement of grouting works. They will be carried out without piezometers and inclinometers, using continuous coring, to a total depth of 90 m.
- Boreholes FB-3, FB-5, and FB-6 are designated for the right bank, where previous investigations have indicated significant rock fracturing. They will also be conducted with continuous coring, and an

inclinometer will be installed in FB-6 due to the presence of a potential landslide. The total drilling depth will be 140 m.

- Geophysical investigations for the grouting curtain have been completed to a satisfactory extent, and no additional works are prescribed. Benchmark boreholes (588 m) are planned in the middle row of the grouting curtain for coring and testing, while control boreholes (560 m) will be carried out in areas of high or low grout intake. Their exact locations will be determined later, based on the results of the grouting process.

The document *D3.6 Landslide Analysis – Geotechnical Investigations and Risk Assessment of Landslides, including Mitigation Measures* provides a comprehensive assessment of potential landslides within the reservoir area, integrating geological and geotechnical analyses. The study reviewed existing documentation, conducted field visits to assess terrain stability, and applied the Analytical Hierarchy Process (AHP) method for landslide susceptibility mapping.

Key findings:

- Several potential landslide zones were identified, particularly on the left and right banks of the reservoir.
- Stability assessments indicated possible instability under adverse conditions, such as rapid reservoir drawdown or seismic events.
    - Potential impacts of landslides on the dam, reservoir, and surrounding infrastructure were evaluated.

Recommendations and measures:

- Additional investigations, including boreholes for groundwater level monitoring and trial pits to determine soil composition, are recommended.
- Remedial measures include the removal of loose, unstable material and the implementation of a monitoring system (piezometers, inclinometers, visual inspections) during reservoir filling and testing.

The overall landslide risk is assessed as low to moderate, with a primary focus on maintaining the stability of the reservoir and dam.

4.6 Receptors and Area of Influence

As stated in the conditions obtained from PUC "Đunis" Ub, for the needs of the Detailed Regulation Plan for “Pambukovica Dam on the Ub River” (“Official Gazette of the Municipality of Ub”, No. 30/16), two water wells outside the Plan's scope have been identified. Due to their great distance, the water from the accumulation will not affect the quality and level of water in these water wells.

Additionally, one water well within the Plan's scope has been identified, which is intended to be closed to prevent mixing of groundwater and high waters during the realization of the accumulation.

The rise in groundwater is expected to be localised within the immediate reservoir perimeter, primarily within the reservoir zone itself and typically within 100 m from the water body. Since potential changes in groundwater dynamics are directly influenced by the filling and functioning of the reservoir, the area of influence includes the accumulation surface, as shown in Figure 15. These changes are expected to have limited impact beyond this area and are not anticipated to affect most of the year.

The area of influence for soil and erosion impacts is expected to extend around 100 m from the construction site, including areas around borrow pits and storage sites. Erosion control measures will be concentrated in these areas to minimise the spread of erosion and to contribute to reducing the zone of influence.

The area positively impacted by the operation of the dam includes the soil around the reservoir boundary and the soil within the irrigation zone, as the dam will provide better water distribution for irrigation and improve soil quality in these areas. The area of influence of the irrigation system, as shown in Figure 15, extends to the wider agricultural zone east of the reservoir.

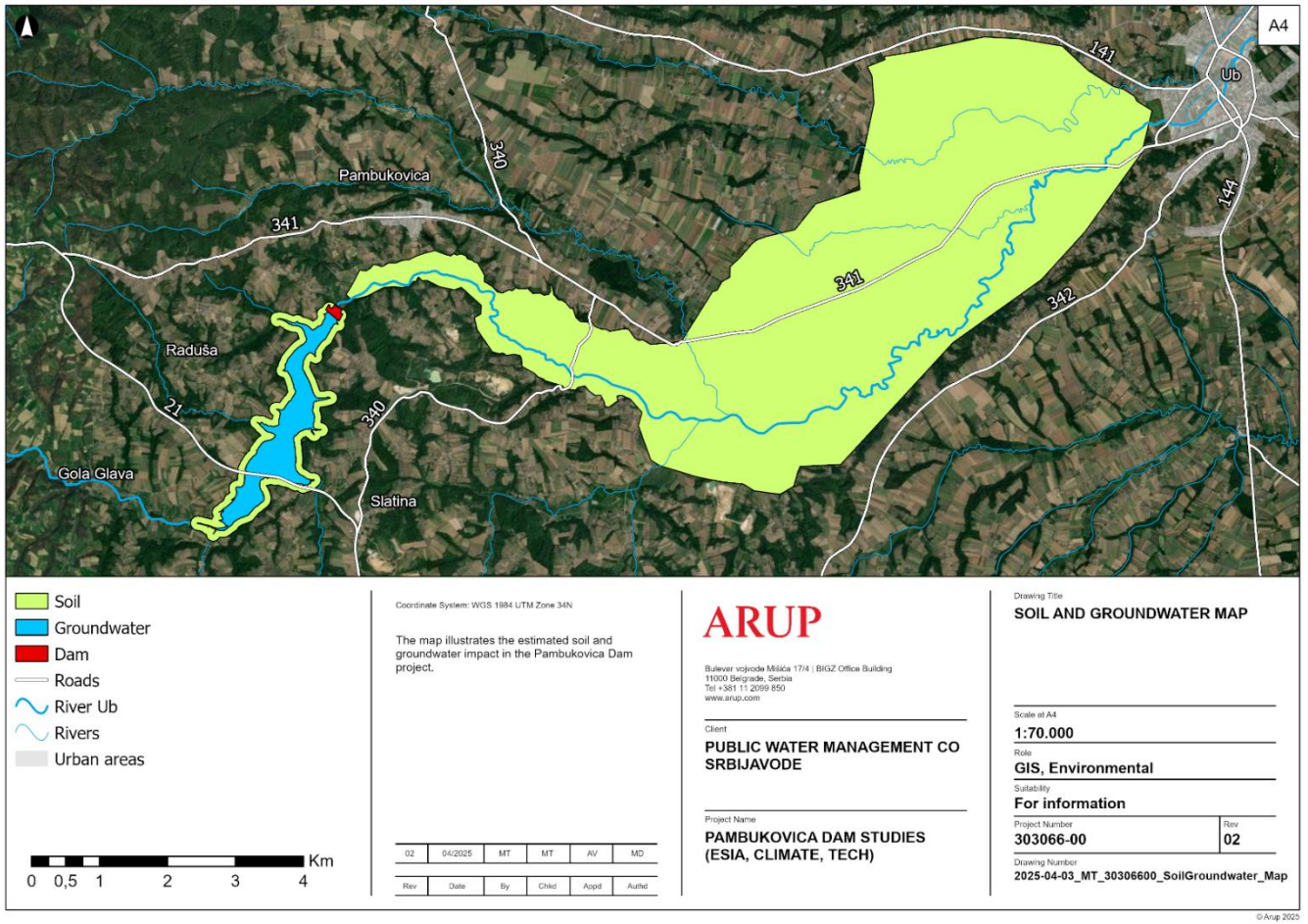

Figure 15 Area of influence of the irrigation system

4.7 Project Activities and Identification of Impacts

The impact on soil and groundwater may occur during the construction, operation, and decommissioning phases of the Project.

The project activities that may cause impacts on soil and groundwater include:

- earthworks (excavation, filling, material storage at temporary sitesl, trenching for the installation of water-bearing pipes), which may lead to contamination of soil and groundwater with suspended materials,
- the formation of borrow pits and material storage sites without adequate anti-erosion measures, which can intensify erosion processes,
- defective construction equipment and operator negligence, which can result in leaks of hazardous substances (oil, fuel), causing temporary or permanent contamination,
- uncontrolled disposal of excavated and construction material, which can damage the soil and affect the appearance of the surrounding area,
- improper storage and handling of hazardous materials (e.g., coatings, additives),
- abstraction and use of groundwater for construction purposes, which may lead to changes in groundwater levels and affect local water availability.

Impacts Identification

- Groundwater quality and level – Potential contamination from hazardous substances, changes in groundwater levels due to abstraction.
- Soil quality – Potential contamination from spills, leaks, and improper disposal of materials.
- Soil erosion – Increased erosion due to excavation, material storage sites, and lack of protective measures.
- Land stability - Changes in land topography due to excavation and structure removal, potentially leading to landslides or subsidence.

During the operational phase, the potential of the soil will be impacted, as soil currently used for agricultural production will be flooded. However, on the positive side, irrigation will be provided for a significantly larger area of soil, improving its agricultural productivity.

4.8 Impact Assessment and Mitigation

4.8.1 Groundwater

4.8.1.1 Preconstruction

Activities during the preconstruction stage are not expected to result in a significant impact to groundwater. As a result, the impacts are categorised as indirect, local, and temporary, resulting in a negligible magnitude. Given the presence of sensitive receptors in the area, which are considered to have a medium level of vulnerability from a conservative perspective, the significance of the impacts in groundwater are deemed negligible.

4.8.1.2 Construction

During the construction phase of the Project, certain activities may affect groundwater levels and quality, including:

- excavation and drainage of the foundation area for the dam and associated structures, and excavation works related to the irrigation zone and pipeline installation,
- use of heavy machinery and construction materials,
- improper disposal of excavated material,
- use of batch plant,
- improper storage and handling of hazardous materials (e.g., coatings, additives)
- abstraction and use of groundwater for construction purposes

Excavation and drainage in the foundation area may alter the natural groundwater flow, leading to the interception of groundwater and localised changes in groundwater levels.

Leaks of fuel, oil, or other chemicals from construction equipment, as well as improper storage and handling of hazardous materials (e.g., coatings, additives), may cause local groundwater contamination. These pollutants can degrade groundwater quality, affecting its usability, particularly for drinking water or irrigation. Additionally, improper disposal of excavated material or construction waste may contribute to contaminant infiltration.

Leaching of cement or additives from concrete may increase the pH level of groundwater near the construction site. Furthermore, diverting surface and groundwater during foundation works may lead to a localised drop in groundwater levels and altered flow patterns.

Groundwater abstraction for construction may lower groundwater levels, affecting nearby wells and ecosystems. It can alter natural flow patterns, reduce recharge rates, and, if poorly managed, introduce contaminants through spills or improper handling of materials. Excessive depletion may also contribute to land subsidence, impacting infrastructure stability.

In conclusion, the impacts on groundwater levels and quality, soil erosion, soil quality and land stability are direct, localised, and short-term; consequently, their magnitude is regarded as moderate. Given that the receptor in this instance is the groundwater and the soil, it is deemed medium vulnerable to these impacts, resulting in a medium significance.

Mitigation measures will include, but are not limited to:

- Conduct baseline measurements of groundwater levels in affected wells before construction begins, and carry out regular monitoring during the construction and operation phases.
- Preventing and containing leaks from construction equipment to avoid groundwater contamination.
- Storing hazardous materials (e.g., coatings, additives, fuel, oil) in designated, bunded areas with secondary containment and regular inspections to prevent leaks.
- Properly managing excavated materials to prevent contaminants from infiltrating groundwater.
- Using impermeable liners in concrete washout pits.
- Implementing erosion control measures to minimize contaminant infiltration and stabilize disturbed areas.

Based on the provisions of the Water Law, if the project proponent intends to drill a well at the dam and reservoir site to utilise groundwater for worker camp supply, concrete batching, tanker rinsing, road wetting, or any other construction-related activity, the following steps must be undertaken:

- Verify groundwater status – Check if groundwater is of potable quality and designated for public supply; its use may be restricted.
- Obtain a water permit – Since construction-related groundwater use is classified as special water use, a permit is required.
- Comply with water regulations – Secure necessary approvals (water conditions, consent, permit) before drilling.
- Protect public water supply – Ensure groundwater use does not affect designated drinking water sources unless specially approved.

Project documentation in the volume 22003-I-B-02 (Geotechnical Conditions Report for the construction of the Pambukovica Dam with Reservoir on the Ub River) recommends:

- Visual observation in the filling phase and test operation mode of the accumulation. No further assessment is recommended by the project documentation in this volume.

Project documentation in the volume 22003-I-E1 (E1 - Report on Geotechnical Conditions for the construction of the Pambukovica Dam with Reservoir on the Ub River, 2022), in the Section 8 recommends.

- Installation of additional piezometers for groundwater monitoring (and/or excavation for geodetic benchmarks) for monitoring the stability of slopes in the future area dams and reservoir slopes with simultaneous engineering geological mapping of cores.
- Underground water flow tracing.

4.8.1.3 Operation

When the dam becomes operational and water begins to accumulate in the reservoir, the principle of hydrostatic pressure may lead to changes in hydrodynamic conditions and groundwater levels. These include:

- the groundwater level in surrounding areas may rise due to the accumulation of a large amount of water in the dam's reservoir,
- the impact on aquifers may be significant, as water from the reservoir can alter the flow of groundwater, increasing moisture in the surrounding layers,
- changes in groundwater levels may cause the infiltration of contaminants into underground layers or alter the direction of their movement.

These impacts are typical and expected for dam projects of this nature. Although they arise from the operation of the project, they are generally not subject to mitigation measures but will be monitored to track any long-term effects. Groundwater levels will be measured twice a year throughout all phases of the Project using installed piezometers.

4.8.1.4 Decommissioning

During decommissioning phase of the Project and the restoration of the area to its natural state, the following impacts on groundwater may occur:

- rapid draining of the reservoir may cause destabilization of the hydrostatic pressure, affecting the groundwater flows,
- removal of embankments and other structures may release sediments that could block groundwater flows or contaminate surrounding layers,
- restoring the natural river flow after the dam removal may result in changes in the groundwater regime, including potential lowering of groundwater levels, inadequate removal of construction materials (e.g., concrete foundations) may lead to local groundwater contamination. During this stage, impacts on groundwater levels and quality are direct, localised, and temporary; consequently, their magnitude is regarded as moderate. Given that the receptor in this instance is the groundwater and the soil, it is deemed medium vulnerable to these impacts, resulting in a moderate significance of impact.

Potential mitigation measures:

- controlled draining of the reservoir,
- restoration of natural flow (ensuring a controlled and gradual restoration of the river's natural flow to minimize changes in the groundwater regime, including careful monitoring of groundwater levels during this process),
- proper removal of construction materials.

4.8.2 Soil

4.8.2.1 Preconstruction

Activities during the preconstruction stage are not expected to result in a significant impact to soil. As a result, the impacts are categorized as indirect, local, and temporary, resulting in a negligible magnitude. Given the presence of sensitive receptors in the area, which are considered to have a medium level of vulnerability from a conservative perspective, the significance of the impacts in soil and groundwater are deemed negligible.

4.8.2.2 Construction

During the construction phase of the Project, the following impacts on soil may occur:

- Soil disturbance: Excavation and earthworks may cause soil compaction, erosion, and loss of topsoil.
- Soil contamination: Spillage of fuel, oil, or chemicals from construction equipment, improper storage and handling of hazardous materials (e.g., coatings, additives), and improper disposal of construction waste or excavated materials can lead to local soil contamination.

Therefore, impacts in soil erosion, soil quality and land stability are direct, localised, and short-term; consequently, their magnitude is regarded as moderate. Given that the receptor in this instance is the soil, it is deemed medium vulnerable to these impacts, resulting in a moderate significance.

Mitigation measures will include, but are not limited to:

- minimizing soil disturbance by limiting excavation areas and preserving topsoil for later use;
- proper waste disposal to ensure that construction waste and excavated materials are stored and disposed of safely;
- storing hazardous materials (e.g., coatings, additives, fuel, oil) in designated, bunded areas with secondary containment and regular inspections to prevent leaks

- implementing erosion control measures (e.g., silt fences, mulching, and temporary vegetation) to prevent soil erosion.

4.8.2.3 Operation

Impact on soil during the operational phase results from the permanent flooding of certain coastal areas. In the flooded zones, prolonged saturation may lead to a reduction in soil fertility and the loss of agricultural function. Additionally, the implementation of flood protection measures (such as embankments or drainage infrastructure) may alter the natural characteristics of soil in surrounding areas.

However, in newly formed areas along the reservoir banks where water levels fluctuate, there is potential for the development of fertile alluvial soil over time, depending on sediment composition and land management practices. Furthermore, the impact on soil quality is also positive in areas within the irrigation system or irrigation zone, as the soil will be irrigated, improving its fertility. Therefore, the impacts on soil quality during the operational phase are mixed: potentially negative in permanently flooded areas, and potentially positive in newly exposed, periodically inundated zones, and in the irrigation zones.

Thus, the impacts on soil quality are characterised by both adverse and beneficial aspects, resulting in a moderate magnitude. Given the presence of sensitive receptors in the area (such as agricultural land and natural habitats), which are considered to have a medium level of vulnerability from a conservative perspective, the overall significance of impacts on soil quality is assessed as moderate.

According to EIA, the following measures for erosion control and stabilization of the catchment area up to the Pambukovica profile have been proposed:

- preparation of specific forestry management plans for protective forests, afforestation of forest land (common land), improvement of degraded, sparse forests with incomplete canopy, and thinning of deciduous forests.
- construction of erosion control barriers, such as flood control dams and check dams.
- imposing restrictions or complete bans on deforestation or cutting of orchards, determining methods for land cultivation and utilization (pastures, meadows, forests, and uncultivated areas), and prohibiting the formation of unsecured waste disposal sites for excavated material.
- measures for the protection of pipelines from erosion through the combination of structural and natural solutions.

The concept of soil erosion protection is defined within the Preliminary Design of the Dam with Reservoir on the Ub River, in the document "Project for Anti-Erosion Works in the Catchment Area" (Energoprojekt Hidroinženjering a.d., 2018).

In accordance with the provisions of the Water Law, an analysis of field conditions within the catchment area that gravitates toward the future Pambukovica Dam has identified the need to introduce the following prohibition measures to prevent the development of erosion processes:

- Prohibition of erosion damage to endangered areas (damage to the grass cover on slopes greater than 12.5% for the purpose of creating arable land);
- Prohibition of annual tillage (applies to all plots with a slope greater than 9%, except in the case of terracing and contour strip cultivation);
- Prohibition of plowing downhill and requirement to plow along the contour lines;
- Prohibition of grazing on grassland during a specified time period;
- Prohibition of grazing in forests and forest plantations;
- Prohibition of trimming foliage;
- Prohibition of uncontrolled logging and clearing of forests;

- Prohibition of mechanical damage to land of all forms (includes prohibition of all surface destruction through sand or gravel extraction and any other damages that disrupt the stability and morphological condition of a particular area or region);
- Prohibition of planting annual crops on steep land, or determination of reorientation of agricultural production towards perennial crops (meadows, clover, orchards, forests, etc.)

4.8.2.4 Decommissioning

During the decommissioning phase of the Project and the restoration of the area to its natural state, the following impacts on soil may occur:

- Soil erosion and degradation: The removal of embankments and other structures may leave the land exposed, increasing the risk of erosion and soil degradation.
- Soil contamination: Improper handling or disposal of construction debris, including concrete remnants, may introduce contaminants into the soil. Soil compaction and disturbance: Heavy machinery used for demolition and restoration activities may lead to soil compaction, reducing permeability and affecting soil health.
- Alteration of land stability: Changes in land topography due to excavation and structure removal may impact soil stability, potentially leading to landslides or subsidence.

During the decommissioning phase, the impacts on soil quality, soil erosion, and land stability are assessed as direct, localised, and temporary, resulting in a moderate magnitude. However, given that soil is a medium vulnerable receptor, the significance of these impacts is classified as moderate.

Potential mitigation measures:

- Implement erosion control measures (e.g., re-vegetation, slope stabilization techniques).
- Properly manage and dispose of construction debris to prevent soil contamination.
- Minimize heavy machinery use in sensitive areas to reduce soil compaction.
- Restore the natural topography and soil structure through grading and land rehabilitation efforts.

All the mitigation measures outlined in this chapter will be detailed in the CESMP (Contractor's Environmental Management Plan).

Table 9 - Impact Assessment Table – Soil and Groundwater

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Groundwater quality and level	Modification of groundwater quality and quantity. Preconstruction	Groundwater sources	Negligible	Medium	Negligible	None required.	Negligible
Groundwater quality and level	Modification of groundwater quality. Construction and decommissioning	Groundwater sources	Moderate	Medium	Moderate	Ensure the implementation of general best practice housekeeping measures on-site, including: Regular waste removal and maintaining site cleanliness. Proper storage and handling of materials and chemicals to prevent soil and water contamination. Regular maintenance and inspection of construction equipment to minimise the risk of leaks of oil, fuel, and other pollutants. Establishing clearly defined zones for refuelling and waste disposal in compliance with	Minor

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						environmental regulations. Properly managing excavated materials to prevent contaminants from infiltrating groundwater. Using impermeable liners in concrete washout pits. Implementing erosion control measures to minimize contaminant infiltration and stabilize disturbed areas.	
Groundwater quality and level	Modification of groundwater quantity. Construction	Groundwater sources	Moderate	Medium	Moderate	Verify groundwater status – Check if groundwater is of potable quality and designated for public supply; its use may be restricted. Obtain a water permit – Since construction-related groundwater use is classified as special water use, a permit is required. Comply with water regulations – Secure necessary approvals (water conditions,	Minor

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						consent, permit) before drilling. Protect public water supply – Ensure groundwater use does not affect designated drinking water sources unless specially approved. Monitoring on two piezometers. Conduct baseline measurements of groundwater levels in affected wells before construction begins, and carry out regular monitoring during the construction and operation phases.	
Groundwater quality and level	Modification of groundwater quantity. Operation	Groundwater sources	Negligible	Medium	Negligible	None required.	Negligible
Soil quality Soil erosion Land stability	Modification of soil quality. Increase in soil erosion	Soil	Negligible	Medium	Negligible	None required.	Negligible

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
	Modification of land stability Preconstruction						
Soil quality	Modification of soil quality. Construction	The soil in the area affected by construction activities (construction site, borrow pits, irrigation zone)	Moderate	Medium	Moderate	Ensure the implementation of general best practice housekeeping measures on-site, including: Regular waste removal and maintaining site cleanliness. Proper storage and handling of materials and chemicals to prevent soil and water contamination. Regular maintenance and inspection of construction equipment to minimise the risk of leaks of oil, fuel, and other pollutants. Establishing clearly defined zones for refuelling and waste disposal in compliance with environmental regulations.	Minor

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						Properly managing excavated materials to prevent contaminants from infiltrating groundwater.	
Soil erosion	Increase in soil erosion Construction and decommissioning	The soil in the area affected by construction activities (construction site, borrow pits)	Moderate	Medium	Moderate	Implementing erosion control measures (e.g., silt fences, mulching, and temporary vegetation), Segregate excavated soils into stockpiles dependent on material type and provide erosion control while stockpiled	Minor
Land stability	Modification of land stability Decommissioning	The soil in the area affected by decommissioning activities	Moderate	Medium	Moderate	Implement erosion control measures (e.g., re-vegetation, slope stabilization techniques) Restore the natural topography and soil structure through grading and land rehabilitation efforts	Minor
Soil quality	Modification of soil quality.	The soil in the area affected by construction activities (construction site,	Negligible	Moderate	Negligible	None required.	Negligible

Type of Impact	Potential Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
	Operation	borrow pits, irrigation zone)					

Table 10 - Mitigation and Monitoring - Soil and Groundwater

Type of Impact	Potential Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Groundwater quality	Modification of groundwater quality.	Groundwater sources	Ensure implementation of general best practice housekeeping measures, Develop and implement CESMP Which includes detailed groundwater control and mitigation measures. According to Article 7 of Regulation on the Manner and Procedure of Managing Construction and Demolition Waste ("Official Gazette of RS", No. 93/2022), the Investor is required to develop a Waste Management Plan, which includes an assessment of the volume of excavated soil generated by construction activities and the method of its disposal. The Plan must be submitted as part of the construction permit application and adhered to throughout the project's duration.	During construction and decommissioning activities/beginning of activities on site
Groundwater quality and level	Modification of groundwater quantity.	Groundwater sources	Ensure monitoring on two piezometers, one on the left and one on the right bank at the dam profile, in accordance with the Regulation on Limit Values of Pollutants, Harmful and Hazardous Substances in Soil ("Official Gazette of the RS," No. 30/18 and 64/19), Annex 2 – Remediation Values of Pollutants, Harmful and Hazardous Substances in the Aquifer Layerc	During all phases, twice a year.
Groundwater quality and level	Modification of groundwater quantity.	Groundwater sources	Based on the provisions of the Water Law ("Official Gazette of the RS", Nos. 30/10, 93/12, 101/16, 95/18, and 95/18 – other law), if the project proponent intends to drill a well at the dam and reservoir site to utilise groundwater for worker camp supply, concrete batching, tanker rinsing, road wetting, or any other construction-related activity, the following steps must be undertaken: Verify the status of groundwater at the site; Obtain a water permit in accordance with Article 68 of the Water Law; Comply with the conditions set out in the water act; Ensure that groundwater use does not compromise public water supply;	During all phases

Type of Impact	Potential Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
			(For more detailed see Chapter 3.2)	
Groundwater quality and level	Modification of groundwater quantity and level.	Groundwater sources and wells	a) Conduct baseline measurements of groundwater levels in affected wells before construction begins b) Carry out regular monitoring during the construction and operation phases.	a) Before start of construction b) Quarterly monitoring
Soil quality	Modification of soil quality	The soil in the area affected by construction activities (construction site, borrow pits)	Develop and implement CESMP which includes detailed soil management and mitigation measures.	During construction and decommissioning activities/beginning of activities on site
Soil erosion	Increase in soil erosion	The soil in the area affected by construction activities (construction site, borrow pits)	Ensure monitoring of erosion control measures, Develop and implement CESMP, including comprehensive soil erosion prevention measures.	During construction and decommissioning activities/beginning of activities on site
Land stability	Modification of land stability	The soil in the area affected by decommissioning activities	Ensure monitoring of erosion control measures, Develop and implement CESMP, including comprehensive soil stability prevention measures.	During construction and decommissioning activities/beginning of activities on site

5. Resources and Material Management

5.1 Introduction and Purpose

Effective management of resources and materials is a critical component of sustainable construction practices. The efficient sourcing, utilization, and monitoring of materials and resources are essential to minimize environmental impacts, optimize resource use, and ensure compliance with environmental and social standards.

This chapter outlines the approach and principles for managing resources and materials during the construction phase of the Project. It emphasizes sustainable practices, including the reuse of materials, reduction of waste, and careful planning to mitigate adverse effects on the environment and local communities. By integrating these practices, the Project aims to balance construction needs with ecological and social responsibilities, contributing to long-term sustainability goals.

5.2 Legislation and Standards

EBRD Performance Requirements and Guidelines

The principles of resource efficiency and pollution prevention are outlined in Performance Requirement 3 (PR3) of the European Bank for Reconstruction and Development (EBRD). PR3 emphasizes the importance of using resources, including energy, water, and raw materials, efficiently to minimize environmental impacts while fostering sustainable development.

PR3 promotes the adoption of best practices and technologies to reduce pollution emissions and waste generation throughout the project lifecycle. This includes measures for cleaner production, waste recovery, and recycling, ensuring that resource management aligns with environmental sustainability goals.

Aligned with international standards and host country regulations, PR3 provides a framework for managing environmental risks and improving operational efficiency. It highlights the significance of planning and implementing measures to prevent or minimize adverse environmental impacts associated with resource and material use.

EU regulations and directives

- Waste Framework Directive (Directive 2008/98/EC, as amended by Directive (EU) 2018/851)
- Landfill Directive (Directive 1999/31/EC)
- EU Circular Economy Action Plan (2020)

The management of excavated materials for the dam project aligns with key EU regulations and policies on resource efficiency and waste management. The Waste Framework Directive establishes a waste hierarchy that prioritizes reuse and recycling, ensuring that suitable excavated materials are repurposed where feasible. For materials deemed unsuitable for reuse, disposal measures comply with the Landfill Directive to prevent environmental contamination and ensure proper site selection. Additionally, the project incorporates principles from the EU Circular Economy Action Plan by promoting sustainable material use and minimizing waste generation through resource-efficient construction practices.

National Legislation

The main national legal framework considered, related to Resources and material management is:

- Law on Environmental Protection ("Official Gazette of RS", Nos. 135/04, 36/09, 72/09, and 43/11 – decision of the Constitutional Court).

- Law on Waste Management ("Official Gazette of RS", Nos. 36/09, 88/10, and 14/16).
- Rulebook on Waste Categories, Testing and Classification ("Official Gazette of RS", Nos. 56/10 and 93/10).
- Law on Mining and Geological Exploration ("Official Gazette of the Republic of Serbia", No. 101/2015, 95/2018 - other law, and 40/2021).
- Regulation on Technical and Other Requirements for Cement ("Official Gazette of RS", No. 55/06).

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

5.3 Methodology

An impact assessment has been conducted based on available documents, including the Environmental Impact Assessment (EIA), Project for a Building Permit, and Spatial Plans, as well as the characteristics of the project and the study area. The assessment relied on a desk-based review of secondary data sources, including project documentation, publicly available information, and applicable legislation and standards relevant to resource and material management.

The assessment of decommissioning impacts considers key methodological aspects distinct from the construction phase, with an emphasis on material management and site restoration. The methodology includes evaluating potential pathways for recycling and reusing materials, the dismantling process, and site rehabilitation to ensure long-term stability. Specific decommissioning considerations, such as the structural dismantling of dam components and post-decommissioning monitoring, will be addressed through a dedicated decommissioning plan, ensuring alignment with sustainability principles and regulatory requirements.

This chapter will assess the significance of the impacts related to resource and materials management, taking into account both the magnitude of the impact (negligible, minor, moderate, and major) and the vulnerability of receptors (low, medium, and high). This assessment will adhere to the methodology outlined in **Book 1 - Introduction**. The findings of the impact assessment will serve as a basis for defining mitigation measures and identifying any residual negative impacts, where full mitigation is not feasible.

5.4 Assumptions and limitations

Assumptions and limitations presented in the Book 1 Introduction are relevant for this topic.

Resources and material management specific assumption and/or limitations:

- Assumption that the clay, terraced, alluvial, and rocky materials available at the identified borrow pits and quarries meet the required specifications for construction, although final evaluations may reveal variations in quality.
- The designated temporary and permanent disposal sites are assumed to have sufficient capacity and stability to accommodate the estimated volume of unsuitable materials. No unforeseen geological or hydrological issues anticipated at these locations.
- Cement, steel, wood, fuel, and other supplementary materials will be available from local suppliers with the required permits and licenses, with no expected disruptions in supply chains.
- Additionally, the proposed mitigation measures are assumed to be implemented effectively, ensuring compliance with environmental regulations and minimizing impacts.
- Detailed site-specific investigations by the Contractor may lead to adjustments in material quantities, extraction methods, or disposal strategies. The quality of materials excavated during construction may vary, potentially resulting in higher-than-anticipated volumes of unsuitable material for disposal.

- Extreme weather events or community concerns, could impact the feasibility of using certain resources or sites.

5.5 Baseline

5.5.1 Introduction

During the Environmental Impact Assessment (EIA) phase, the study thoroughly examined the aspects of resource and material management related to the construction and operation of the Pambukovica dam. The geological composition of the area is characterized by gravel-sandy materials with clay fractions, forming a well-connected aquifer with the primary flow of the Ub River. The sediments include alluvial deposits and Triassic limestones, creating a unique hydrogeological unit with good filtration properties. The aquifer is primarily recharged by river inflow, with additional recharge from the hinterland1.

The availability and composition of construction materials are influenced by the geological and geomorphological characteristics of the project area. Excavation activities will involve various material types, including clay, alluvial, terraced, and rocky deposits. These materials will be sourced from borrow pits and quarries within the project's area of influence. The characteristics of these materials determine their suitability for different structural components of the dam, embankments, and access roads. Additionally, excavation and material extraction will generate surplus material, requiring appropriate handling in designated locations.

This chapter presents an overview of the materials to be used in the construction of the dam, along with the management of material generated during excavation and construction activities. The project involves extensive excavation, material extraction, and deposition to construct the dam, embankments, access roads, and related infrastructure.

5.5.2 Materials Sourcing and Quantities

5.5.2.1 Clay Materials for Core and Embankments

The construction of the dam's core, fore-embankment, and downstream drainage structures will require approximately 56,500 m³ of clay. This clay will be sourced from the designated borrow areas within the reservoir area on both the left and right banks of the river, with a total estimated quantity of around 80,000 m³ of loose material. The clay material is medium plasticity, of deluvial and proluvial origin, and will be sourced from four potential borrow pits (P1 to P4).

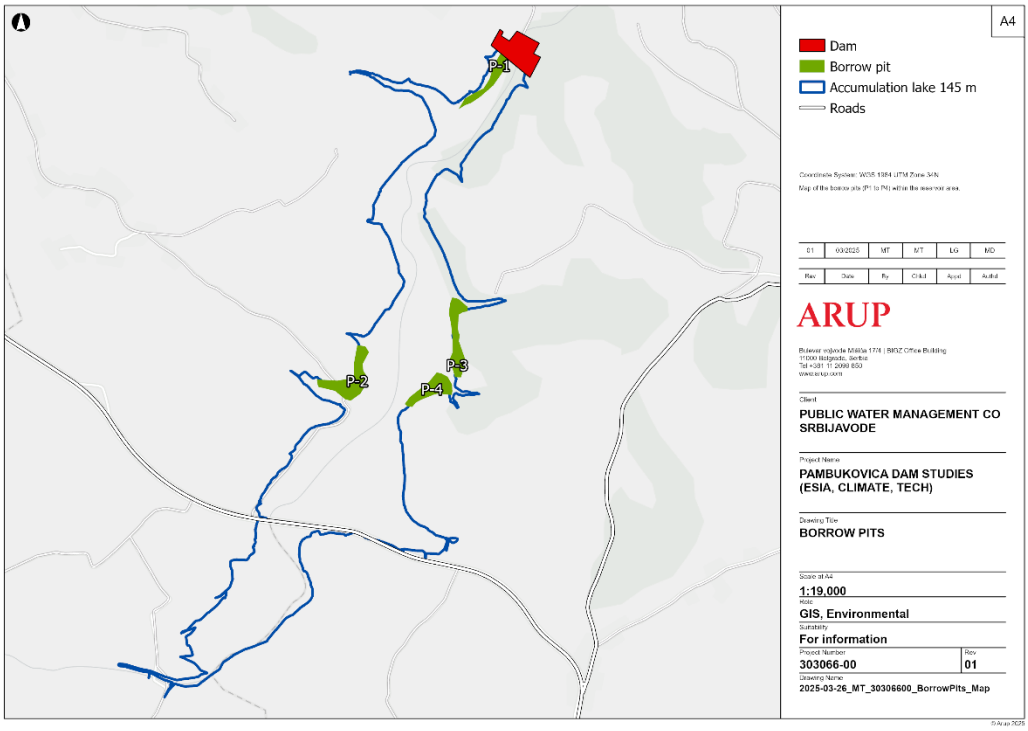

Figure 16 - Map of potential borrow pits for clay materials (P-1;P-2;P-3 and P-4)

5.5.2.2 Excavated Material for Embankment and Support Structures

Excavated terraced, alluvial, and fragmented rock materials will be used for the construction of embankments and support structures, including the upstream fore-embankment and foundations of various project components. The total required volume of these materials is approximately 80,000 m³, while the estimated volume of loose material before compaction is 120,000 m³. These materials will be sourced from excavation activities at the dam site and associated structures, including the side spillway, dam body, diversion gallery, and injection gallery.

5.5.2.3 Terraced and Alluvial Materials for Embankment and Support Structures

Terraced and alluvial materials will be used for filling embankments and support structures, including the upstream fore-embankment and the foundations of various project components. The estimated required quantity of these materials is approximately 80,000 m³, with a loose material volume of 125,000 m³ after accounting for compaction and transport losses. These materials will be sourced from the reservoir area, primarily from the D1 borrow pit area which extends from the dam profile to the upstream road elevation area.

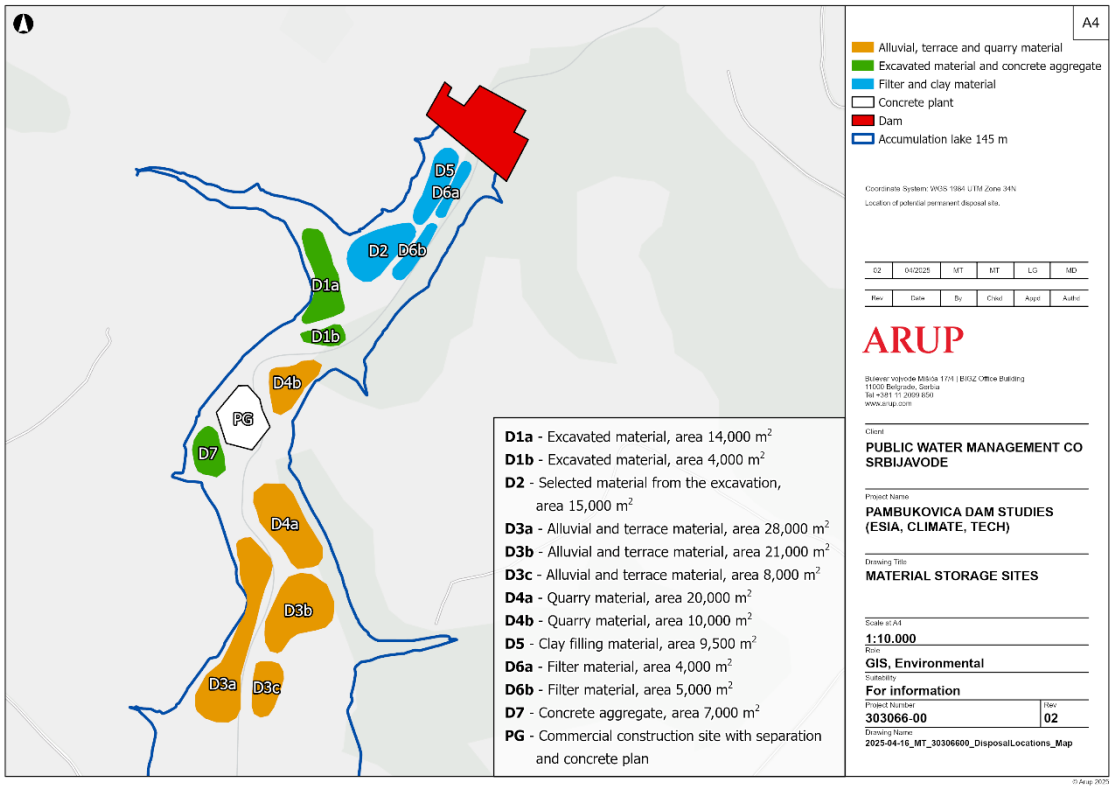

Figure 17 - Map of the material storage sites inside accumulation area

5.5.2.4 Rock Materials for Embankment Protection

Rock materials for protecting embankments and constructing drainage layers, including riprap and aggregates, will be sourced from the nearby Čučuge limestone quarry, and located approximately 5.5 km from the dam site. The current operational status of the quarry has not been officially confirmed, however available information suggest that quarry is not active. The total required rock material volume is about 75,000 m³, which will be expanded to 125,000 m³ in its loose state to account for transportation and handling.

The connection between the Čučuge quarry and the future construction site, including material disposal areas, will be made via existing roads that approach the mentioned locations from the upstream direction, thus shortening the transport distance.

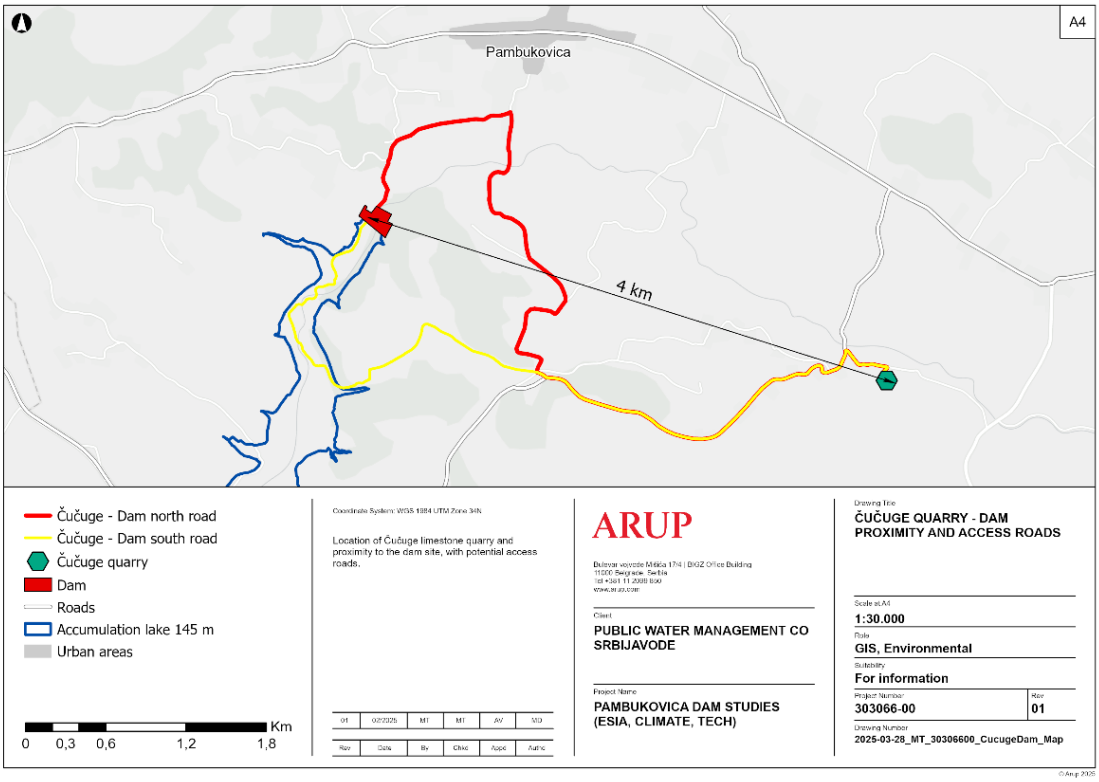

Figure 18 - Location of Čučuge limestone quarry and proximity to the dam site

5.5.2.5 Borrow pits for filter layers

The estimated volume of material required for filter layers, including sandy and gravelly-sandy filter material, is approximately 47,000 m³. Fine sandy filter material is expected to be sourced from the stockpiles of the "Kopovi Ub" company, while coarse gravelly-sandy filter material will be obtained by crushing stone material from the Čučuge quarry.

5.5.2.6 Concrete Aggregates

Concrete Aggregates and Cement Concrete aggregates will be sourced from the Čučuge quarry, while cement will be procured from the Titan cement factory in Kosjerić. The total amount of concrete to be used in the project is estimated to be 35,500 m³. To produce this amount of concrete, the required quantity of aggregates will be approximately 48,000 m³.

The total cement requirement is 12,425 tons for 35,500 m³ of concrete (350 kg/m³). With an average of 200 m³/day poured in the second year, daily cement consumption will be around 70 tons, requiring a six-day reserve of 420 tons. Three 150-ton silos will be provided for cement storage.

All necessary permits must be obtained for aggregate extraction from Čučuge quarry, in accordance with national regulations. These requirements should be clearly defined in the Resource and Material Management Plan to ensure compliance with legal and environmental standards.

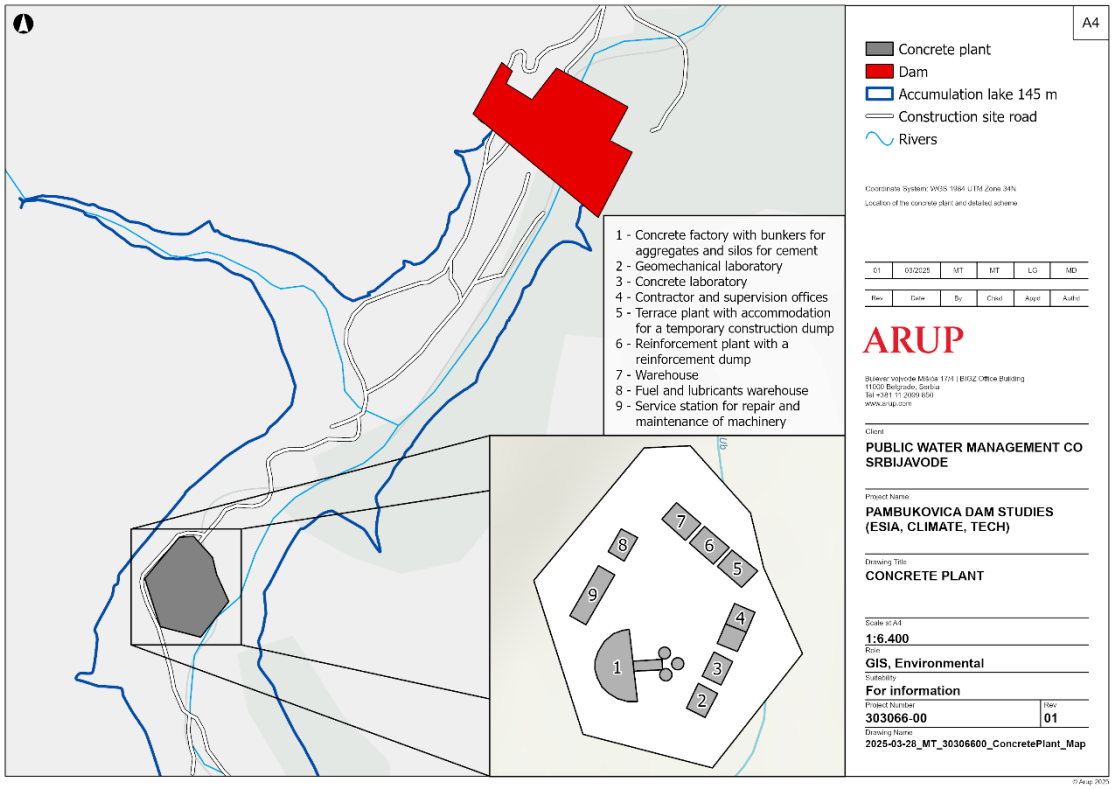

Figure 19 - Location of the concrete plant and detailed scheme

5.5.2.7 Other materials

Steel, cement, wood, fuel, and oil derivatives will be purchased from licensed local suppliers.

5.5.3 Surplus Material Management

5.5.3.1 Excavation of Materials

The total estimated volume of excavated material for construction purposes is around 360,000 m³. Half of this material consists of quaternary deposits, such as terraced, alluvial, and deluvial materials, while the other half is rocky material.

For embankment construction and other related infrastructure, approximately 154,000 m³ of excavated material is needed. However, due to quality constraints, not all of this material will be suitable for use in embankments. An additional 30% (approximately 47,000 m³) is expected to be unsuitable, resulting in a total of around 200,200 m³ of suitable material for embankment construction.

5.5.3.2 Permanent Disposal Sites

The remaining 160,000 m³ of excavated material, which is unsuitable for use in embankments, needs to be disposed of in permanent disposal sites. Additionally, excess material from the construction of permanent roads (P1 and P2) amounts to approximately 16,200 m³. The total volume of material to be permanently disposed of is estimated at 225,000 m³.

Tables below are summarizing the quantities of materials from excavation and their intended use. All quantities presented in tables are sourced from Design from Building Permit.

Table 11 - Quantities of materials from excavation and their intended use

Description	Volume (m3)
Total excavated material	360,000
Quaternary materials (terrace-alluvial and deluvial)	180,000
Stone materials	180,000

Table 12 - Total required material for construction

Description	Volume (m3)
Material needed for embankment and other objects	154,000
Additional 30% material required for embankment	200,200

Table 13 - Total material to be disposed

Description	Volume (m3)
Material to be disposed of permanently	160,000
Material unsuitable for embankment (30% of 154,000m3)	47,000
Excess material for construction of permanent roads (P1 & P2)	16,200
Total material to be permanently disposed	225,000

Excess material that does not meet construction quality standards may be disposed of outside the accumulation zone, with one potential location being the abandoned Čučuge quarry on the right bank of the Ub River, which can be accessed by paved road. The location is shown at the Figure 20 below.

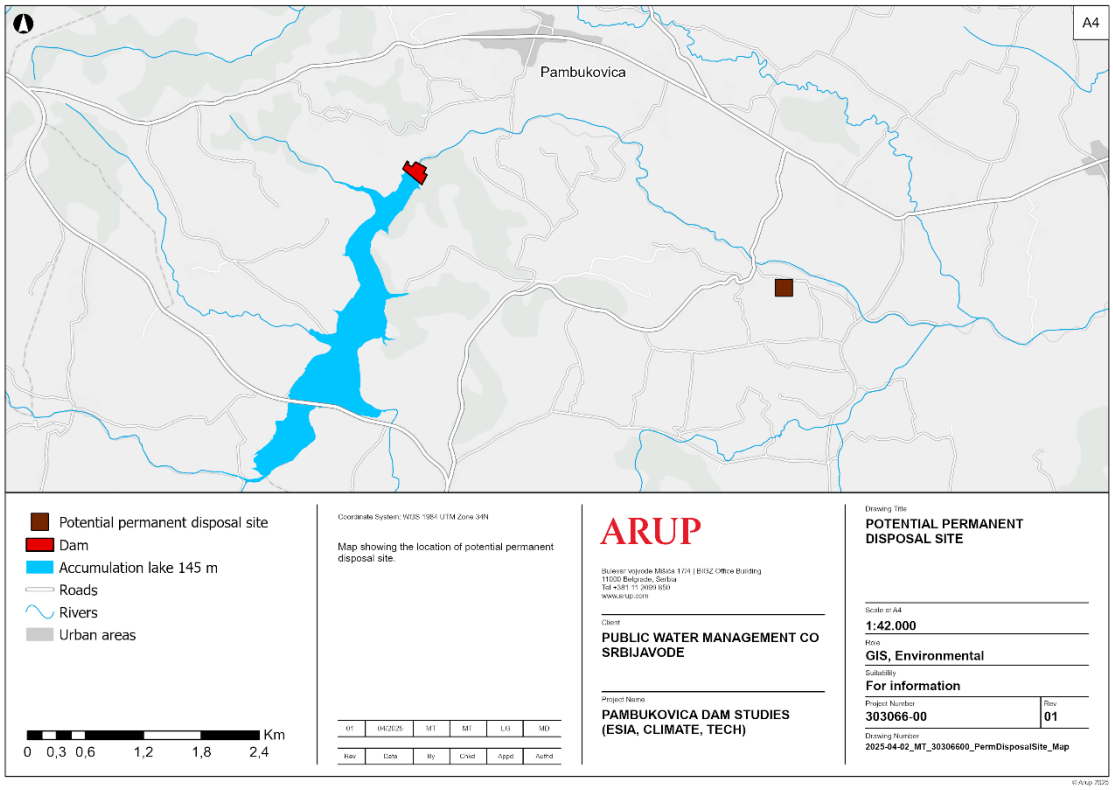

Figure 20 - Location of potential permanent disposal site (based on the Design for Building Permit)

To dispose of waste in an abandoned quarry, several legal procedures must be followed in accordance with Serbian legislation. These steps include obtaining the necessary permits and approvals to ensure that waste disposal is done in an environmentally responsible and legally compliant manner:

- Waste Disposal Permit: Obtain a permit from the relevant environmental authorities to ensure the waste can be disposed of in an environmentally safe manner.
- Land Use Approval: Confirm that the abandoned quarry is suitable for waste disposal by obtaining approval, in line with zoning regulations.
- Environmental Protection Permit: Obtain a permit that may include monitoring and protection measures for air, water, and soil quality around the disposal site.
- Local Government Approval: Secure consent from local authorities to use the abandoned quarry for waste disposal, ensuring compliance with local regulations.
- Waste Management Plan: Develop and implement a plan to manage the waste disposal process, ensuring safe handling and disposal of materials.
- Monitoring and Reporting: Implement a system to regularly monitor the site for environmental impacts, including water and air quality.
- Rehabilitation Plan (if necessary): Prepare a rehabilitation plan for the quarry to restore the site after the waste disposal process is completed.

5.5.3.3 Material storage sites and Site Access

Material storage sites will be located within the expropriated project area, located up to 1.5 km from the dam profile, ensuring that water flow and land stability are not disrupted. These sites will be equipped with access

roads, and care will be taken to ensure that materials are placed in such a way that they do not disrupt watercourses or impact the environment. These sites will be monitored throughout construction to ensure proper management.

The exact locations of these disposal sites are specified in Design for Building Permit. Material storage sites for the construction of the dam and associated structures are shown on Figure 21 below. The largest quantities of material for the embankment will be used in the bodies of the dam, the fore-dam, and the downstream embankment. The material for the dam and fore-dam embankment will be extracted from excavations for the structures and from the future reservoir (it is assumed that the material for the dam embankment will be exploited in the riverbed and on the banks, i.e., from the future reservoir at a distance of up to 2 km from the dam profile). Given the quantities of material from excavations, as well as selected material from excavations that will be used in the dam and structures, and the locations of clay borrow pits (P1-P4), it is proposed that these material storage sites (D1a, D1b, D2, D5) be located in the reservoir area closest to the dam profile, at a distance of 500-600 m.

Additionally, disposal sites for filter material (D6a, D6b) to be extracted from the Čučuge quarry and from the deposits of the "Kopovi Ub" company will be set up at this location.

Storage sites for selected terrace material from the reservoir area (D3a, D3b, D3c) and storage sites for stone material for the embankment and concrete aggregate, which will be extracted from the Čučuge quarry (D4a, D4b, D7), will be located upstream, extending the locations of the mentioned excavated material storage sites, at a distance of up to 1.5 km from the dam profile.

Access from the dam profile to the storage sites will be provided by construction roads on the left and right banks. Measures to prevent material erosion, sliding, and washing away include careful placement of materials, construction of access roads, and continuous monitoring to ensure proper management and environmental protection.

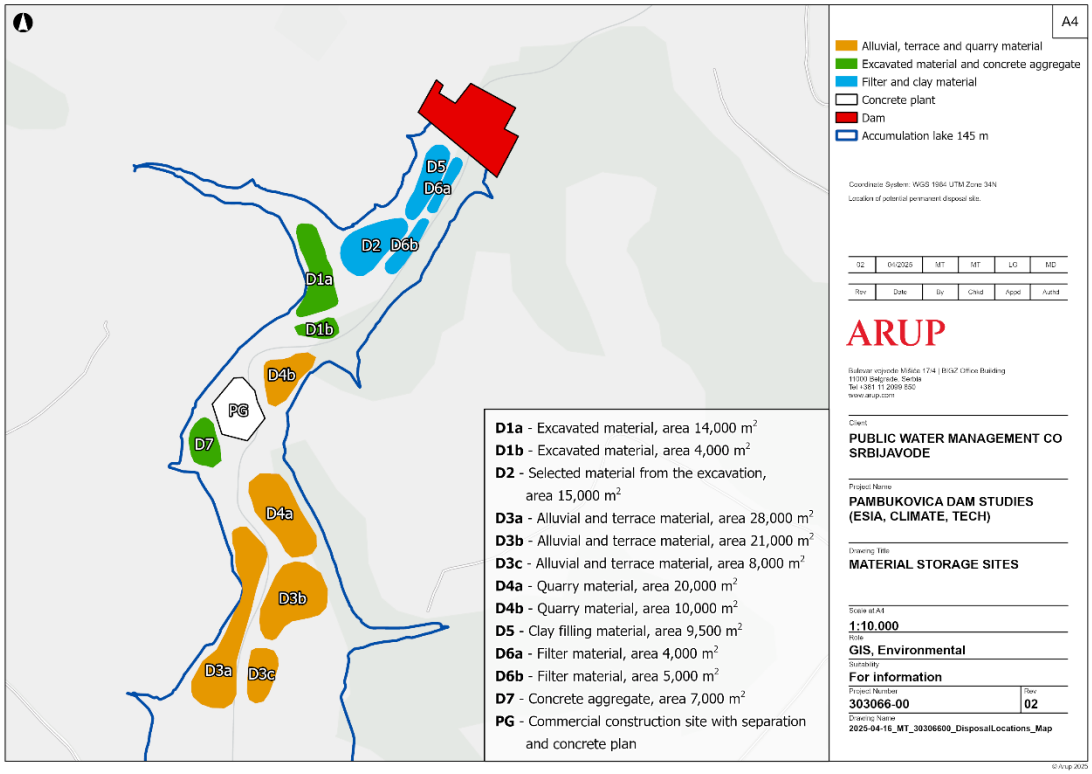

Figure 21 - Site map of material storage sites

5.5.4 Removal of Humus and Forest Vegetation

Before the commencement of construction, preparatory works must be carried out. These works include securing the site (fencing and properly marking the construction site), as well as all other activities that ensure the immediate environment, life and health of people, and the safe functioning of traffic. The locations designated for the dam and associated structures must be cleared of all obstacles, trees must be cut down, stumps removed, shrubs, small vegetation, and grass layers must be cleared and deposited at a landfill approved by the relevant municipal enterprises. The humus must be completely removed and stored aside in the vicinity, taking care of its subsequent use for landscaping the locations.

5.5.4.1 Removal of Humus

The removal of humus involves stripping the topsoil layer, which includes grass, small vegetation, and forest humus, to an average depth of 25 cm. If it is determined during the works that a thicker layer of humus needs to be excavated, the supervising authority is required to issue an order to the contractor to carry out the necessary removal. These orders will be issued through the construction log. The volume of removed humus will be determined by direct measurement in the profiles of the excavated natural humus by the supervising authority and the contractor, with the calculation based on the cubic meters of removed natural humus. The removed humus and associated forest vegetation shall not be deposited at a landfill but stored in designated storage areas, yet to be defined, for later use, such as site restoration, landscaping, or erosion control. Humus will be separated from woody vegetation, such as felled trees and shrubs, which may represent a useful resource for the local population. These materials will be either reused within the project for appropriate purposes or made available to the local community in coordination with relevant authorities.

The removal of humus will be carried out as follows:

- Stripping humus to an average depth of 25 cm from areas with slopes less than 10°, collecting all debris from tree cutting from all areas up to an elevation of 145.5 m.a.s.l., cleaning debris from the surfaces,

and transporting it to the landfill. Calculation will be based on cubic meters. The total estimated amount of humus to be removed is 321,124.41 m³.

5.5.4.2 *Removal and Cutting of Forest Vegetation*

The cutting and removal of trees (including stump removal and filling of holes) will be carried out according to the land use map. The project should include the cutting and removal of trees with stump removal and filling of holes, as well as the removal of underbrush (forest along the watercourse and boundaries), up to an elevation of 145.5 meters above sea level (m.a.s.l.) It is estimated that these works will be carried out over an area of approximately 33.2 ha according to EIA.

Tree measurements and counts were carried out on control plots with diagonal transects through selected areas. Tree diameter was measured at a height of 1.3 meters (breast height), and all data were recorded for each control area. After processing the data, the number of trees and their diameter classes were determined.

Based on habitat data, it is estimated that around 33.76 hectares of woodland will be cleared according to Biodiversity Net Gain Calculation. Using typical tree density values for these habitat types, the number of trees to be removed is estimated at approximately 13,500, though this figure may vary depending on actual site conditions and species composition. This number should be considered as an indicative estimate, derived from the Biodiversity Net Gain methodology, and may be subject to revision following detailed site surveys and final project design.

5.5.4.3 *Storage of Removed Humus and Forest Vegetation*

It is necessary to designate storage locations for the removed humus within the Resource and Material Management Plan. These areas should be carefully selected to ensure that they do not interfere with construction activities or environmental protection measures. The humus should be stored in piles and covered to prevent erosion and nutrient loss, and it can later be used for landscaping and the rehabilitation of disturbed areas.

The removed forest vegetation, including tree trunks, branches, and stumps, should be temporarily stored outside the work zone for safety reasons and kept easily accessible for potential use of the local community. If not utilized by the end of the construction phase, further handling of this vegetation should be planned within the Resource and Material Management Plan, ensuring its appropriate disposal or repurposing. The stored vegetation may be given for use to the local community or used for purposes such as mulching, composting, or biomass energy production.

5.5.5 Electricity Supply

The construction site will be powered through a connection to the existing 10 kV overhead power line, equipped with a 10/0.4 kV transformer. Additionally, a backup power supply via diesel generators will be provided in the event of power outages. The total power demand for the construction site and accommodation of on-site staff is estimated at 360 kW. Although the exact method of connection to the existing overhead line has not yet been defined, the construction of a new power network is not anticipated. The final design will define the connection methodology; however, this is not expected to have any significant impact from the perspective of resource and material management. This supply ensures that all operations can proceed smoothly, including those dependent on electrical equipment, while mitigating the risk of downtime in case of power failure.

5.5.6 Water Supply

Technical water for the construction site will be sourced from the Ub River. A pump will draw water directly from the river into cisterns, which will then be used mostly for maintenance or areas and dust suppression. Water from the Ub River is not expected to be used for any technological process, including concrete production. While the exact water requirements for the construction phase have not yet been determined due to the ongoing finalization of the design, they are not expected to be significant. At this stage, no estimates

are available that would indicate the approximate volume of water to be consumed throughout the construction phase.

Water usage during the operational phase is anticipated to be negligible. The planned extraction will comply with prescribed nominal daily limits to avoid disrupting the river's ecological parameters, thereby minimizing reliance on local potable water sources and reducing potential environmental and community impacts.

At the time of writing, it remains uncertain whether groundwater will be used as a water source. However, should the need for well construction and groundwater abstraction arise, all steps outlined in the Soil and Groundwater chapter must be followed, in accordance with the relevant provisions of the Water Law.

By properly managing the materials sourced, used, and disposed of, the project aims to mitigate the adverse environmental impacts typically associated with large-scale construction projects while adhering to local regulations and best practices for sustainable resource consumption and management.

5.6 Receptors and Area of Influence

The area of influence encompasses the immediate construction site, including the dam, embankments, access roads, and related infrastructure. It also includes the designated borrow pits and material extraction sites, which are essential for sourcing construction materials such as clay, terraced, alluvial, and rock materials. The borrow pits are located within the reservoir area on both the left and right banks of the Ub River, with four primary pits (P1 to P4) identified for material extraction.

In addition to the construction zone, the AoI extends to the both material storage sites and permanent disposal areas. Material storage sites for excavated material for construction are situated up to 1.5 km from the dam site. These sites will be equipped with access roads, and care will be taken to ensure that materials are placed in such a way that they do not disrupt watercourses or impact the environment. These sites will be monitored throughout construction to ensure proper management.

Permanent disposal sites for surplus material not suitable for construction are planned within the project's expropriated area, which includes the potential use of the abandoned Čučuge quarry. These areas will serve as storage locations for surplus materials and unsuitable excavation materials.

The Ub River and its immediate vicinity are also an integral part of the AoI, particularly in terms of water supply for the construction process. The river will be used to source technical water for construction activities, and efforts will be made to prevent any adverse environmental impacts on the river ecosystem and its surroundings during the project's implementation.

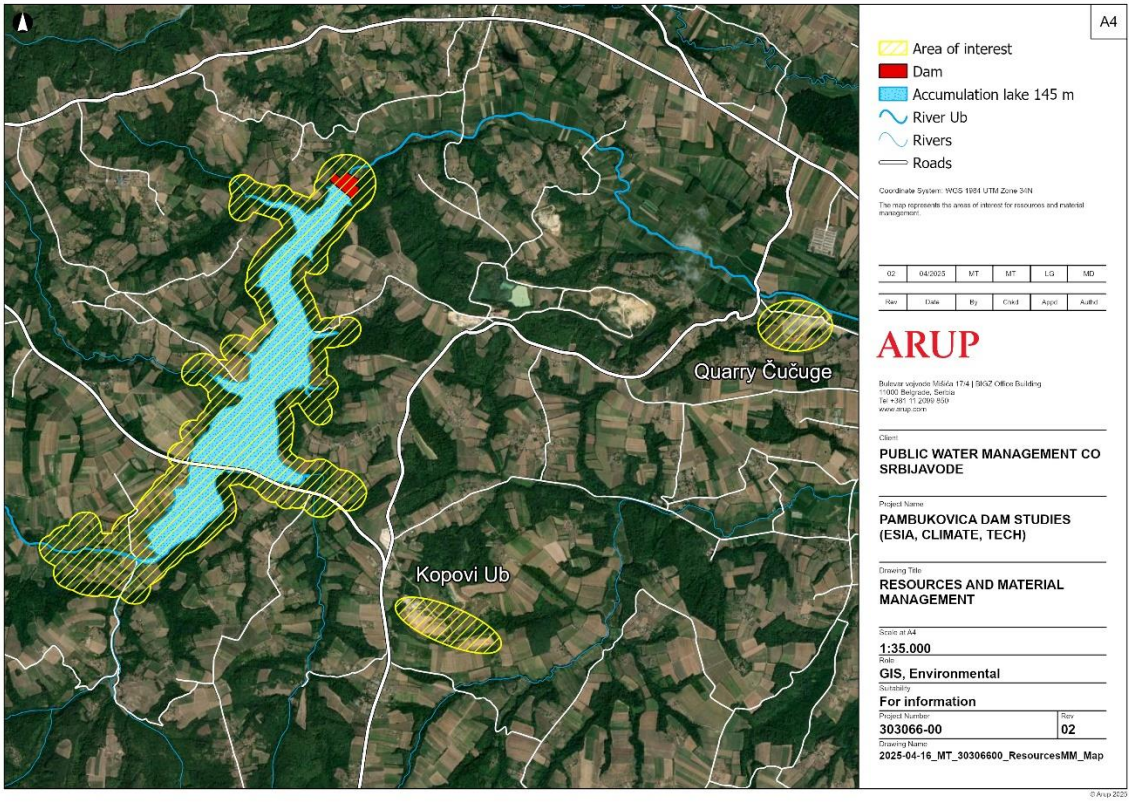

Figure 22 - Expected area of influence in terms of the resource and material management

5.7 Project Activities and Identification of Impacts

This chapter outlines the key project activities related to resource and material management during the construction of the dam and associated infrastructure. It also identifies potential environmental and social impacts arising from these activities. The following activities are identified as having a direct effect on the sourcing, use, storage, and disposal of construction materials:

Project Activities:

- Excavation of materials
- Clay extraction from borrow pits (P1 to P4)
- Terraced and alluvial material extraction from reservoir area (e.g., D1)
- Rock material sourcing from Čučuge quarry
- Extraction and delivery of sandy and gravelly-sandy filter material
- Procurement of concrete aggregates and cement
- Removal of humus and forest vegetation
- Establishment and use of temporary and permanent material storage and disposal sites
- Transport and handling of materials on-site
- Water sourcing for construction from the Ub River
- Electricity supply for construction operations

- Identified Impacts Related to Resource and Material Management
- Depletion of local natural resources due to large-scale extraction of clay, terraced/alluvial materials, and rock materials from nearby quarries and reservoir borrow areas
- Generation of surplus and unsuitable material from excavation activities, requiring safe and compliant permanent disposal
- Need for designated and regulated disposal sites, including legal and environmental compliance (e.g., use of abandoned Čučuge quarry)
- Pressure on local material suppliers, including cement, aggregates, fuel, and steel, potentially affecting availability and requiring proper procurement planning
- Increased demand for technical water from the Ub River, requiring sustainable water resource management during construction
- Risk of material mismanagement during on-site storage and transport, potentially leading to inefficiencies or delays if access and layout are not properly managed
- Potential resource use inefficiencies if unsuitable materials are not identified and separated early during excavation and sourcing processes
- Requirement for coordinated storage of humus and forest vegetation, ensuring reuse for landscaping and avoiding unnecessary waste accumulation
- Legal and permitting obligations for all resource-related activities (e.g., quarry use, waste disposal), requiring integration into the Resource and Material Management Plan.

5.8 Impact Assessment and Mitigation

This chapter evaluates the potential impacts associated with resource and material management during the dam's lifecycle and outlines mitigation measures for each project phase: pre-construction, construction, operation, and decommissioning.

5.8.1 Pre-Construction Phase

During the pre-construction phase, the primary activities include planning, design, permitting, and preparatory actions that occur before any on-site construction works begin. These early activities may result in localised and relatively minor environmental and social impacts, such as:localised

- Land Acquisition and Planning: Identification and securing of land for borrow pits, quarries, and disposal sites, which may cause community concerns related to land use rights, accessibility, and displacement.
- Stakeholder Consultations: Engagement with local communities and authorities regarding land use, project timelines, and potential impacts.
- Design and Material Planning: Estimation of required quantities and specifications for construction materials to avoid over-extraction and ensure efficient procurement.
- Resource Efficiency Planning: Identification of circular approaches and reuse potential for materials, such as creating specifications ("material passports") for potential reuse.
- Initial Environmental Measures: Planning for erosion control, habitat protection, and sediment management in line with expected site interventions

Mitigation Measures:

- Stakeholder Engagement: Conduct transparent and inclusive consultations with affected communities and relevant stakeholders to address concerns related to land use, material sourcing, and site access.
- Material Forecasting: Prepare detailed forecasts of material demand to avoid excessive extraction, reduce procurement costs, and support sustainable resource use.
- Reuse Planning: Identify opportunities for reusing surplus and excavated materials during later construction phases to minimize waste and reduce the need for additional raw material extraction.
- Circular Procurement: Integrate circular economy principles in the design and procurement processes by selecting materials that are durable, recyclable, and locally sourced where possible.
- Erosion and Sediment Control: Develop and implement predefined erosion and sediment control strategies—such as drainage channels, sediment traps, and vegetation buffers—prior to the start of construction works to mitigate soil and water impacts.

5.8.2 Construction Phase

The construction phase is anticipated to generate significant environmental and social impacts related to material sourcing, excavation, transportation, and surplus material management. Material extraction from borrow pits and quarries will cause land degradation, generate dust and noise, and disrupt local ecosystems. The disposal of approximately 225,000 m³ of unsuitable materials at permanent sites poses potential risks to land stability and water quality. The operation of the concrete plant and water extraction from the Ub River are expected to strain local resources. These activities can cause several environmental and social impacts:

- Vegetation Clearing and Soil Stripping: Removal of forest cover and humus layer over the construction footprint, leading to habitat destruction, increased erosion risks, and dust generation.
- Establishment of Access Roads and Temporary Facilities: Construction of internal roads, worker camps, and material storage areas, contributing to noise, emissions, and landscape alteration.
- Material Extraction and Transport: Excavation from borrow pits and quarries, generating dust, noise, and long-term changes in topography and land use.
- Disposal of Unsuitable Materials: Approximately 225,000 m³ of unsuitable material will be disposed of at permanent sites, potentially affecting soil stability and water quality.
- Water Abstraction: Construction water sourced from the Ub River may lead to temporary local depletion, affecting downstream aquatic ecosystems.
- Concrete and Asphalt Production: Operation of batching plants on-site leads to localised air, noise, and water resource impacts.
- Heavy Machinery Operations: Fuel consumption, emissions, and road wear from transport and construction equipment.
- Material and Energy Use: High demand for electricity, fuel, and raw materials during construction increases the project's environmental footprint.

Mitigation Measures

- Vegetation clearing should be limited to areas defined by the construction design, avoiding unnecessary removal and reducing habitat loss.
- Stripped topsoil and humus layers should be stored separately in designated stockpile areas and protected to enable reuse in site rehabilitation.

- Implement erosion control measures such as silt fences, sediment traps, and temporary drainage channels to reduce runoff and sedimentation.
- Construction of access roads and work areas should be planned to minimize land disturbance and avoid sensitive habitats and steep slopes.
- Excavated materials should be sorted by type (e.g., clay, rock, sand) and assessed for suitability for reuse in embankment construction, backfilling, or road surfacing.
- Unsuitable or surplus materials should be documented and transported to designated disposal sites with measures in place to prevent erosion and surface water contamination.
- Borrow pits and disposal areas should be stabilized progressively using compaction, drainage controls, and temporary vegetation cover.
- Construction water abstraction from the Ub River must be monitored to ensure sustainable withdrawal rates that do not harm aquatic ecosystems.
- Concrete batching operations should incorporate water recycling systems and optimized material planning to minimize the overuse of cement, aggregates, and water, thereby reducing material waste and conserving natural resources.
- Set up a monitoring program for material, energy, and water consumption, with regular reporting to support adaptive management and improve resource efficiency.

5.8.3 Operation Phase

In the operation phase, the primary impacts relate to long-term changes in land use for areas utilized as borrow pits, quarries, and disposal sites, potentially limiting future development options for surrounding communities. Furthermore, residual surplus waste sites, particularly permanent disposal areas, could present ongoing risks to land stability or environmental integrity if not adequately managed. These activities can cause several environmental and social impacts:

- Residual Waste and Environmental Risk: If permanent disposal sites are not properly managed, there may be ongoing risks of land instability, erosion, and contamination. Surplus waste in disposal areas may degrade the local environment, potentially impacting soil, water, and air quality.

Mitigation Measures:

- Regularly monitor disposal sites for signs of instability or environmental degradation, and implement corrective actions as needed.
- Develop and implement long-term site rehabilitation plans to restore disturbed areas and minimize adverse environmental effects.
- Establish vegetation cover on disposal sites to reduce erosion and enhance soil stabilization.
- Ensure that any remaining surplus material is assessed for potential reuse in future infrastructure projects.

5.8.4 Decommissioning Phase

Decommissioning activities are expected to involve site restoration, including the dismantling of temporary structures and restoring areas used for construction facilities. These activities may generate significant quantities of construction and demolition waste while potentially disturbing previously rehabilitated areas. These activities can cause several environmental and social impacts:

- Generation of Construction and Demolition Waste: The dismantling of temporary structures and removal of infrastructure will produce large amounts of waste, requiring proper disposal or reuse strategies.

- Disturbance of Rehabilitated Areas: Decommissioning activities may disrupt previously restored sites, potentially affecting soil stability and vegetation cover.

Mitigation Measures:

- Prepare a detailed decommissioning plan that will include all project activities that would be part of the decommissioning phase, as well as measures to minimize waste and prioritize recycling or reuse of materials.
- Conduct phased dismantling to reduce immediate environmental pressure and allow for effective waste management.
- Restore the land to its intended post-decommissioning use, ensuring the area is rehabilitated in a way that supports ecological recovery and local community needs.
- Ensure all temporary facilities are removed, and the land is restored to conditions suitable for its intended post-decommissioning use.

By implementing the proposed mitigation measures during all project phases, potential adverse impacts on resource and material management will be minimized, ensuring compliance with environmental regulations and the sustainable development goals of the project.

5.8.5 Management plans

The Resource and Material Management Plan (RMMP) will be developed by the contractor to ensure the efficient and sustainable use of raw materials while minimizing environmental impacts. This plan will outline the necessary permits and regulatory approvals for material extraction, ensuring compliance with national regulations. It will include accurate estimation of material quantities to prevent excessive extraction and waste generation, as well as designate approved borrow pits and quarries with rehabilitation measures to restore disturbed areas post-extraction. Additionally, the plan will establish procedures for managing surplus materials, prioritizing reuse and recycling, and ensuring proper disposal of unsuitable materials. Procurement strategies will require sourcing materials such as cement, aggregates, and fuel from licensed suppliers that meet environmental and quality standards. To mitigate transportation-related impacts, the RMMP will incorporate logistics planning, including efficient scheduling of material deliveries to minimize road strain, emissions, and noise. Furthermore, proper stockpiling and storage measures will be defined to prevent contamination and material degradation. Regular monitoring and compliance assessments will be conducted to track material usage, waste generation, and adherence to regulatory requirements, ensuring responsible resource management and overall project sustainability. The following activities should be identified as part of the RMMP:

- Clay Materials: Extracted from designated borrow pits within the reservoir area for dam core and embankments, with transport to the construction site.
- Terraced and Alluvial Materials: Sourced from borrow pits for embankment and support structures, involving excavation and compaction.
- Rock Materials & Aggregates: Extracted from a nearby quarry for embankment protection, drainage layers, and concrete production, requiring transportation logistics.
- Other Materials: Procurement of cement, steel, fuel, and other supplies from licensed local suppliers.
- Excavation & Waste Management: Excavation of construction materials, with unsuitable material designated for disposal.
- Disposal Areas: Management of surplus material through material storage and permanent disposal sites, ensuring environmental compliance.
- Concrete Production: On-site concrete plant operation requiring efficient handling of raw materials.

- Power & Water Supply: Electrical supply with backup generators and water sourced for construction activities.
- Topsoil & Vegetation Removal: Stripping of humus and vegetation, with storage and reuse for landscaping and site rehabilitation.
- Depositing Area Management: Stabilization of borrow pits and disposal areas to prevent erosion and environmental impact.

To facilitate the potential reuse of surplus materials in future projects, a material passport should be developed, providing clear specifications on material properties, origin, and suitability for various applications. If deemed outside the scope of the RMMP, these material passports could be managed under a separate documentation framework to ensure accessibility and integration into future planning efforts.

Erosion and Sediment Control Plan (ESCP) – To mitigate soil erosion and prevent sediment from entering water bodies, this plan would detail best management practices for excavation and construction runoff.

Site Restoration and Rehabilitation Plan (SRRP**)** – To address post-construction impacts, this plan would ensure proper site restoration, including soil stabilization, vegetation replanting, and landscape rehabilitation.

Table 14 - Impact assessment Table – Resource and Material Management

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Depletion of natural resources (clay, stone, sand, gravel)	Use of local natural resources for construction of embankment, foundation, and infrastructure (e.g., clay, terrace and alluvial material, stone from quarries, concrete aggregates)	Natural resource base (soil, minerals)	High	High	Major	Restrict extraction to designated sites; implement site rehabilitation plans; require a Resource and Material Management Plan (RMMP) to ensure proper permitting, material estimation, and controlled disposal or reuse of surplus materials; implement reuse and recycling strategies for excavated materials.	Minor
Generation of excess excavated material unsuitable for construction	~30% of 360,000 m³ excavated material will be permanently disposed of due to unsuitability	Land and soil resources at disposal sites	High	Medium	Major	Select suitable disposal locations Stabilize disposal sites to prevent erosion Separate and store usable fractions for potential future use	Moderate
Water use for technical needs	Water sourced from Ub River may temporarily affect river flow and availability	Water resources (Ub River)	Low	Medium	Minor	Permit for water extraction to be obtained by relevant authorities Use only quantities prescribed by the permit.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						Monitor withdrawals. Employ water-saving practices where possible. Do not extract water below Serbian minimal flow level prescribed by legislation.	
Pressure on local construction material suppliers	Increased demand for cement, steel, reinforcement, and aggregates may stress local supply chains and create competition with other users	Local construction material suppliers and markets	Medium	Low	Minor	Plan procurement in coordination with local stakeholders	Negligible
Strain on Local Infrastructure	Increased traffic, road degradation, and emissions from material transport and disposal.	Local infrastructure, air quality	Medium	Medium	Moderate	Plan transport routes and schedules; coordinate deliveries to off-peak times; use well-maintained vehicles to reduce emissions.	Minor
Residual Waste and Long-Term Land Stability Risks	Poorly managed disposal sites may lead to erosion, contamination, or prevent future land use.	Local environment, communities	High	Medium	Major	Monitor disposal sites; rehabilitate disturbed areas; establish vegetation cover and implement long-term site management.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Energy and Fuel Consumption	Use of heavy machinery and transport vehicles contributes to emissions and fossil fuel dependency.	Air quality, climate	Medium	Medium	Moderate	Optimize machinery schedules; monitor energy use; prioritize fuel-efficient and hybrid machinery; explore renewable sources for site offices.	Minor

Table 15 - Mitigation and monitoring – Resource and Material Management

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Resource Extraction and Management	Improper material extraction and disposal can cause degradation and pollution.	Natural resources, local ecosystems	Restrict activities to designated areas; develop and implement a (RMMP) for material extraction; site rehabilitation after use.	Continuous during construction; post-construction rehabilitation
Procurement of Materials	Use of non-compliant suppliers may lead to environmental harm.	Local economy, supply chain	Ensure sourcing from licensed suppliers with environmental credentials.	Pre-construction and procurement phase
Water Consumption & Efficiency	High water demand for dust suppression, concrete mixing, and sanitation.	Local water sources, communities	Use water-efficient technologies; prioritize water recycling where possible; implement water use monitoring plan; evaluate water abstraction limits. If groundwater is used for purposes such as worker camp supply, concrete batching, tanker rinsing, road wetting, or other construction-related activities, water consumption must be monitored and recorded through monthly logs.	Construction & Operation Phases; Water use monitoring monthly, adjust plan if needed

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Energy Consumption & Emissions	Use of fuel and electricity for construction equipment may increase emissions and operational costs	Air quality, climate, local residents	Track energy/fuel use (e.g., diesel logs, generator meters); maintain equipment for efficiency; evaluate energy-saving alternatives	Construction phase; energy logs monthly; generator and equipment checks quarterly
Concrete Plant Operations	Operation of concrete plant and water extraction from Ub River impacting local water resources.	Water resources	Install sedimentation ponds; monitor water extraction and consumption; develop a Water Management Plan to regulate and limit extraction; ensure regular maintenance of sedimentation ponds.	Construction Phase; Ongoing monitoring and adaptive management during operation
Material Management and Disposal	Accumulation of surplus and unsuitable materials may pose long-term risks	Land stability, visual landscape	Monitor disposal site stability; rehabilitate and vegetate areas; assess reuse potential of stored material	Construction and post-construction; annual monitoring
Legal Compliance	Extraction and disposal without permits may lead to regulatory violations	Regulatory authorities	Secure permits for quarrying, water use, and waste disposal; update RMMP with permit conditions	Prior to construction and updated annually
Long-Term Land Use Change	Borrow pits, quarries, and disposal sites limiting future development.	Local communities	Rehabilitate borrow pits post-construction; implement site monitoring and long-term land use plan; restore disturbed areas for community access.	Operation Phase; Rehabilitate sites post-construction, monitoring throughout operation phase

6. Waste and wastewater

6.1 Introduction and Purpose

The construction and operation of the proposed dam and associated reservoir are expected to generate significant quantities of waste and wastewater, requiring careful assessment and management to mitigate environmental and social impacts. The purpose of this assessment is to ensure that the dam project aligns with national and international environmental regulations, as well as sustainable development goals. Specifically, the assessment focuses on identifying, predicting, and evaluating the potential environmental and social impacts associated with project activities throughout its lifecycle, from pre-construction to decommissioning.

The Environmental Impact Assessment (EIA) for the Pambukovica dam examined waste and wastewater management during construction and operation. Waste management involves proper storage, transport, and disposal of hazardous and non-hazardous waste, adhering to legal requirements and regular reporting. Hazardous waste must not be stored at the producer's site for more than 12 months, and explosive materials must be handled by trained adults.

Wastewater management includes regular cleaning of the reservoir and retention zones upstream of the dam to prevent sedimentation and water overflow. It prohibits the free discharge of drilling mud into the soil or watercourse. The quality of water downstream must be monitored regularly, and degraded areas around the river must be rehabilitated after the completion of works. Vegetation cover must be established on endangered sites using native species.

Specifically, this assessment aims to identify, predict, and evaluate impacts related to waste and wastewater, including construction waste such as excavated materials, hazardous waste from chemical use, and wastewater from construction and operational activities. By analysing baseline conditions and proposing targeted mitigation measures, the ESIA ensures that the dam project is developed in a manner that protects natural resources, reduces pollution, and upholds the health and safety of local communities.

6.2 Legislation and Standards

EBRD Performance Requirements and Guidelines

The principles of waste and wastewater management are outlined in Performance Requirement 1 (PR1) and Performance Requirement 3 (PR3) of the European Bank for Reconstruction and Development (EBRD). PR1 focuses on the importance of identifying and managing environmental and social risks, with a specific emphasis on waste management and pollution prevention. It emphasizes that waste generation, including hazardous and non-hazardous waste, should be minimized through effective management practices, and wastewater should be treated and disposed of in a manner that prevents harm to the environment and human health.

PR3, as outlined previously, also supports efforts to reduce waste generation, enhance waste recovery and recycling, and ensure that all waste management practices are in line with international best practices and regulatory frameworks. This includes the treatment of wastewater to meet local and international standards, reducing pollutants, and reusing treated water wherever feasible. PR3 also encourages the use of efficient technologies and processes that contribute to minimizing environmental impacts throughout the project lifecycle, including managing and monitoring wastewater discharges and solid waste disposal.

Together, these Performance Requirements provide a robust framework for minimizing waste and wastewater impacts, ensuring compliance with environmental standards, and promoting the sustainable management of resources and waste materials throughout the project.

EU regulations and directives

- Waste Framework Directive (Directive 2008/98/EC, as amended by Directive (EU) 2018/851)
- Directive (EU) 2018/851 (Amendment to the Waste Framework Directive)
- Directive on Industrial Emissions (Directive 2010/75/EU, Integrated Pollution Prevention and Control - IPPC Directive)

These directives form the legislative foundation for waste and wastewater management in the EU. The Waste Framework Directive establishes general principles for waste management, while its 2018 amendment strengthens measures related to waste prevention, recycling, and the circular economy. The Industrial Emissions Directive ensures strict control of industrial pollution, including emissions into water, enforcing the application of Best Available Techniques (BAT) to minimize environmental impact.

National Legislation

The main national legal framework considered, related to Waste and wastewater is:

- Law on Environmental Impact Assessment ("Official Gazette of RS," Nos. 135/04, 36/09);
- Law on Environmental Protection ("Official Gazette of RS," Nos. 135/04, 36/09, 36/09 - other law, 72/09 - other law, 43/11 - Constitutional Court decision, 14/16, 76/18, and 95/18 - other law);
- Law on Waters ("Official Gazette of RS," Nos. 30/10, 93/12, 101/16, 95/18, and 95/18 - other law);
- Law on Waste Management ("Official Gazette of RS," Nos. 36/09, 88/10, 14/16, and 95/18 - other law);
- Law on Packaging and Packaging Waste ("Official Gazette of RS," Nos. 36/09 and 95/18 - other law);
- Law on Health and Safety at Work ("Official Gazette of RS," Nos. 101/05, 91/15, and 113/17 - other law);
- Law on Fire Protection ("Official Gazette of RS," Nos. 111/09, 20/15, 87/18, and 87/18 - other law);
- Law on Chemicals ("Official Gazette of RS," Nos. 36/09, 88/10, 92/11, 93/12, and 25/15).

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

6.3 Methodology

An impact assessment has been conducted based on available documents, including the Environmental Impact Assessment (EIA), Project Design, and Spatial Plans, as well as the characteristics of the project and the study area. The assessment relied on a desk-based review of secondary data sources, including project documentation, publicly available information, and applicable legislation and standards relevant to waste and wastewater management.

The methodology addresses the types of waste and wastewater likely to be generated during the construction and operation phases, including excavation materials, construction debris, hazardous waste, and wastewater from various sources.

This chapter will assess the significance of the impacts related to waste and wastewater, taking into account both the magnitude of the impact (negligible, minor, moderate, and major) and the vulnerability of receptors (low, medium, and high). This assessment will adhere to the methodology outlined in **Book 1 – Introduction.**

For each phase, waste management practices and wastewater treatment options will be aligned with national regulations and international standards.

6.4 Assumptions and limitations

Assumptions and limitations presented in the Book 1 Introduction are relevant for this topic.

Waste and wastewater specific assumption and/or limitations:

- Adequate disposal and recycling facilities at the municipal / regional level for hazardous and non-hazardous waste will be accessible during both the construction and operational phases, meeting local and international standards.
- Estimated volumes of waste and wastewater may change due to unforeseen factors such as changes in construction methods, project delays, or variations in workforce size.

6.5 Baseline

The Kolubara River basin, including the area surrounding the Pambukovica Dam project site, faces significant waste and wastewater management challenges. Waste disposal infrastructure is limited, particularly in rural and peri-urban areas, where sewage systems are inadequate or entirely absent. In many cases, domestic and agricultural wastewater is discharged directly into local watercourses, contributing to surface and groundwater contamination. The lack of centralized wastewater treatment facilities means that most wastewater is either untreated or only partially treated before being released into the environment.

Municipal waste collection services are also limited, with rural households often relying on informal waste disposal methods, such as open dumping or burning. While larger towns and cities have access to official landfill sites, many communities in the project's vicinity lack proper waste management services, increasing the risk of illegal dumping and environmental degradation.

Currently, there is no dedicated waste management facility within the immediate vicinity of the project area. Solid waste from local households and small businesses is either collected periodically by municipal services or disposed of informally. Industrial waste generation is low, but agricultural activities contribute to organic waste accumulation and potential water pollution through the runoff of fertilizers and pesticides.

Regarding wastewater infrastructure, the nearest treatment facility is in Ub, but it has limited capacity and does not serve the entire region. Most households rely on septic tanks, many of which are poorly maintained and prone to leaking, increasing the risk of contamination of groundwater and nearby water bodies.

During the construction phase of the Pambukovica Dam, wastewater generation is expected, arising from activities such as machinery maintenance, worker accommodation, and general construction site needs. The disposal of these wastewater streams will need to be managed carefully to avoid contamination of the Ub River and surrounding environment.

6.6 Receptors and Area of Influence

The Area of Influence (AoI) for waste and wastewater management during the construction and operation of the dam and reservoir encompasses the immediate vicinity of the dam site, the construction zones, and surrounding areas that could potentially be impacted by waste generation or wastewater discharge. This area is defined as extending approximately 50 meters from the sources of waste generation and wastewater discharge, including the dam construction site and related infrastructure.

Receptors

The Ub River is the primary watercourse in the project area and plays a vital role in local ecosystems and community livelihoods. Increased waste and wastewater generation pose risks to water quality, potentially affecting aquatic habitats and downstream water users.

Surrounding Land - the project area includes agricultural land and natural habitats that could be impacted by improper waste disposal or wastewater discharge. Soil contamination and disruption to land stability are potential concerns.

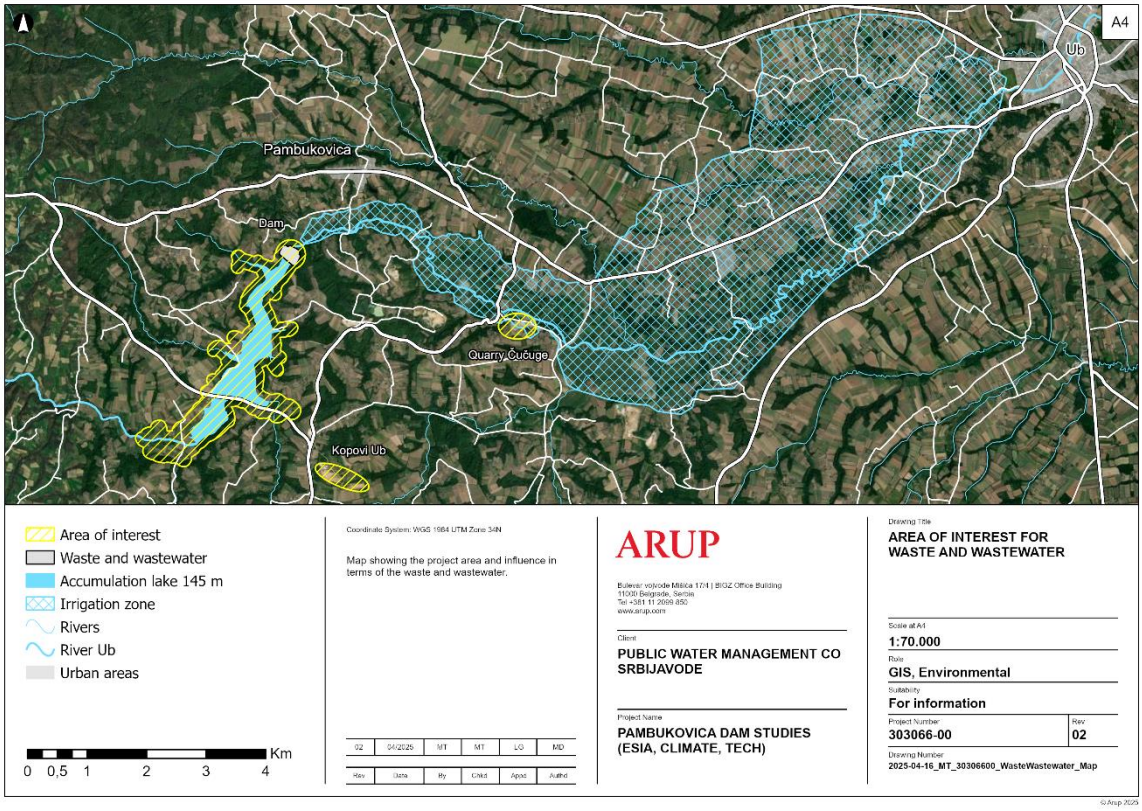

Figure 23 - Area of interest – Waste and wastewater

6.7 Project Activities and Identification of Impacts

This chapter outlines the key project activities related to the generation, handling, and disposal of waste and wastewater during the construction and operation of the Pambukovica Dam. It also identifies potential environmental impacts resulting from these activities. The following activities are identified as having a direct effect on waste production, wastewater discharge, and associated environmental risks:

Project Activities

- Site preparation and vegetation clearance, including removal of existing debris and illegal landfills (if present) in the cadastral municipalities of Pambukovica and Raduša
- Excavation and earthworks, including soil removal and groundwater pumping with necessary sediment removal prior to discharge
- Embankment and concrete works, generating concrete residues, hardened concrete, washout water, and steel scraps
- Mechanical and structural works involving cutting, welding, and installation, generating metal waste, oils, lubricants, geotextile scraps, and chemical containers
- Installation of pipelines, electrical and sewage infrastructure, with related waste including cut pipes, cables, and construction debris
- Management of sanitary wastewater from worker facilities via licensed service providers

- Operation and refueling of diesel generators and compressors, requiring spill prevention and emissions control
- Wastewater generation from construction activities (concrete washout, surface runoff, and pumped groundwater) and from operational phase maintenance and sanitary facilities
- Management of operational waste such as used lubricants, tools, and sediment from the reservoir, as well as treatment residues from water purification processes
- Decommissioning of dam and infrastructure, involving large-scale demolition works, material recovery, hazardous waste screening, and site rehabilitation

Identified Impacts Related to Waste and Wastewater Management

- Generation of non-hazardous waste (e.g., concrete debris, metal scraps, construction materials), requiring proper segregation, recycling, and disposal
- Generation of hazardous waste (e.g., oils, lubricants, chemical containers), requiring safe handling, storage, and disposal in line with hazardous waste regulations
- Risk of soil and water contamination from improper disposal of hazardous waste and untreated wastewater (e.g., concrete washout)
- Increased wastewater discharge from construction and operational activities, requiring adequate treatment to meet national discharge standards
- Spill risks from fuel handling and chemical use, necessitating strict protocols, spill response plans, and safe storage practices
- Demolition waste and residual contamination during decommissioning, requiring controlled disposal and environmental site assessment

By implementing effective waste and wastewater management strategies including proper segregation, treatment, and disposal the project aims to reduce its environmental footprint and ensure compliance with applicable environmental regulations.

6.7.1 Categories of Waste that will be generated as result of activities:

6.7.1.1 Non-Hazardous Waste

Generated from construction activities, site operations, and worker accommodations, these wastes can be recycled, reused, or disposed of in authorized landfills.

- Construction Waste: Concrete residues, broken bricks, asphalt, excavated soil and rock (unsuitable for reuse), wood scraps, plastic and packaging materials, metal residues.
- Municipal Waste: Paper, cardboard, plastic bottles, organic food waste, and glass.
- Road and Infrastructure Waste: Asphalt residues, cut sections of pipes and cables, surplus geotextiles and sealing tape.
- Concrete Waste: Hardened concrete, mortar, concrete washout sludge, cement dust

6.7.1.2 Hazardous Waste

Requires special handling, storage, and disposal due to potential environmental or health risks.

- Contaminated Soil & Absorbents: Soil contaminated with fuel, oil, or chemicals, and used absorbents (e.g., sawdust, pads).
- Oil, Fuel & Lubricants: Used engine and hydraulic oils, fuel residues, oil filters, greasy rags.
- Chemical Waste: Paints, solvents, adhesives, sealants, chemical containers.
- Explosive Waste: Unused or defective explosives, packaging from explosive materials.
- Hazardous Construction Waste: Bituminous materials, insulation materials containing hazardous chemicals.

6.7.1.3 Wastewater

Requires management to prevent environmental contamination and meet regulatory standards.

- Sanitary Wastewater: Waste from portable toilets and showers, greywater from washing areas.
- Industrial & Construction Wastewater: Concrete washout, washing water contaminated with oil, slurry from drilling.
- Stormwater Runoff: Surface water carrying sediments, oil, and chemicals, dewatering water.

6.7.1.4 Emergency Waste

Generated in response to spill or fire incidents.

- Fire-damaged materials, contaminated PPE, absorbents, and burnt packaging or debris

6.8 Impact Assessment and Mitigation

This section evaluates the potential environmental and social impacts associated with waste generation and wastewater production across all phases of the project, including pre-construction, construction, operation, and decommissioning. The chapter also provides mitigation measures to minimize negative effects and ensure compliance with environmental regulations.

6.8.1 Pre-Construction Phase

The pre-construction phase encompasses planning, permitting, preliminary surveys, and preparatory work prior to the commencement of physical construction. Although this phase typically generates lower volumes of waste and wastewater, it may still result in environmental and social impacts if not managed properly. Key activities during this phase include site investigations and geotechnical surveys, establishment of temporary facilities, mobilization of equipment, and permit compliance and stakeholder coordination. Following environmental and social impacts can be expected:

- Domestic Waste Generation – Limited amounts of paper, packaging, and food waste from personnel during early activities.
- Wastewater Generation – Minor sanitary wastewater from early-stage staffing and field teams.
- Improper Storage Risks – Initial delivery of materials or chemicals could pose risks if not stored properly during this phase.

Mitigation Measures:

- Waste Segregation and Disposal – Implement basic waste management practices including bins for recyclables and general waste, coordinate collection with municipal services or licensed companies.

- Sanitary Waste Management – Provide portable toilets and ensure regular maintenance by licensed service providers.
- Hazardous Material Storage – Store any fuels, lubricants, or chemicals in designated areas with secondary containment to prevent spills.

6.8.2 Construction Phase

The construction phase represents the most intensive period in terms of waste and wastewater generation. Key activities include land clearing, vegetation and topsoil removal, excavation, material processing, infrastructure development .and worker-related activities. These activities can cause several environmental and social impacts:

- Vegetation removal and Biomass Waste – Tree cutting, brush clearing, and topsoil removal will generate organic waste and disturb habitats. Refer to Chapter 5.8 for further details on vegetation and hummus removal activities and proposed mitigations.
- Construction Waste – Includes non-hazardous and hazardous materials such as concrete residues, wood, plastics, scrap metal, packaging, and bituminous materials.
- Hazardous Waste – Generated from fuel use, lubricants, paints, solvents, and other chemicals associated with machinery and construction.
- Wastewater from Construction Activities – Concrete washout water, drilling fluids, and dewatering of excavated zones.
- Sanitary Wastewater – Generated from worker accommodation, mess areas, and sanitary facilities.
- Stormwater Contamination – Runoff from construction areas may carry sediments, oils, and other pollutants to nearby water bodies.
- Sediment Accumulation and Turbidity – Improper sediment management can lead to water quality degradation and reduced reservoir capacity.
- Local Road Demolition and Reconstruction – The State Road No 21 (Sabac-Valjevo) will be demolished and then raised to a higher level to accommodate the new infrastructure. This will involve significant excavation and construction activities, generating large volumes of waste and wastewater.

Mitigation Measures:

- Excavation Waste Management Plan – Where possible, surplus excavated materials should be reused for road construction, embankments, and landscaping to minimize disposal needs.
- Controlled Land Clearance – Implement selective vegetation clearing to preserve existing biodiversity where possible. Biomass should be composted, mulched, or securely stored and made available to local communities where appropriate.
- Waste Segregation and Recycling – Provide designated collection points for different waste categories, ensuring that reusable materials are repurposed. Detailed plan should be developed through Waste Management Plan.
- Safe Handling of Hazardous Waste – Oils, lubricants, and solvents should be stored in secondary containment units and disposed of through licensed waste management companies.
- Concrete Washout Management – Establish dedicated washout areas with lined containment pits to prevent high-pH discharge into the environment.
- Wastewater Treatment Measures – Sedimentation ponds, oil-water separators, and temporary treatment facilities will be utilized to treat wastewater before discharge. A watertight septic tank will be

constructed to manage sanitary wastewater. During construction, portable chemical toilets will be installed, which will be regularly emptied by a licensed company specializing in waste management services.

- Implement upstream sediment traps to control the amount of sediment reaching the reservoir, reducing the risk of sedimentation and maintaining water quality.
- Ensure regular removal and maintenance of sediment traps to sustain their effectiveness in managing sediment transport.
- Stormwater Control – Install drainage ditches, retention ponds, and sediment barriers to prevent pollution from surface runoff.
- Sanitary Wastewater Treatment – Provide portable toilets with licensed disposal services and explore options for on-site septic systems or temporary wastewater treatment units.

6.8.3 Operation Phase

During the operation phase, waste and wastewater generation will continue, though at a reduced scale compared to construction. These activities can cause several environmental and social impacts:

- Accumulation of Sediments in the Reservoir – Over time, sediment deposition may reduce storage capacity and require periodic dredging.
- Waste from Maintenance Activities – Routine upkeep will generate scrap materials, packaging waste, used lubricants, and replacement parts.
- Hazardous Waste Generation – Oils and lubricants from maintenance machinery, chemical residues from water treatment processes.
- Wastewater from Operational Processes – Overflow discharge, maintenance-related contaminated water, and sanitary wastewater from staff.

Mitigation Measures:

- Maintain and clean upstream sediment traps on a regular basis to prevent excessive sediment buildup and ensure effective reservoir functioning.
- Utilize the bottom outlet for controlled sediment flushing to manage long-term sediment deposition and sustain reservoir capacity.
- Conduct periodic sedimentation studies to assess accumulation rates and implement adaptive management strategies for long-term sustainability.
- Sustainable Waste Management Practices – Encourage recycling and proper disposal of maintenance-related waste.
- Safe Handling of Hazardous Waste – Implement strict controls on lubricant and chemical storage, with designated disposal pathways.
- Wastewater Quality Monitoring – Ensure operational discharges meet regulatory standards before being released into the environment.

6.8.4 Decommissioning Phase

Decommissioning of the dam and associated infrastructure will generate large volumes of demolition waste and pose risks of contaminated material disposal. These activities can cause several environmental and social impacts:

- Demolition Waste – Large quantities of concrete, steel, wood, and other construction materials will require disposal or recycling.
- Residual Hazardous Waste – Potential contamination from old fuel storage, oils, and chemicals used during operation.
- Wastewater from Demolition Activities – Dust suppression and decontamination procedures may generate wastewater requiring treatment.

Mitigation Measures:

- Deconstruction Instead of Demolition – Prioritize dismantling and material recovery to maximize recycling potential.
- Hazardous Waste Identification and Treatment – Conduct environmental site assessments to detect contaminated materials and safely dispose of them.
- Water Use Optimization – Use water-efficient demolition techniques to minimize wastewater generation.
- Erosion Control During Site Rehabilitation – Implement revegetation and soil stabilization measures to prevent post-demolition erosion and runoff pollution.

The irrigation infrastructure project is part of the second phase of the Pambukovica dam and reservoir construction. This phase involves the development of irrigation systems to support agricultural activities in the surrounding areas. It is expected that the activities for this phase will be similar to those in the dam construction phase, involving earthworks, excavation, and the installation of various infrastructure components. However, as the irrigation project design is still under development, it is not possible to determine the specific details at this stage. Further planning and design work will be required to outline the exact activities and materials needed for the successful implementation of the irrigation system.

6.8.5 Management plans

A comprehensive Waste Management Plan (WMP) and Spill Prevention and Response Plan (SPRP) will be developed to address the various waste streams and potential spill risks during construction and operation. These plans will include:

- Identification of Waste Streams: Classification of waste into hazardous and non-hazardous categories, including excavation materials, construction debris, hazardous chemicals, and municipal waste.
- Waste Segregation and Recycling: Strategies for separating recyclable materials such as metal scraps, plastics, and concrete for reuse or proper disposal.
- Hazardous Waste Handling: Specific procedures for the collection, storage, and disposal of hazardous waste in accordance with regulatory requirements.
- Waste Disposal and Treatment: Designation of authorized disposal sites for construction and operational waste, ensuring compliance with environmental regulations.
- Wastewater Treatment and Discharge: Proper treatment of wastewater from construction activities, including sediment removal and compliance with discharge limits.
- Monitoring and Compliance: Regular inspections and reporting to ensure adherence to waste management protocols and regulatory compliance.
- Spill Prevention Measures: Implementation of fuel and chemical storage protocols, secondary containment systems, and routine inspections to prevent leaks and spills.
- Emergency Spill Response: Procedures for immediate containment, cleanup, and reporting of spills, ensuring minimal environmental impact and worker safety.

- Sediment Management Plan – Regular sediment monitoring will inform dredging schedules and ensure proper handling of removed materials.

Additional plans that will complement these core management strategies include:

- Concrete Washout and Wastewater Management Plan: Establishes protocols for handling high-pH wastewater from concrete mixing, ensuring that it doesn't contaminate soil and water resources.
- Stormwater Management and Monitoring Plan: Focuses on controlling stormwater runoff during construction and operation, preventing contamination of water bodies.

The implementation of these plans will minimize environmental impacts, promote sustainability, and ensure responsible waste and spill management throughout the project lifecycle.

Table 16 - Impact Assessment Table – Waste and wastewater

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Vegetation and Biomass Waste (Pre-Construction)	Clearance of vegetation, tree removal, and biomass disposal may disrupt local habitats.	Local biodiversity, soil quality	Medium	Medium	Moderate	Selective clearing, biomass repurposing (mulching/erosion control), and controlled disposal.	Minor
Construction Debris and Domestic Waste (Pre-Construction)	Removal of existing structures or accumulated waste from past land use may introduce non-hazardous and potentially hazardous waste.	Construction site, local environment	Medium	Medium	Moderate	Waste segregation and disposal in registered landfills. Detailed Waste Management Plan to address waste handling methods.	Minor
Soil Erosion and Sediment Runoff (Pre-Construction)	Exposed land areas may lead to increased sediment transport into nearby watercourses.	Soil, watercourses	High	High	Major	Install silt fences, sediment basins, and temporary drainage systems.	Minor
Initial Wastewater Generation (Pre-Construction)	Worker accommodation, sanitary facilities, and equipment setup will contribute to wastewater production.	Water resources, public health	Medium	Medium	Moderate	Install portable toilets with scheduled emptying and disposal by licensed service providers.	Minor
Construction Waste (Construction)	Non-hazardous and hazardous materials including concrete residues, wood, plastics, scrap metal,	Construction site, local environment	Medium	Medium	Moderate	Waste segregation at source, recycling, and disposal in registered landfills.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
	packaging, and bituminous materials.						
Hazardous Waste Generation (Construction)	Oils, lubricants, paints, solvents, and fuel residues from machinery and construction activities.	Local environment, water resources, workers	High	High	Major	Secure storage in secondary containment; disposal through licensed contractors.	Minor
Wastewater from Equipment and Concrete Works (Construction)	High-pH concrete washout water, drilling fluids, and dewatering of excavated areas.	Soil, water resources	High	High	Major	Establish lined washout pits; prevent uncontrolled discharge.	Minor
Worker Sanitary Wastewater (Construction)	Human waste and greywater from accommodation, sanitary facilities, and mess areas.	Water resources, public health	Medium	Medium	Moderate	Provide portable toilets with licensed disposal services and explore on-site septic systems or temporary wastewater treatment units.	Minor
Stormwater Contamination (Construction)	Rainwater runoff may mobilize sediments, oils, and chemicals, leading to contamination of nearby water bodies.	Local water bodies, aquatic life	High	High	Major	Install drainage ditches, retention ponds, and sediment barriers to prevent pollution from surface runoff.	Minor
Sediment Accumulation in Reservoir (Operation)	Over time, sediment deposition may reduce storage capacity and require periodic dredging.	Reservoir water quality, storage capacity	High	High	Major	Regular sediment monitoring and dredging.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Maintenance Waste (Operation)	Routine upkeep will generate scrap materials, packaging waste, used lubricants, and replacement parts.	Local land, water resources	Medium	Medium	Moderate	Implement waste management plans; encourage recycling.	Minor
Hazardous Waste Generation (Operation)	Oils and lubricants from maintenance machinery, chemical residues from water treatment processes.	Local environment, water resources	High	High	Major	Implement strict controls on lubricant and chemical storage, with designated disposal pathways.	Minor
Wastewater from Operational Processes (Operation)	Overflow discharge, maintenance-related contaminated water, and sanitary wastewater from staff.	Local water bodies, water quality	Medium	Medium	Moderate	Wastewater quality monitoring, treatment of discharge to meet regulatory standards.	Minor
Local Road Demolition and Reconstruction (Operation)	Excavation and construction activities generating large volumes of waste and wastewater.	Local communities, land	High	Medium	Major	Plan and manage excavation and waste disposal to mitigate land disturbance.	Minor
Spill Risks from Storage (Operation)	Potential accidental spills of chemicals, fuel, and oils may affect soil and water.	Soil, surface water, groundwater	High	High	Major	Spill Prevention and Response Plan, secondary containment, regular inspection.	Minor
Demolition Waste (Decommissioning)	Large quantities of concrete, steel, wood, and other construction	Local land, air quality	High	Medium	Major	Prioritize dismantling and material recovery to maximize recycling potential.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
	materials requiring disposal or recycling.						
Residual Hazardous Waste (Decommissioning)	Potential contamination from old fuel storage, oils, and chemicals used during operation.	Local environment, water resources	High	High	Major	Environmental site assessments to detect contaminated materials and safely dispose of them.	Minor
Wastewater from Demolition Activities (Decommissioning)	Dust suppression and decontamination procedures may generate wastewater requiring treatment.	Local water bodies, soil	Medium	Medium	Moderate	Use water-efficient demolition techniques; treat wastewater before discharge.	Minor

Table 17 - Mitigation and Monitoring – Waste and wastewater

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Site Preparation & Clearance	Removal of vegetation, soil stripping, and establishment of access roads may lead to habitat disturbance, increased erosion, and uncontrolled waste generation.	Local ecosystems, soil, water bodies	Implement a Site Clearance Plan; replant vegetation; install erosion control measures (sediment barriers, revegetation); manage and properly dispose of waste.	Pre-Construction
Excavation Waste & Disposal	Large volumes of surplus excavated materials requiring proper disposal, potentially impacting land stability and water quality.	Land stability, water bodies	Reuse materials where possible for embankments and roads; designate controlled disposal sites with drainage and stabilization measures. Develop an Excavation and Waste Disposal Management Plan.	Construction
Construction Waste	Non-hazardous debris (concrete, wood, plastics, etc.) from construction.	Construction site, local environment	Sort and segregate waste at the source; prioritize recycling and repurposing; dispose of non-recyclable materials at authorized landfills. Develop a Waste Management Plan (WMP).	Construction

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Hazardous Waste	Spills and improper disposal of hazardous construction and maintenance materials.	Workers, local environment, water resources	Store hazardous waste in sealed, labelled containers with secondary containment; use licensed hazardous waste disposal operators; maintain waste inventory logs. Include protocols in the Waste Management Plan (WMP).	Construction & Operation
Wastewater Management	Potential contamination of water resources and local environment due to untreated wastewater from construction and operational activities.	Water resources, local environment	Construct a wastewater treatment system, sanitary facilities, and other hygiene-related infrastructure throughout the entire watershed area of the reservoir. Develop a Wastewater Treatment and Discharge Plan.	Pre-construction, construction, and operation phases
Concrete Washout Wastewater	High-pH wastewater from concrete mixing and washing may contaminate soil and water.	Soil, water bodies	Establish designated lined washout pits; prevent uncontrolled discharge; regularly monitor pH levels and treat before disposal. Develop a Concrete Washout and Wastewater Management Plan.	Construction
Sanitary Wastewater (Worker Camps & Facilities)	Inadequate wastewater management could lead to contamination of water sources and public health risks.	Water resources, public health	Install portable toilets or on-site wastewater treatment systems; ensure proper disposal through licensed wastewater service providers. Include in Waste Management Plan (WMP).	Construction & Operation
Stormwater Contamination	Runoff carrying sediments, oils, and chemicals into nearby water bodies.	Local water bodies, aquatic life	Implement stormwater control measures (e.g., retention ponds, silt traps, proper drainage); conduct regular water quality monitoring. Develop a Stormwater Management and Monitoring Plan.	Construction & Operation
Spill Risk from Fuel/Chemicals	Leaks or spills from storage of oils, fuels, and chemicals.	Soil, surface and groundwater	Spill Prevention and Response Plan; secondary containment; regular checks.	Construction & Operation
Sediment Accumulation in Reservoir	Gradual deposition reduces reservoir capacity.	Reservoir water quality, capacity	Sediment Management Plan; dredging as needed; regular monitoring.	Operation
Demolition Waste	Concrete, steel, and structural waste during decommissioning.	Local land, air quality	Dismantling approach; material recovery; maximize recycling.	Decommissioning
Residual Hazardous Waste	Remaining fuels, chemicals, and oils from prior use.	Water, soil, local environment	Site assessments; safe removal and disposal of hazardous waste.	Decommissioning

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Wastewater from Demolition	Water from decontamination and dust control needs treatment.	Soil, water resources	Use low-water techniques; treat wastewater before release.	Decommissioning

7. Cultural heritage

7.1 Introduction and Purpose

Cultural heritage represents an invaluable resource, encompassing historical and scientific knowledge, fostering economic and social development, and sustaining the cultural identity, traditions, and continuity of communities. Recognizing its importance, ESIA includes a comprehensive evaluation of the potential impacts of the Project and its associated activities on cultural heritage assets in the surrounding area.

The Environmental Impact Assessment (EIA) for the Pambukovica dam project assessed cultural heritage aspects in the project area, which includes significant sites like the Church and Monastery in Dokmir and archaeological sites in Brgule, Liso Polje, Kalenić, and Radljevo. The assessment identified potential impacts on these sites and proposed mitigation measures, such as documentation and reconnaissance before construction. The study also highlights the importance of adhering to national and international cultural heritage protection laws, ensuring compliance with regulations set by the Institute for Protection of Cultural Monuments Valjevo.

This chapter specifically examines the interaction between the Project and local cultural heritage resources, assessing potential risks and opportunities. It identifies areas where the Project might influence cultural heritage positively or negatively and proposes mitigation measures to minimize adverse effects while maximizing benefits.

The approach underscores the commitment to preserving and enhancing cultural heritage as part of a broader effort to achieve sustainable development and foster positive relationships with local communities. Through careful planning and collaboration with relevant stakeholders, the ESIA aims to support the protection of cultural heritage while facilitating responsible project implementation.

7.2 Legislation and Standards

EBRD Performance Requirements and Guidelines

The management and conservation of cultural heritage are guided by the principles outlined in Performance Requirement 8 (PR8) of the European Bank for Reconstruction and Development (EBRD). PR8 acknowledges the significance of cultural heritage for current and future generations, emphasizing the need to protect it and minimize adverse impacts that may arise during business operations.

PR8 encourages a precautionary approach to managing and sustainably utilizing both tangible and intangible cultural heritage assets. These assets, which include traditional skills, knowledge, beliefs, and minor dialects or languages, play a vital role in supporting economic and social development while maintaining cultural identity and practices.

In achieving these objectives, PR8 aligns with relevant international conventions and instruments, as well as host country laws and regulations. This includes legislation pertaining to cultural heritage, antiquities, planning or building permits, conservation areas, protected areas, and indigenous cultural protections. Adherence to these frameworks ensures the responsible preservation of cultural heritage in alignment with both local and international standards.

EU regulations and directives

- European Convention on the Protection of the Archaeological Heritage (Valletta Convention, 1992)
- EU Guidelines for the Protection of Cultural Heritage in the Context of Development Projects (2000)

The Valletta Convention establishes a legal framework for protecting archaeological heritage within development projects. It requires EU Member States to implement preventive measures, such as prior documentation, rescue excavations, and integration of heritage preservation into land-use planning. The convention also promotes cross-border cooperation in protecting archaeological sites.

The EU Guidelines for the Protection of Cultural Heritage in the Context of Development Projects provide a structured approach to safeguarding cultural heritage during infrastructure development. These guidelines emphasize impact assessments, mitigation strategies, and adherence to national and international heritage protection laws to ensure that cultural assets are preserved and integrated into sustainable development planning.

National legislation

The main national legal framework considered, related to cultural heritage is:

- The Law on Cultural Heritage ("Official Gazette of RS", no. 71/94, 52/2011 - other laws, 99/2011 - other laws, 6/2020 - other laws and 35/2021 - other laws and 129/2021 - other. law)

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

7.3 Methodology

The assessment of cultural heritage impacts was conducted using a combination of desktop research, field surveys, stakeholder consultations, and regulatory reviews. The methodology followed international best practices, including the EBRD Performance Requirements (PR8) on Cultural Heritage and national heritage protection regulations.

Desktop Study

A review of existing literature, historical records, and cultural heritage databases was carried out to identify known cultural heritage sites within the project's area of influence. This included maps, archaeological reports, and previous assessments.

Field Surveys

Targeted on-site inspections and surveys were conducted in collaboration with cultural heritage specialists and representatives from the Institute for the Protection of Cultural Monuments in Valjevo. These surveys aimed to identify and document cultural heritage assets, including medieval "*stećaks*" and newly discovered cultural monuments within the project area.

Stakeholder Consultations

Consultations were held with relevant institutions, local communities, and cultural heritage experts to gather insights on the cultural significance of identified sites and to discuss appropriate mitigation measures. Particular attention was given to the relocation of the identified unregistered cultural heritage monument in parcel 896 KO Raduša.

Regulatory and Policy Review

The assessment considered national cultural heritage protection laws and international guidelines, ensuring compliance with legal requirements for heritage conservation, chance find procedures, and community engagement.

Impact Assessment and Mitigation Development

Potential impacts were evaluated based on:

- Sensitivity of receptors (e.g., historical significance of sites).

- Magnitude of impact (e.g., physical displacement, loss of cultural value).
- Significance of impact (assessed using a structured impact matrix).

This assessment will adhere to the methodology outlined in **Book 1 -Introduction**.

Mitigation measures, including protection, monitoring, and relocation strategies, were developed to minimize adverse effects and ensure compliance with conservation standards.

7.4 Assumptions and limitations

Assumptions and limitations presented in the Book 1 Introduction are relevant for this topic.

Cultural heritage specific assumption and/or limitations:

- Community engagement / involvement can affect understanding and implementation of proposed measures.
- Regulatory and legal restrictions may hinder access to certain cultural heritage sites or information.

7.5 Baseline

According to the Decision of the Institute for Nature Protection of Serbia, the area planned for the construction of the Pambukovica dam and reservoir on the Ub River is not located within any protected areas where protection procedures have been implemented or initiated. It is also not part of the ecological network or located in an area with recorded natural assets, so no impacts on natural assets of special value are anticipated.

In the immediate vicinity of the planned dam and reservoir, there are two cultural monuments: a medieval church and a rural settlement from the Eneolithic period. Additionally, there are two *stećaks* (monumental medieval tombstones) on the left bank of the river. Since the medieval church and the Eneolithic rural settlement are outside the scope of the Detailed Regulation Plan, no impact on these cultural sites from the future reservoir is expected.

Experts from the Institute for the Protection of Cultural Monuments in Valjevo have identified two preserved medieval *stećaks* in the broader project area. However, due to dense vegetation and limited accessibility, their exact locations have not yet been determined. At this stage, it is not possible to confirm whether these *stećaks* are located within the future reservoir area. Similarly, their potential cultural significance—whether at the local, regional, or national level—has not yet been formally assessed, nor is it currently known whether they are part of a registered or unregistered heritage inventory. These aspects will need to be further examined and clarified during the detailed site survey and potential archaeological investigations in cooperation with Institute for the Protection of Cultural Monuments in Valjevo.

Additionally, during a site visit conducted as part of the social activities of the project, another private cultural monument was noted in the area as it can be seen in the Picture 1 below. This monument is identified as tangible cultural heritage that refers to traditions, beliefs and practices and associated places and objects. Recognition of the importance of tangible cultural heritage has grown in recent years, as reflected in the EBRD requirement for meaningful consultation with affected communities (PR8, paragraph 9).

Picture 1 - Cultural monument in Raduša, Municipality Ub

The monument is located on parcel 896 KO Raduša, Opština Ub, which is shared with KO Gola Glava, Opština Valjevo, parcel number 3251/2. The coordinates of the monument are E 7412148,663 and N 4918673,541. The boundary of the expropriation will include the monument, so it is planned for the monument to be relocated outside the area of the reservoir.

In the vicinity of the project, Monastrey Merksinac built in 1841 needs to be noted as important asset in the local cultural and religious context. Monastery Merksinac is located close to the future access road (and currently active local road). Location of the Monastery is presented in the Figure 25 in the next chapter.

In the wider vicinity of the project, significant cultural monuments include the Church and Monastery of Dokmir, dating back to the early 15th century. The municipality of Ub also contains the following archaeological sites:

- "Pljoštanica" in Brgule, dating from the Vinča culture.
- "Mađarsko groblje-Popovac" in Liso Polje, a Roman settlement with a villa rustica from the 3rd-4th century.
- "Kod stare kuće" (necropolis, Roman period) in Kalenić.
- "Crkvište" (medieval site) in Radljevo.

Archaeological research is being intensively conducted in the surface mines of the Kolubara mining basin, focused on protective interventions during earthworks.

According to the conditions for the preservation, maintenance, and use in the development of the Detailed Regulation Plan for the Pambukovica dam, issued by the Institute for the Protection of Cultural Monuments in Valjevo (File Number 350-02-00040/2018-14, March 20, 2018), the area of the Detailed Regulation Plan includes two archaeological sites:

- Remains of a medieval Orthodox church in Raduša, located at 140 m above sea level.
- A rural settlement from the Eneolithic period in Slatina.

Exact location of identified archaeological sites is presented in the Figure 24 bellow:

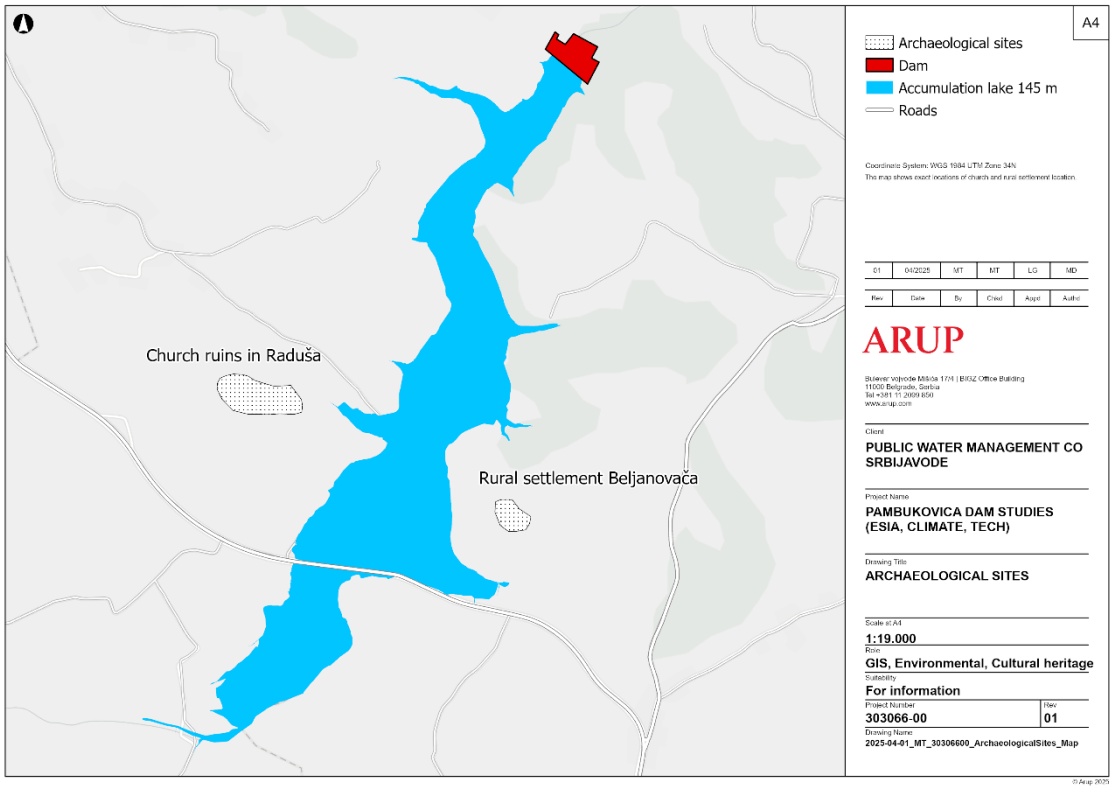

Figure 24 - Archaeological sites identified by Institute for the Protection of Cultural Monuments in Valjevo in relation to the Project location

Intangible Cultural Heritage

In accordance with the UNESCO definition, intangible cultural heritage encompasses practices, representations, expressions, knowledge, and skills—as well as the instruments, objects, artefacts, and cultural spaces associated therewith—that communities, groups, and individuals recognize as part of their cultural heritage. During the preparation of this ESIA, a review of national and international registers of intangible cultural heritage was conducted, including the official list maintained by the Republic of Serbia and the UNESCO Intangible Cultural Heritage Lists. No elements of intangible cultural heritage unique to the project area or region were identified through these sources.

Furthermore, site surveys and stakeholder consultations conducted as part of the ESIA process did not reveal the presence of any unregistered or undocumented intangible cultural heritage specific to the project area. While the potential for undocumented practices cannot be entirely excluded, it is considered unlikely based on the available evidence and expert judgment.

Review of Significance of the Two Identified Stećaks

Following information are currently available:

- Two medieval stećci have been observed on the left bank of the River Ub, within or near the planned inundation zone of the future reservoir.
- They have not been formally registered as protected monuments in the central heritage registry of Serbia.
- They were noted during a field reconnaissance by the Valjevo Institute, but due to vegetation and lack of exact coordinates, were not fully documented.

Based on their isolated presence, absence from formal registries, and current knowledge from local experts, these stećci may represent locally significant funerary monuments, related to historical rural communities in

the Ub region. Most nationally designated *stećci* sites in Serbia are concentrated in western regions (e.g. Drina valley, Prijepolje, Perućac). The lack of national registration or academic study suggests that there is a low likelihood that these may be considered of national significance. Furthermore, the two stećci are not UNESCO-listed and it is highly unlikely that these could be considered of international significance.

However, due to the lack of precise location and incomplete documentation, their full significance cannot yet be fully determined. As such, requirement made by the Institute for the Protection of Cultural Monuments in Valjevo for these to be further examined and clarified during the detailed site survey and potential archaeological investigations in coordination with the Institute are in line with the international good practice.

7.6 Receptors and Area of Influence

Cultural resources within the project's area of influence may include physical features and sites of historical or cultural importance that could be affected by project activities. These include:

- Monuments and historical features: This includes identified structures such as the preserved medieval *stećaks* located on the left bank of the river. At this stage, it is not possible to confirm whether these *stećaks* are located outside or within the future reservoir area. It also includes unregistered monument located on privately owned parcel 896 KO Raduša, Opština Ub, which has been recognized for its cultural value.
- Potential archaeological sites**:** These refer to areas where previously undocumented archaeological remains may be discovered during excavation or earth-moving activities. Such findings could include structural remnants, burial sites, or artifacts associated with past human activity.
- Monastery Merksinac located close to the future access road.

Further assessment will be required during subsequent project phases to verify the presence, significance, and required protection measures for these features.

Area of Influence

The area of influence (AoI) for cultural heritage extends beyond the direct footprint of the dam construction site and encompasses all areas where cultural heritage assets could potentially be impacted by the project's activities. The classification of AoI into direct, indirect, and broader categories reflects the varying degrees of impact the project may have on cultural heritage. While direct impacts involve physical alterations to known heritage sites, indirect effects may arise from environmental changes, and broader influences consider social and cultural shifts in surrounding communities. This distinction helps in structuring mitigation measures tailored to each level of impact.

Direct Area of Influence

- The immediate project area, including the dam, reservoir, embankments, access roads, and other infrastructure that may physically disturb or alter the landscape of identified cultural heritage sites.
- The medieval *stećaks* potentially located in the wider area on the left bank of the river.
- Other potential archaeological sites within the footprint of the dam and surrounding infrastructure development.

Indirect Area of Influence

- Areas in close proximity to the direct project area that could be affected by project activities such as noise, vibration, visual impact, or land disturbance during the construction and decommissioning phases.

Broader Area of Influence

Communities located near the project area, particularly those whose traditions and cultural practices are connected to the project site. These communities may be impacted through changes to their way of life, such as through the relocation of unregistered heritage monuments or disruption of traditional practices and spaces.

Social impacts arising from the loss of access to or disturbance of culturally significant sites, as well as the engagement of local communities in consultations and cultural heritage safeguarding efforts.

Area of interest for Cultural heritage is presented at the Figure 25 below:

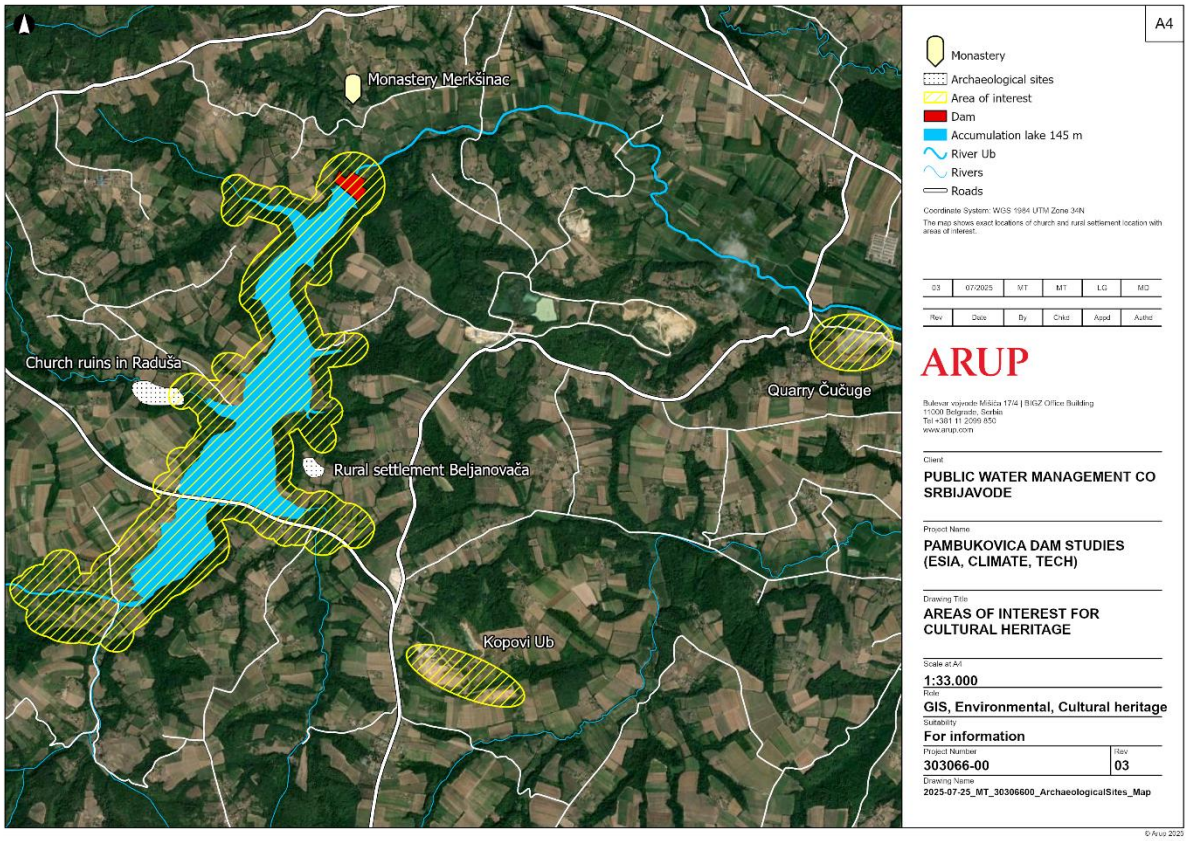

Figure 25 - Area of interest – Cultural heritage

Key Considerations

The identification and protection of cultural heritage receptors will be integral to the project's impact management strategy. Special attention will be given to:

- Ensuring that cultural heritage resources are adequately identified and documented before any project activities commence.
- Maintaining ongoing consultations with local communities, cultural heritage experts, and authorities, particularly during the pre-construction and construction phases, to mitigate any adverse effects.
- The relocation of culturally significant assets, such as the registered and unregistered cultural heritage monuments, will be handled with care and in full coordination with the affected communities to ensure minimal disruption.

By identifying and defining the receptors and area of influence, the project can develop tailored mitigation measures to prevent or minimize negative impacts on cultural heritage, ensuring that the integrity of cultural assets is maintained throughout the project's lifecycle.

7.7 Project Activities and Identification of Impacts

7.7.1 Description of activities

The construction and operation of the Pambukovica Dam and reservoir on the Ub River will involve many activities that may impact cultural heritage sites in the project area. These impacts will primarily result from excavation, earthworks, material transport, infrastructure development, and operational activities. Given the rich cultural heritage within the project area, including the Church and Monastery in Dokmir and various archaeological sites in Brgule, Liso Polje, Kalenić, and Radljevo, construction activities pose a risk of disturbing known and undiscovered cultural heritage assets.

The following activities have been identified as relevant to cultural heritage impacts:

- Site Preparation and Clearance: Includes vegetation removal, land levelling, and access road construction, which may disturb surface-level archaeological features.
- Excavation and Earthworks: Large-scale soil removal and grading may expose, or damage buried cultural heritage artifacts and structures. Excavation will also include foundation works, reservoir shaping, and trenching for utilities.
- Material Transport and Storage: Movement of construction materials, including stone and aggregates sourced from quarries, may impact sites along transport routes through vibration and accidental disturbances.
- Blasting and Heavy Machinery Operations: Blasting activities and the use of heavy machinery may cause vibration-related damage to nearby cultural heritage structures.
- Construction of Permanent Structures: Includes embankments, spillways, and associated infrastructure that could permanently alter the landscape and impact cultural sites.
- Water Flow Regulation and Reservoir Filling: Alterations to the natural water regime may submerge archaeological sites.

7.7.2 Resulting Impacts

The construction and operation phases will result in various impacts on cultural heritage, requiring appropriate mitigation measures. Identified key impacts include:

- Physical Damage to Archaeological and Historic Sites: Excavation, earthworks, and heavy machinery operations may disturb, damage, or destroy known and unknown cultural heritage sites.
- Vibration and Structural Integrity Risks: Blasting and construction near sensitive structures may weaken foundations and lead to degradation.
- Soil Erosion and Water Impact: Disturbance of cultural layers during excavation may alter the stratigraphy of archaeological sites, while changes in water flow may submerge heritage features.
- Restricted Access to Cultural Sites: Temporary or permanent road diversions and land use changes may limit access to religious, historical, or community heritage sites.
- Relocation of unregistered Cultural Heritage

Overall, the project activities and identification of impacts under the Cultural Heritage chapter of the ESIA aim to balance infrastructure development with the preservation of cultural heritage and environmental sustainability.

7.8 Impact Assessment and Mitigation

This section evaluates the potential impacts of the project on cultural heritage across all phases, including pre-construction, construction, operation, and decommissioning. It identifies risks to known and unknown cultural assets, assesses their significance, and proposes mitigation measures to ensure their protection. The chapter follows an impact assessment methodology, considering the magnitude of effects and the sensitivity of cultural heritage receptors, to balance project development with heritage conservation.

7.8.1 Pre-Construction

Identified Impacts

- During the pre-construction phase, cultural heritage assets may be affected due to inadequate documentation, lack of integration into project planning, and potential oversight of significant sites. The primary impacts include:
- Risk of Damage to Identified Cultural Heritage Sites: Without detailed documentation, preserved *stećaks* and other cultural heritage features could be overlooked or improperly managed.
- Potential Loss of Undocumented Cultural Heritage: Insufficient surveys may fail to identify additional archaeological, historical, or cultural heritage features within the project area.
- Displacement of unregistered Cultural Heritage: The relocation of a cultural monument associated with traditions and practices from parcel 896 KO Raduša, Opština Ub, may affect its significance.

Mitigation Measures

To mitigate these risks, the following measures will be implemented:

- Comprehensive Site Surveys: Conduct detailed field survey of the reservoir area to confirm any presence of unregistered cultural heritage, and identify location the two *stećaks* in coordination with the Institute for Protection of Cultural Monuments.
- Detailed Documentation and Assessment: Inventorying and assessing cultural heritage sites before construction begins.
- Stakeholder Engagement: Regular consultation with cultural heritage authorities and local communities.
- Planning for Relocation: Ensuring that relocation of unregistered monument at private parcel 896 KO Raduša, Opština Ub is conducted with measures that preserve its cultural value. If required, ensure relocation of the two *stećaks* in line with conservation measures defined by the Institute for Protection of Cultural Monuments.
- Planning of Transport Routes to avoid Sensitive Sites: During the pre-construction phase, transport routes for heavy machinery and material delivery will be planned and designed to avoid proximity to culturally significant structures, including nearby churches.

7.8.2 Construction

Identified Impacts

- Construction activities involve extensive excavation, land clearing, and heavy equipment use, which can directly or indirectly affect cultural heritage assets. The main anticipated impacts include:
- Potential Damage to Known Cultural Heritage Sites: Construction works (including transport) near documented sites could lead to physical damage.

- Exposure of Undiscovered Archaeological Artifacts: Excavation and land disturbances may unearth previously unknown archaeological materials.
- Visual and Vibrational Impact on Nearby Heritage Assets: Heavy machinery may cause vibrations that could deteriorate fragile cultural sites.

Mitigation Measures

To manage these risks, the following measures will be implemented:

- Development of a Chance Find Procedure (CFP): Integrated into the project's Environmental and Social Management Plan to ensure immediate action in case of unexpected discoveries.
- Training for Construction Personnel: Educating workers on cultural heritage awareness and CFP implementation.
- Monitoring and Oversight: Regular site monitoring by cultural heritage specialists.
- Coordination with Authorities: Immediate reporting of any findings to relevant cultural institutions.
- Planning of Transport Routes and Mitigation Measures to avoid Sensitive Sites: During the pre-construction phase, transport routes for heavy machinery and material delivery will be planned and designed to avoid proximity to culturally significant structures, including nearby churches. Where avoidance is not feasible, conduct vibration risk assessments, define buffer zones and/or mitigation measures, and implement vibration monitoring during construction as defined in Section 3.8.2

7.8.3 Operation

Identified Impacts

Once operational, the dam and reservoir are not expected to interact significantly with cultural heritage sites. The key considerations include:

- Loss of Accessibility to Relocated Cultural Sites: Communities may experience reduced access to cultural monuments that have been relocated.
- Changes in Local Cultural Practices: The project may indirectly affect traditional practices linked to the river and its surroundings.

Mitigation Measures

- Community Engagement: Involvement of local communities in maintaining relocated sites.
- Interpretation and Preservation Initiatives: Developing informational materials or signage to maintain cultural connections.

7.8.4 Decommissioning

Identified Impacts

The decommissioning phase may pose risks similar to those during construction, including:

- Disturbance of Known and Undocumented Cultural Heritage Sites: Large-scale excavation and removal of infrastructure may impact undiscovered heritage assets.
- Physical Damage from Decommissioning Activities: Vibrations and heavy machinery use may threaten nearby heritage structures.

Mitigation Measures

- Application of the Chance Find Procedure (CFP): Ensuring all chance finds are properly managed.
- Continued Archaeological Monitoring: Specialist oversight during decommissioning activities.
- Implementation of Cultural Heritage Management Measures: Preserving cultural integrity even after site restoration.

By integrating these structured impact assessments and mitigation measures, the project aims to protect and manage cultural heritage effectively throughout its lifecycle.

7.8.5 Management Plans

To mitigate these impacts, a Cultural Heritage Management Plan (CHMP) will be implemented, incorporating:

- Detailed Site Reconnaissance and Documentation: Before construction begins, all known cultural heritage sites will be surveyed and recorded.
- Preventive Excavations and Rescue Archaeology: If cultural heritage is unexpectedly discovered during project activities, the following Chance Find Procedure (CFP) will be implemented to ensure its protection and preservation:
  - Immediate Cessation of Work: All construction or excavation activities in the vicinity of the find will be halted immediately.
  - Notification: The project manager will notify the relevant cultural heritage authorities and experts to assess the find.
  - Protection Measures: Temporary protection measures will be put in place to prevent any damage or disturbance to the find.
  - Assessment and Documentation: Cultural heritage experts will assess the significance of the find and document it thoroughly.
  - Decision on Further Action: Based on the assessment, the authorities will decide whether the find should be preserved in situ, relocated, or subjected to further investigation.
  - Resumption of Work: Construction or excavation activities will only resume once the authorities have given clearance, and any necessary measures have been implemented.
- Vibration Monitoring and Construction Adjustments: Sensitive sites will be monitored for vibration impact, and alternative construction methods may be applied.
- Community Engagement and Cultural Heritage Consultation: Local communities and cultural heritage experts will be involved in decisions regarding site management and mitigation strategies.
- Legal Compliance and Regulatory Adherence: The project will follow the conditions set by the Institute for Protection of Cultural Monuments Valjevo, ensuring compliance with national and international heritage protection frameworks.
- Post-Construction Heritage Monitoring: Long-term monitoring of affected sites will be conducted to assess and address any unforeseen impacts.

Table 18 - Impact Assessment Table – Cultural Heritage

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Identification of Cultural Heritage	Two preserved medieval *stećaks* on the left riverbank require protection during project activities.	Cultural heritage sites	Medium	High	Moderate	Conduct detailed field investigations and consultations with cultural heritage authorities before construction.	Minor
Comprehensive Site Survey	Risk of missing undocumented archaeological or historical features without a thorough survey.	Cultural heritage sites	Medium	High	Moderate	Perform full site surveys in collaboration with the Institute for the Protection of Cultural Monuments. Document and integrate findings into project planning.	Minor
Chance Find Procedure	Excavation and earthworks may expose unknown cultural heritage assets.	Cultural heritage sites	High	High	Major	Implement a formal CFP as part of the CHMP; stop work immediately upon discovery; notify and coordinate with relevant cultural heritage authorities.	Minor
Vibrational Impact from Construction	Vibrations from blasting and machinery may damage nearby heritage structures.	Manstir Merksinac Other currently unknown cultural heritage sites	Medium	High	Moderate	Conduct vibration risk assessment, mitigation measures and monitoring near sensitive sites; modify construction methods and define and implement additional mitigation measures if	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
						thresholds are exceeded.	
Loss of Access to Cultural Sites	Relocation and land use changes may limit community access to cultural sites and practices.	Local communities	Low	Medium	Minor	Develop alternative access routes; install informational signage at relocated sites to preserve cultural connections.	Negligible
Displacement of unregistered Cultural Heritage	Relocation of cultural monument from parcel 896 KO Raduša may affect traditional practices and heritage value.	Local communities	Medium	High	Moderate	Engage with Institute for Protection of Cultural Monuments and communities; ensure culturally sensitive relocation; preserve significance through interpretation, signage, and access.	Minor
Training for Construction Personnel	Lack of awareness may lead to accidental damage or mishandling of finds.	Construction workers	Medium	Medium	Moderate	Provide cultural heritage training to workers, including CFP procedures and artifact recognition.	Minor
Monitoring and Oversight	Risk of non-compliance or delayed response without adequate heritage oversight.	Cultural heritage sites	Medium	Medium	Moderate	Assign cultural heritage specialists for monitoring; enforce compliance with mitigation measures throughout construction and decommissioning phases.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre-mitigation)	Mitigation	Residual Impact Significance
Coordination with Authorities	Inadequate collaboration with cultural institutions could delay or hinder proper heritage protection.	Cultural heritage authorities	Low	High	Moderate	Maintain regular coordination with the Institute for the Protection of Cultural Monuments and other relevant bodies.	Minor

Table 19 - Mitigation and Monitoring – Cultural Heritage

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Integration of Cultural Heritage into Project Strategy	Cultural heritage receptors may be overlooked without proactive integration into project planning and management.	Cultural heritage receptors	Ensure cultural heritage identification and protection is integrated into the project's Environmental and Social Management System (ESMS) and impact management strategy.	Pre-Construction, Ongoing
Identification of Cultural Heritage	Presence of two preserved medieval *stećaks* on the left bank of the river.	Cultural heritage sites	Conduct detailed site surveys, field investigations, conservation/relocation (if necessary) and consultations.	Pre-Construction
Comprehensive Site Survey	Survey to identify additional archaeological, historical, or cultural features.	Cultural heritage sites	Conduct a full site survey before construction; document findings.	Pre-Construction
Chance Find Procedure	Excavation may uncover unknown cultural heritage sites.	Cultural heritage sites	Develop and implement a Chance Find Procedure (CFP) – as part of CHMP or standalone document.	Construction, Decommissioning
Vibrational Impact from Transport Activities	Heavy vehicle operation and traffic near heritage structures (e.g., churches) may cause structural	Manastir Merksinac	Plan and designate transport routes during the pre-construction phase to avoid proximity to culturally	Route planning during pre-construction; monitoring during construction

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
	damage due to ground-borne vibrations.	Currently unknown cultural heritage sites	sensitive structures. Where avoidance is not feasible, conduct vibration risk assessments, define buffer zones and/or mitigation measures, and implement vibration monitoring during construction.	
Loss of Access to Cultural Heritage Sites	Relocation of cultural heritage sites may limit community access.	Local communities	Develop alternative access routes or provide informational signage.	Post-Construction
Training for Construction Personnel	Lack of awareness about cultural heritage sensitivity.	Construction workers	Provide mandatory cultural heritage training to all personnel.	Pre-Construction, Construction
Monitoring & Oversight	Risk of non-compliance with cultural heritage protection measures.	Cultural heritage sites	Assign cultural heritage specialists to oversee activities.	Construction, Decommissioning
Coordination with Authorities	Need for engagement with cultural heritage authorities.	Cultural heritage authorities	Maintain regular coordination with the Institute for the Protection of Cultural Monuments.	Pre-Construction, Construction, Decommissioning

8. Health and Safety

8.1 Introduction and Purpose

This Chapter addresses the Health and Safety considerations for the construction of Pambukovica Dam Project. The purpose of this Chapter is to ensure that the project is aligned with relevant health and safety national legislation requirements and Project Standards.

Considering the potential risk, some of the construction activities may be classified as high risk with significant potential incident if appropriate mitigation management systems are not adopted.

8.2 Legislation and Standards

EBRD Performance Requirements

- PR 2 Labour Working Conditions

This PR focuses on the labour and working conditions ensuring compliance with national laws and international standards. It outlines the responsibilities of employers to provide safe, fair, and healthy working conditions, including fair wages, working hours, and the right to form and join worker organizations.

- PR 4 Health, Safety and Security

This PR addresses the health, safety, and security considerations for workers and affected communities. It emphasizes the implementation of risk management strategies, preventive measures, and emergency preparedness to protect against potential health and safety hazards associated with the project.

EU regulations and directives

- Framework Directive on Safety and Health at Work (Directive 89/391 EEC) - general principles for managing safety and health at work, including risk assessment, preventive measures, and worker information and training.
- Directive 2002/44/EC – Protects workers from risks related to mechanical vibration
- Directive 2003/10/EC – Protects workers from risks to hearing and health due to noise exposure.
- Directive 89/654/EEC– Establishes minimum health and safety requirements for workplaces
- Directive 2009/104/EC– Ensures safe use of work equipment by workers
- Directive 89/656/EEC– Regulates the selection, use, and maintenance of PPE)
- Directive 92/58/EEC– Standardizes safety signage in workplaces.
- Directive 90/269/EEC– Protects workers from musculoskeletal disorders caused by manual handling.
- Directive 92/57/EEC– Sets health and safety requirements for construction sites.

The Framework Directive on Safety and Health at Work (Directive 89/391 EEC) sets out general principles for managing workplace safety and health within the EU. It includes provisions for risk assessments, preventive measures, and the dissemination of information and training to workers. The directive aims to create a coherent and comprehensive approach to workplace safety by mandating employers to identify and mitigate risks, implement necessary safety measures, and ensure workers are fully informed and trained on safety protocols. This directive serves as the foundation for subsequent regulations addressing specific workplace hazards and is pivotal in promoting a culture of prevention and safety across all industries.

National Legislation

Occupational safety and health in Serbia are primarily governed by the Law on Occupational Safety and Health, which mandates comprehensive measures to ensure workplace safety. This legislation outlines the responsibilities of both employers and employees, and it emphasizes the importance of preventive measures to minimize work-related injuries and illnesses. Specific provisions are included to safeguard vulnerable groups, ensuring that all workers operate in a secure environment. Additionally, the law requires regular risk assessments, adequate training for all workers, and the implementation of protective measures to maintain high safety standards across various industries.

Traffic Safety Legislation in Serbia is primarily governed by the Law on Road Traffic Safety, which mandates measures to ensure the safety of all road users. This legislation outlines the responsibilities of drivers, pedestrians, and authorities, emphasizing preventive measures to minimize traffic-related injuries and fatalities.

Emergency Response in Serbia is governed by Law on Disaster Risk Reduction and Emergency Situation Management that establishes comprehensive rules aimed at reducing disaster risks, preventing emergencies, and enhancing the resilience and preparedness of individuals and communities. It outlines the responsibilities of citizens, associations, legal entities, local self-government units, autonomous provinces, and the Republic of Serbia in managing emergency situations. Key components include the functioning of civil protection units, early warning systems, international cooperation, and regular risk assessments. The law emphasizes integrated action, cross-sectoral cooperation, and the primary role of local communities in disaster management. It aims to protect people, material, cultural, and environmental assets, ensuring a coordinated and effective response to disasters.

The Law on Planning and Construction in Serbia regulates the conditions and modalities of spatial planning, development, and construction. Key provisions include the organization of construction sites to ensure safe access and environmental protection, the safety of facilities and surrounding areas, and the implementation of preventive measures to secure the construction site, workers, equipment, and machinery.

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

8.3 Assumptions and limitations

Assumptions and limitations presented in the **Book 1 Introduction** are relevant for this topic.

Health and safety specific assumption and/or limitations:

- Unforeseen environmental or social conditions could also impact the project's health and safety outcome.
- Contractor (including all subcontractors) will employ suitably trained workers and ensure provision and use of appropriate working equipment and PPE to undertake their tasks in a safe manner.

8.4 Baseline

Pambukovica Dam is planned to be on river Ub, approximately 21km upstream from the confluence of River Tamnava, that is located 15km west from the settlement of Ub.

As part of the Pambukovica Dam, the following structures are planned: an embankment dam, spillway facilities including a free side spillway with a chute and stilling basin, and a bottom outlet/spillway with a stilling basin. Additionally, the dam will include a water intake for irrigation purposes.

The construction works will be conducted in two distinct phases:

- Construction of the dam and catchment facilities.
- Reconstruction of the existing state road 21 in the vicinity of the Pambukovica reservoir.

According to available information from the Design for Construction Permit and national Environmental Impact Assessment (EIA), approximately 80 workers will be employed for construction activities.

According to the construction organization plan, worker accommodation is planned in the existing facilities in Ub and Pambukovica.

Electricity supply for the site is planned trough existing 10kV power line with a 10\04 kV transformer. A backup power supply is also planned for use in case of power outrages.

The site will be supplied with petroleum, trough a mobile fuel station tanker, which will serve all construction machinery on site.

The construction of the Pambukovica Dam and accompanying structures is planned to last Three years, according to EIA.

For detailed project description please see **Book 2 Project Description.**

In accordance with the technical solution concept and the topography of the terrain, the Design for Construction Permit (Organization of Construction Works) has defined the routes of access roads and temporary construction roads. These routes will facilitate the transport of construction machinery and materials during the construction phase. All access roads can be seen in the Figure 26 below.

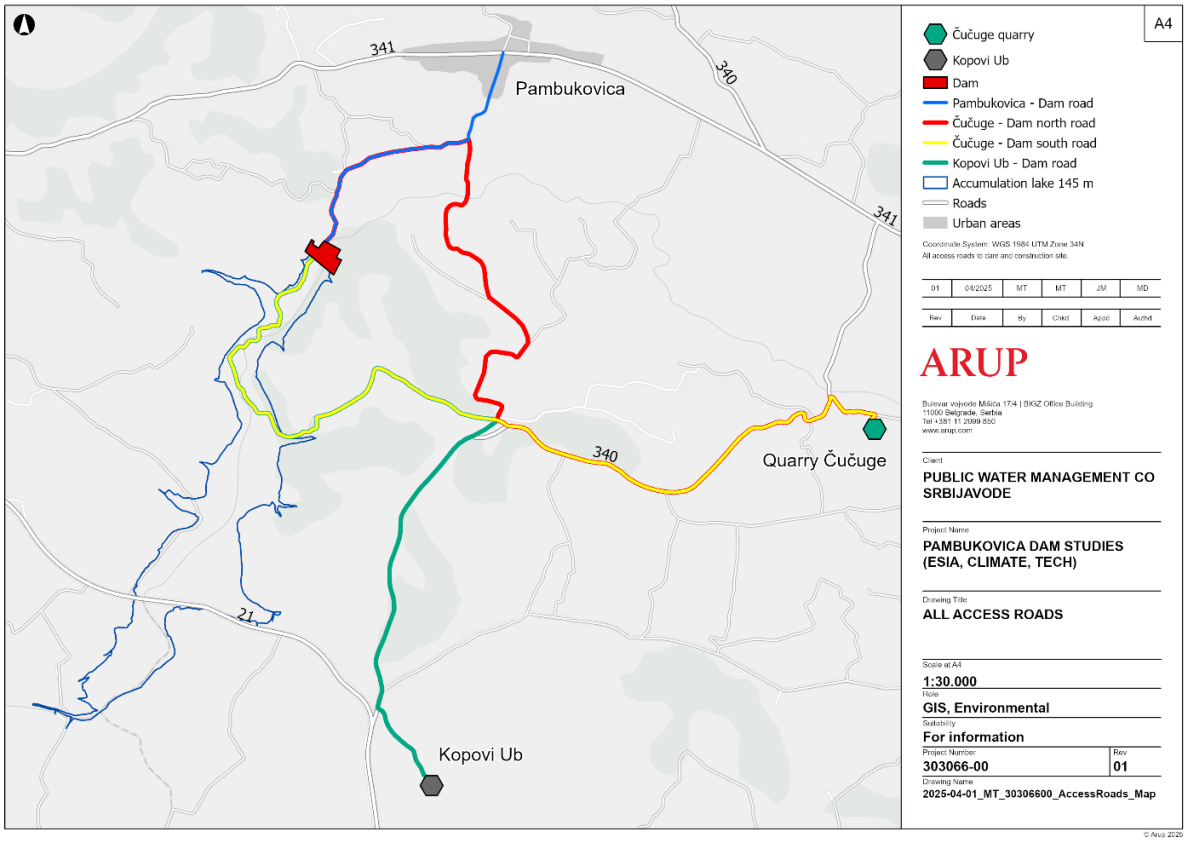

Figure 26 - Access roads that will be used during construction phase

The dam site is accessed via the regional road Ub-Koceljeva, where a local asphalt road branches off at the 15th kilometre from Ub. Access from the dam profile to the disposal sites will be provided by construction roads on the left and right banks as it can be seen in the map below.

In addition to the temporary construction roads, the permanent newly designed road P1 to the dam crest will be built before the start of the dam excavation and will serve as a construction road connecting the downstream and upstream sides. Specifically, when the excavations for the dam foundation begin, the

communication between the upstream and downstream sides via the existing roads passing through the dam profile will be interrupted. The transport of excavated material from the downstream side to the excavation dumps will be carried out via road P1, which continues on the upstream side to the temporary road PP1.

Roads P1 and PP1 will enable the transport of fresh concrete by concrete mixers from the concrete plant at the industrial construction site to the concreting locations.

Simultaneously, the construction of the permanent road P1 commences. This road branches downstream from the existing asphalt road and is routed to the dam crest along the dam's left abutment. Upon completion of the dam and associated structures, this road is intended to serve as a permanent access road to the dam crest from the downstream side during the operational phase.

The Construction Plan includes information for upstream and downstream site roads for project vehicles. Key routes are adapted to facilitate the transport of materials and machinery.

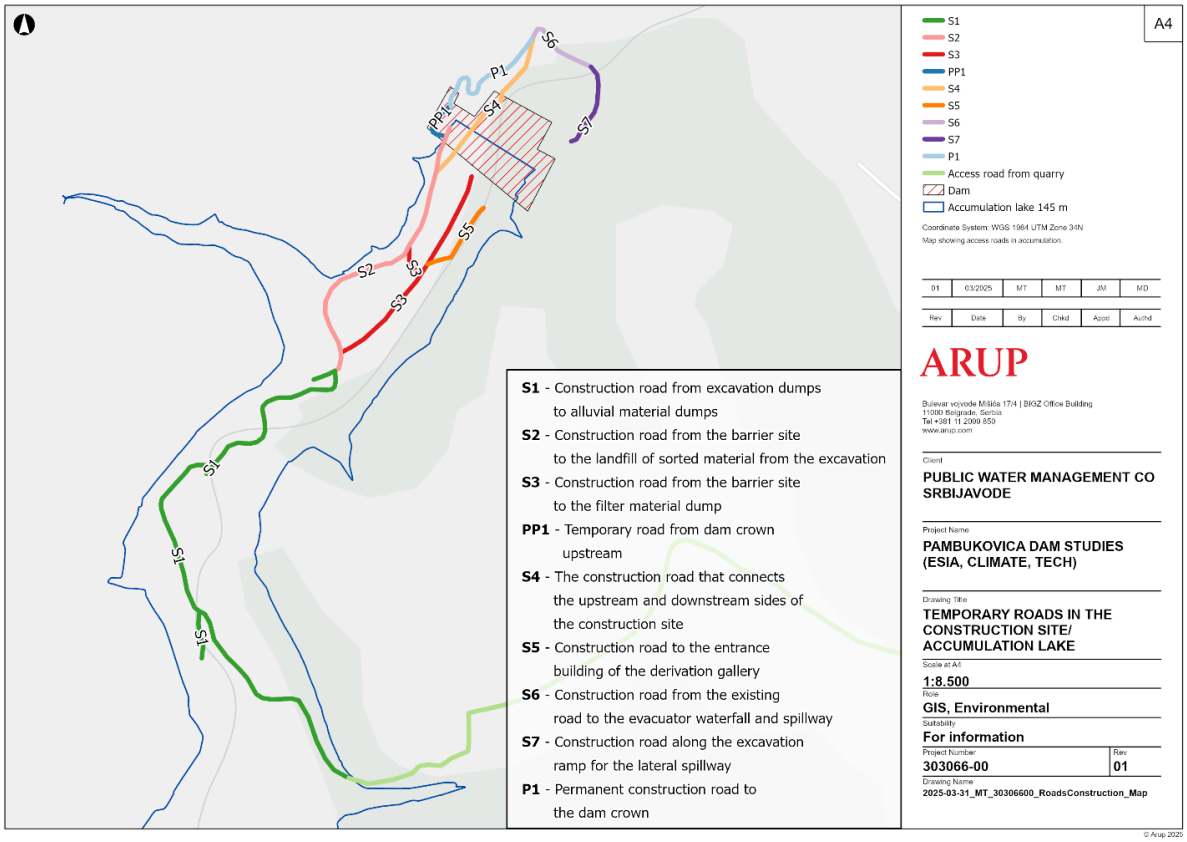

Figure 27 - Temporary and permanent roads to be constructed for the Project purpose

8.5 Receptors and Area of Influence

Area of Influence

As described in the previous section and illustrated in the Figure 3Figure 3 - Expected Area of Influence in terms of Air Quality, the area of influence around the dam along roads used to transport materials, the impact zone extends 50 to 100 meters on either side of the road, where dust and truck exhaust emissions may affect air quality. Additionally, the construction zone along the relocated section of State Road IB No. 21 is expected to impact air quality up to 200 meters from the construction activities. All mitigation measures for all access roads used during the construction activities will need to be identified and described in the TMP.

The Project's area of influence encompasses the zones of construction works, including access roads and all transportation routes, as well as all project facilities such as workers' accommodation, contractor's offices, and maintenance facilities.

The impacts arising during the construction phase are temporary and confined to the immediate surroundings of the work site (including all access roads). These impacts stem from the presence of workers, construction machinery, and transport vehicles, as well as the organization of construction activities and the implementation of various work technologies.

The operation phase of the dam, which includes irrigation, will be done in phases.

The primary irrigation network includes construction of pump stations, pressure pipelines, and tanks for daily balancing of inflows and it is expected to be developed over three years. The secondary irrigation network is planned to be constructed on agricultural plots over the next three years. During the primary irrigation operation phase, there are impacts expected on the traffic and transportation of materials, as there will be traffic generated during the construction of the secondary irrigation network. The Phase 2 irrigation works will be addressed through a separate health and safety assessment.

During operation of the dam, the area of influence encompasses the immediate vicinity of the dam and reservoir. This area will be monitored for any potential impacts on the environment and surrounding communities. The operational phase will require continuous assessment and maintenance to ensure safety and efficiency. Additionally, in case of any emergency situation, please refer to the Emergency Preparedness and Response Plan for detailed procedures and protocols.

Receptors

The receptors include:

- Workers:
  - Construction workers,
  - Operational staff, and maintenance personnel for occupational health and safety;
- Community members:
  - Residents in the vicinity of construction site,
  - Residents along the transportation routes.
- Traffic Participants**:**
  - Drivers (construction vehicles, local traffic)
  - Pedestrians,
  - Cyclists.

Sensitive Receptors

Sensitive receptors for this Project refer to locations or vulnerable groups that may be particularly affected by the construction activities (such as the elderly, children, and people with disabilities) These include health centres, schools, residential areas, and places where vulnerable groups such as the elderly, children, and people with disabilities are present.

In the context of this project, the identified sensitive receptors include Pambukovica Health Centre and one primary school Sveti Sava. No kindergartens or other schools are located in the vicinity of the project area and construction works.

Additionally, no other sensitive receptors have been identified in the area.

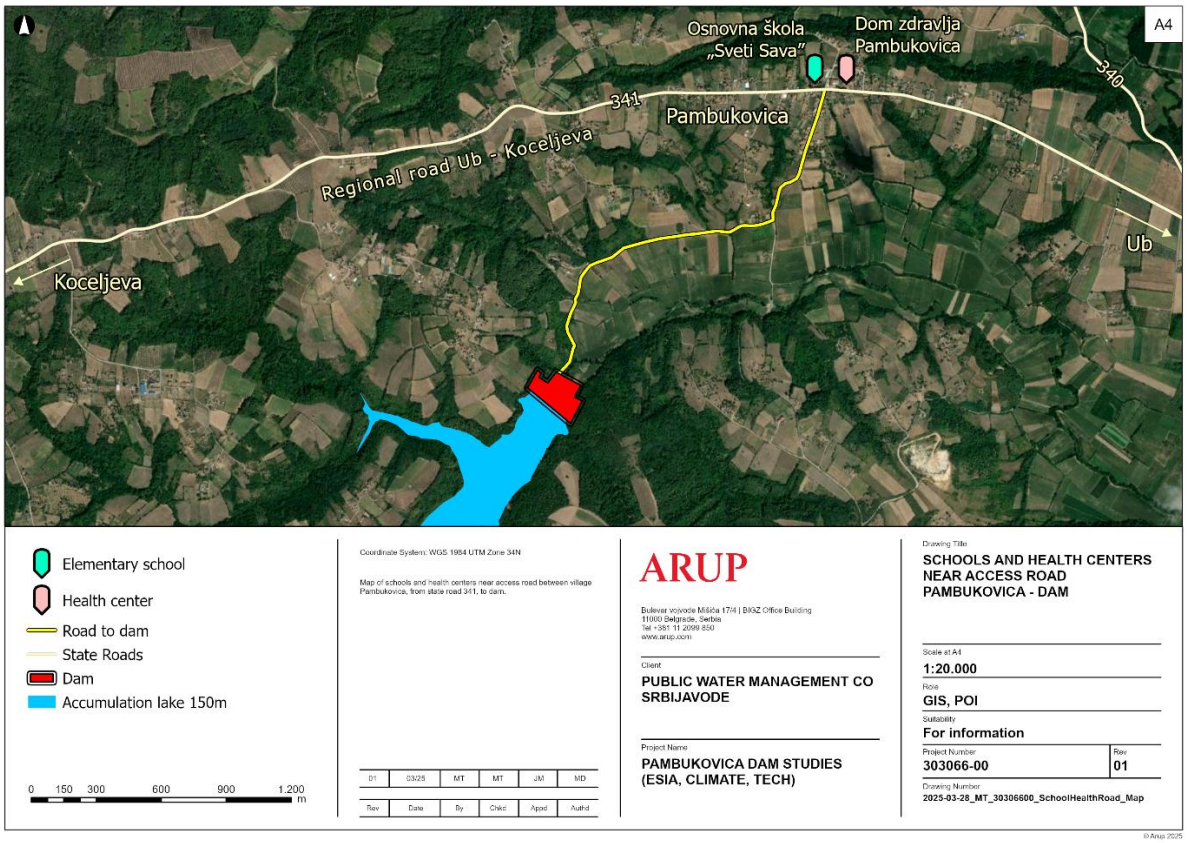

Figure 28 - Sensitive Receptors

8.6 Project Activities and Identification of Impacts

8.6.1 Activities

8.6.1.1 Pre-Construction phase

As stated in the ESIA Volume 1, preconstruction phase includes all activities performed prior to start of construction works, including monitoring, surveys, planning and procurement activities.

Please see **ESIA Volume 1 – Project Description** for full details.

8.6.1.2 Construction phase

Planned construction works include, but are not limited to, the following activities:

- Vegetation clearance,
- Preparation works such as: setting up concrete plant, service station for machinery repair and maintenance; containers for workers accommodation, for on-call staff and security personnel; containers for the contractors and supervisors; concrete plant with aggregate bunkers and cement silos; an auxiliary carpentry and rebar workshop with a canopy for storing timber and reinforcement.
- Construction of temporary construction site roads, and adaptation of existing dirt roads to accommodate construction and transport machinery.
- Earthworks (including excavation works),
- Concrete works on the Dam,

- Reinforcement works,
- Riverbed regulation,
- Excavation of the gallery, including blasting works,
- Other works (including masonry, plastering of interior walls, painting and coating works, painting of interior plastered walls, and insulation works),
- Sheet metal works (including procurement of materials, fabrication, and installation of horizontal gutters made of galvanized sheet metal),
- Flooring works,
- Metalwork (fabrication, transport, and installation),
- Bridge works,
- Works on the road, change of the embarkment,
- Final works, filling of the reservoir and test run of the foundation discharge and guidance system.

8.6.1.3 Operations and Maintenance Phase

During the operational phase of the Pambukovica Dam, the primary activity will be the ongoing maintenance and management of the dam infrastructure. Workers will be exposed to a range of occupational health and safety risks relating to the maintenance activities. These include:

- Managing flow discharges under normal, drought, and flood conditions,
- Maintenance of the irrigation network,
- Conducting regular maintenance of civil works and electromechanical equipment,
- Ensuring reliable and safe operation, early detection of deterioration, and timely repair or rehabilitation,
- Performing visual surveillance, instrumentation monitoring, and periodic safety inspections.

8.6.1.4 Decommissioning Phase

In general, decommissioning of the dam requires as much planning as the construction. Similar construction activities as in the construction phase are expected.

Some of key activities include:

- Dismantling of the dam structure and sediment traps,
- Demolition activities,
- Debris removal and disposal,
- Sediment management,
- Restoration of site and natural ecosystem.

8.6.2 Occupational Health and Safety Impacts

8.6.2.1 Pre-Construction phase impacts

No specific pre-construction phase impacts are expected.

8.6.2.2 Construction Phase Impacts

Construction activities will involve the operation of heavy equipment and trucks, working at height, construction traffic, handling of hazardous materials and other hazardous activities. Due to the nature of the activities being undertaken during construction, occupational health and safety is a key risk with the potential for accidents that may result in personal injuries and fatalities, as well as lost job-hours.

The Construction phase of the project may carry several key health and safety impacts to the construction workers such as:

- Impact of not following safe working procedures: Increased likelihood of accidents and injuries to workers.
- Impacts arising from vegetation clearance activities to workers: Such as risk of physical injuries, serious trauma in case being stuck by trees, equipment failure, improperly maintained tools, flying debris chips from cutting that can injure eyes or skin, falls from working in dense vegetation, that can hide holes, sharp objects, slips and trips due to works in uneven terrain, etc.
- Impact of working in or near open waterbodies: Risk of drowning or water-related accidents.
- Impact of working at height: Potential for severe injuries or fatalities from falls from high structures, ladders, scaffolding, etc.
- Impact of slips, trips, and falls: Common workplace injuries that can lead to serious harm.
- Impact of manual handling: Risk of musculoskeletal disorders and injuries.
- Impact of excavation works: Potential for collapse of excavation sides, causing injuries or fatalities to workers.
- Impact of working in confined spaces: Increased risk of suffocation, toxic exposure, or entrapment.
- Impact of emergency preparedness and response: Inadequate response can lead to severe consequences during emergencies.
- Impact of working with heavy construction vehicles due to poor traffic planning: High risk of accidents and injuries and fatalities.
- Impact of electricity risks: Potential for electric shocks, burns, or fatalities.
- Impact of exposure to dust, noise, and vibration: Long-term health issues such as respiratory problems, hearing loss, and vibration-related injuries.
- Impact of exposure to blasting activities: Risk of injuries from flying debris and shockwaves.
- Impact of exposure to hazardous materials: Potential for chemical burns, poisoning, or long-term health effects.
- Impact of fire risk: Severe injuries, fatalities, and property damage.

8.6.2.3 Operation and Maintenance Phase Impacts

The maintenance key health and safety risks to the workers include: inadequate OHS management, such as inadequate handling of working equipment, inadequate use PPE, failure to follow working procedures (such

as working near water, diving, working at height, work in confined space) that could lead to incidents and pose a health and safety risk to workers.

The operation phase of the project may carry several key health and safety impacts to the workers undertaking maintenance of the dam such as:

- Increased workplace injuries and illnesses due to unsafe work practices, inadequate equipment handling, improper PPE use, and failure to follow procedures,
- Severe worker injuries or fatalities from oxygen depletion or structural collapse in confined spaces.,
- Higher risk of slips, falls, physical strains and drowning when working in or near open waterbodies, compounded by adverse weather conditions, hypothermia, and reduced visibility,
- Impacts on the construction of the Phase 2 irrigation network.

8.6.2.4 Decommissioning Impacts

The removal of dam structures and associated facilities can generate dust, noise, and vibrations, affecting both workers and nearby communities. Occupational health and safety risks are significant, including exposure to hazardous materials, accidents during demolition, and increased traffic-related hazards. These impacts require careful planning, stakeholder engagement, and implementation of mitigation measures such as sediment management, air and noise control, safe dismantling procedures, and post-decommissioning monitoring.

8.6.3 Community and Traffic Safety Impacts

8.6.3.1 Pre-Construction Phase

No specific pre-construction phase impacts are expected.

8.6.3.2 Construction Phase

The community may face health and safety risks due to dam construction activities and state road reconstruction activities. Main impacts that may occur include:

- In the area of execution of construction works:
  - If working areas are not secured, marked and fenced, and pedestrian and vehicle movements not clearly planned, defined and organized, it may lead to community members encroaching onto the construction site, exposing themselves to a range of potential risks (fall into excavation, collision with project vehicles etc.).
  - Impacts related to vegetation clearance such as inadequate transportation of logs trough access roads.
  - In the same way, lack of planning of vehicle movement and organization of construction areas may lead to works encroaching outside of immediate construction site, endangering community members.
- Adverse health effects due to air pollution, dust, noise, and vibrations, leading to respiratory issues, stress, and overall discomfort for nearby communities.
- Potential deterioration of road condition due to the movement of heavy equipment; disruption to local utilities due to planned or accidental damagePotential transport of explosives for blasting purpose.
- Impact on traffic on the State Road IB 21 during execution of construction works.

During the increased traffic and transport of all project vehicles, there is a risk of incidents involving vehicles and other road users, including pedestrians.

These incidents may occur due to:

- Failure to follow traffic rules or
- Lack of community awareness regarding the expected increase in heavy traffic in specific areas.

Sensitive receptors that may be under impact include:

- Primary school Sveti Sava, and
- Pambukovica Health Center

No other sensitive receptors have been identified in the area as part of this study.

8.6.3.3 Operation and Maintenance Phase

During the operation phase of the dam, one of the main impacts identified is the safety of the community, particularly in the context of emergency response.

Furthermore, access to open water body also needs to be considered. There is currently no information available on plans to construct a fence around the dam. While fencing is planned along State Road IB 21 and within the dam facilities, the current design does not include fencing around the dam reservoir itself. Implementing such measures could be crucial in preventing unauthorized access by the public and ensuring overall safety.

Fencing will be provided along Road IB21 and within the dam facilities, however the current design does not include fencing around the dam area, and no information has been provided regarding plans to install one.

Users of the State Road IB 21 (Valjevo – Šabac) will be impacted due to change in the alignment, configuration of the road and presence of the open water body. For regular users, this may present new traffic impact in the initial phases of the road operation.

8.6.3.4 Decommissioning Phase

The removal of dam structures and associated facilities can generate dust, noise, and vibrations, potentially affecting nearby communities and sensitive receptors. These activities may pose health and safety risks, including increased exposure to air and noise pollution. Decommissioning Plan should be developed and implemented and should include mitigation measures should include dust and noise suppression, traffic safety management, adherence to safe dismantling procedures, and post-decommissioning monitoring to ensure community health and safety are maintained.

8.7 Impact Assessment and Mitigation

Assessment of identified impacts in line with proposed methodology (impact magnitude, sensitivity of the receptor, impact significance, mitigation measures, residual impact) is presented in the table later in the text.

8.7.1 Occupational Health and Safety Mitigation Measures

8.7.1.1 Pre-Construction Phase

No specific pre-construction phase impacts are expected.

8.7.1.2 Construction Phase

Based on the identified impacts, following mitigation measures have been proposed.

Develop and implement an Occupational Health and Safety Management Plan (OHSMP) to define control and mitigation measures. For high-risk activities (e.g., work at height, blasting), prepare Risk Assessment

Method Statements (RAMS). The Contractor must also develop a Traffic Management Plan (TMP) to assess risks along all transport routes that will be used, particularly near sensitive locations (e.g., schools, medical facilities). The OHSMP should include specific measures related to activities:

- Vegetation clearance - Use appropriate PPE (chainsaw glowes, chaps, helmet with face shield), conduct daily equipment checks and maintenance, establish safety zones and restrict access during tree cutting, cut at proper angles to control debris direction, ensure all workers are trained in vegetation clearing, chainsaw use and emergency procedures, maintain visual contact when working in teams.
- Excavation and Blasting - Implement a permit-to-work system, ensure adequate PPE (e.g., hearing protection such as ear defenders or muffs), safe blasting procedures, and training. Establish safety zones to account for seismic impact, blast wave impact, and debris dispersion. Follow conditions for the transportation of explosives.
- Working in Confined Spaces - Implement a permit-to-work system, ensure adequate PPE, communication system, emergency response, and access and egress. Avoid using petrol or diesel engines in excavations without proper ventilation arrangements.
- Working Near Open Waterbodies - Use life jackets, barriers, rescue equipment, and provide training on water safety.
- Falls from Heights - Use fall arrest systems (e.g., harnesses), guardrails, and safety nets. Provide training on ladder, and scaffolding use, securing ladders / scaffolds, and non-slip footwear. Monitor weather conditions and halt work in high winds or storms. Ensure proper PPE.
- Manual Handling Operations - Utilize team lifts for heavy items to distribute weight and reduce individual strain. Rotate workers regularly to avoid overexertion and fatigue from repetitive manual handling tasks.
- Hazardous Substances - Use PPE such as face mask respirators and protective clothing (e.g., overalls and gloves). Provide washing facilities with hot and cold running water. Transfer liquids with a pump or siphon rather than spraying solvent-based materials. Use cutting and grinding tools and blasting equipment fitted with exhaust ventilation. Ensure good ventilation in the working area by opening doors, windows, and skylights. Keep containers closed except when transferring. Apply hazardous substances by brush and use as little as needed. Read the label on the container and/or the safety data sheet. Approach the manufacturer or supplier directly for more information if necessary. Only workers that received appropriate training can handle hazardous substances.
- Emergency Response - Develop and implement an Emergency Preparedness and Response Plan during construction works, which will define control and mitigation measures. Clear access routes must be maintained for emergency vehicles.
- Workers' Accommodation - Maintain worker accommodation conditions to ensure a good standard of personal hygiene and hygiene in canteens to prevent contamination and the spread of diseases resulting from inadequate sanitary facilities. The accommodation must comply with the requirements of the EBRD Workers' Accommodation Guidance Note.
- Grievance Mechanism – Ensure that workers have access to grievance mechanism, and to have option for submitting anonymous grievances.

8.7.1.3 Operation and Maintenance Phase

General occupation and health pre-cautions should be applied to all operation workers and for maintenance workers, specific mitigation measures should be implemented whether direct or indirectly hired.

In order to mitigate potential risks during operation phase an Occupational Health and Safety Management Plan should be developed and implemented that is specific to operational activities. The OHSMP for the

operational phase should cover maintenance responsibilities, organization, risk assessment, training, traffic management, performing maintenance and inspection, reporting incidents etc.

- General Occupational Health and Safety - Develop and implement an OHSMP specific to operational activities, covering maintenance responsibilities, risk assessment, training, traffic management, and emergency response. Include also impacts and all relevant mitigation measures for the construction of the phase 2 irrigation network.
- Work in confined space - Implement permit to work system, ensure adequate PPE, communication system, emergency response, access and egress.
- Working on or near open waterbodies - Implement permit to work system, ensure adequate PPE such as life jackets, barriers, rescue equipment, training on water safety.
- Emergency response - Develop and implement EPRP. Coordinate the implementation of EPRP with Ministry of Interior.

8.7.1.4 Decommissioning Phase

Develop and implement a Decommissioning Plan that includes planning and risk assessment with detailed procedures for dismantling and removal activities.

Decommissioning Plan should include, but not limited to:

- Planning and risk assessment, with detailed procedures for dismantling and removal activities,
- Worker safety measures, including permit-to-work systems for all high-risk activities,
- Controls for air, noise, and dust emission.
- Provision of appropriate personal protective equipment,
- Traffic Safety management
- Waste Management activities,
- Community health and safety measures, including notification of local communities in advance of decommissioning activities; and
- Grievance Mechanism.

The Decommissioning Plan should also incorporate training, supervision, and ongoing monitoring to maintain high health and safety standards during all phases of the decommissioning work. Planning and preparation for decommissioning would need to be initiated at least 5 years before targeted start of decommissioning.

8.7.2 Community and Traffic Safety Mitigation Measures

8.7.2.1 Pre-Construction Phase

No specific pre-construction phase impacts are expected.

8.7.2.2 Construction Phase

In order to mitigate identified community health and safety impacts the contractor should as a part of the CESMP or standalone Community Health and Safety and Security Plan include:

- Mitigation measures for mitigating impacts from vegetation clearance, dust, noise, and vibration suppression through sound barriers, silencers, and water sprinkling.
- Construction work scheduling to minimize disturbances, with timely community notifications for road closures.
- Contractor to carry out the relocation of any affected infrastructure and utilities and provide advance notification to users of any disruption, alternatives for the period of disruption and full and prompt reestablishment of function.
- Contractor to carry out prompt repairs of any accidentally affected utilities and provide information to local communities on how and when services will be re-established
- Undertake, prior to the start of construction, a pre-condition survey of all access roads to be used. The survey will be conducted by a civil engineer experienced in roads and will use photographic, video and other supporting materials to document the road condition in survey reports. Surveys will be undertaken together with responsible entities depending on the type of road and witnessed by the local municipality representatives.
- Contractor to maintain quality of all used roads and promptly repair any damages.
- A grievance mechanism to address community concerns effectively.

The future Contractor will be responsible for managing traffic during the construction phase. To prevent potential traffic accidents involving members of the local community and Project, the Contractor will develop specific measures and procedures as a part of the TMP, which is planned be developed as part of the CESMP or as stand-alone document.

When it comes to ensuring security of the site and limitation of encroachment from the community, the Contractor should develop as a part of it CESMP or standalone Community Health and Safety and Security Plan policies and procedures that will be applied across work site, offices and auxiliary facilities.

8.7.2.3 Operation and Maintenance Phase

The operation of the Pambukovica Dam involves several critical activities aimed at maintaining the infrastructure and ensuring its safe and efficient functioning. To safeguard the surrounding community, safety mitigation measures must be implemented. These measures should be designed to address potential risks and enhance the overall safety of both the dam workers and the local population.

During the operational phase, the primary activities include managing flow discharges under various conditions, maintaining the irrigation network, conducting regular maintenance of civil works and electromechanical equipment, ensuring reliable and safe operation, and performing visual surveillance and periodic safety inspections. Each of these activities presents specific occupational health and safety risks that need to be mitigated to protect the community and workers.

To ensure community safety during potential emergencies, it is essential to implement Emergency Preparedness and Response Plan. This plan should address all foreseeable emergencies that could impact community surrounding the dam.

Fencing will be provided along Road IB21 and within the dam facilities, however the current design does not include fencing around the dam or the reservoir area, and no information has been provided regarding plans to install one.

In order to enhance community safety and manage public risk effectively, it is recommended to install clear and visible signage around the dam and the reservoir area. These measures would help inform the community of potential risks associated with the dam, and guide them on safe practices and restricted areas.

A Road Safety Audit (RSA) was conducted for Phase 1, focusing on the review of technical documentation that may impact traffic safety, along with proposing measures to enhance traffic safety. The following recommendations were identified to improve traffic safety:

- Installing speed limit signs in specific sections of the road,
- Placing warning signs (for slippery conditions) on parts of the road adjacent to water bodies,
- Installing protective fencing along the road near the lake.

It is recommended that RSA is performed for this project at each phase of the Project:

- During the Design for Construction Permit phase,
- During the construction phase (to confirm that all design measures have been implemented)
- One year into operation.

For all details on the RSA report, please refer to the separate RSA Report.

8.7.2.4 Decommissioning Phase

The removal of dam structures and associated facilities can generate dust, noise, and vibrations, potentially affecting nearby communities and sensitive receptors. These activities may pose health and safety risks, including higher risk for traffic-related accidents. To manage these risks effectively, Decommissioning Plan should be developed and implemented. The Decommissioning Plan should include careful planning and engagement with stakeholders as well as mitigation measures that include traffic safety management, implementation of safe dismantling procedures, and post-decommissioning monitoring to safeguard community health and safety.

8.7.3 Emergency Response Mitigation Measures

As part of this ESIA, Emergency Preparedness and Response Plan (EPRP) has been developed as a separate document within this ESIA. Summary of the EPRP is provided below.

EPRP has been developed based on the requirements given in the following documents:

- International Commission on Large Dams (ICOLD), Dam Safety Management, 2017
- United States Federal Dam Safety Commission (US FDSC): FEMA 64 guide for preparation of EPPs for dams, 2013
- Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities, the World Bank, 2020
- Canadian Dam Association Guidelines for Public Safety Around Dams, 2011
- EBRD Guidance Note - Environmental and Social Guidance Note for Hydropower Projects,
- World Bank – Good Practice Note on Dam Safety, 2021.

Pambukovica Dam Clasification

The Pambukovica Dam has been classified as an Extreme Hazard Dam based on international guidelines and dam safety assessments conducted in accordance with ICOLD (International Commission on Large Dams), US FDSC (FEMA 64), and World Bank standards. This classification was determined through dam breach modelling and risk analysis, which considered:

- Dam dimensions: Height of 30.5 meters and reservoir volume of 8.15 million m^3.
- Population at risk (PAR): Over 1,000 individuals downstream.
- Potential societal loss of life (LoL): Averaged LoL exceeding 10 in breach scenarios.
- Downstream damage potential: High, including impacts on infrastructure, agriculture, and settlements.

The classification was formally established through the Dam Safety and Risk Assessment process, which included hydraulic modelling of breach scenarios (instantaneous breach, overtopping, and internal erosion) and mapping of inundation zones

Development of the draft Emergency Preparedness and Response Plan

The EPRP was developed with a thorough consideration of potential failure scenarios and the population at risk. This included comprehensive dam breach modelling that evaluated various scenarios such as instantaneous breach, overtopping, and internal erosion. The findings from these evaluations underscore the extreme hazard posed by the dam, highlighting a significant population at risk and a notable potential societal loss of life in the event of a failure.

The data derived from these assessments serve as tools in identifying populations at risk, classifying potential loss of life, and determining failure probabilities.

The EPRP outlines clear organizational responsibilities, actions, reporting requirements, and the resources available to manage emergencies effectively. It is developed based on internationally recognized guidelines and standards, such as those from the ICOLD and the US FDSC.

Effective emergency response measures include the use of fencing to control access in areas where there is a risk of falls, vandalism, and unauthorized access to flow control equipment. Barricades and vehicle gates, when used, should be designed to prevent additional hazards to the public. Properly secured and marked barriers are essential to ensure that safety measures are effective without introducing unintended risks.

Additionally, informing the community about emergency procedures, evacuation routes, and safe assembly points is vital. Regular training and drills should be conducted to ensure the community is well-prepared and aware of the actions to take during an emergency. The EPRP's focus on community safety during the dam's operation phase underscores the commitment to protecting lives and maintaining public confidence in the project's safety protocols.

EPRP sets procedures that are applicable to all activities performed in various components of the dam during its Operation and Maintenance as Pambukovica. The EPRP also considers all activities involving Srbijavode staff. It outlines procedures, actions and the minimum requirements managing emergency events.

Mitigation Measures and Emergency Preparedness

Given the dam's hazard classification, a range of mitigation measures has been identified and proposed. These measures are intended to reduce risk and enhance emergency response capabilities. They will be further elaborated and refined during the finalisation of the Emergency Preparedness and Response Plan (EPRP).

Mitigation Options Include:

- Early Warning System (EWS)
  - Installation of sirens and automated alerts linked to reservoir level sensors.
  - Manual and automated monitoring of seepage, vertical movements, and pore water pressures.
- Evacuation Planning
  - Development of evacuation routes and transport logistics (road, water, air).
  - Coordination with the Ministry of Interior Emergency Department for mobilization.
- Rescue and Rehabilitation
  - Mobilization of rescue teams and equipment.
  - Design and implementation of urgent rehabilitation works by Srbijavode or contracted entities.

- Communication Systems
  - Use of mobile networks (A1, Yettel, MTS) and radio systems for emergency coordination.
  - Backup communication protocols in case of network failure.

- Notification Procedures
  - Multi-tiered alarm levels (1 to 4) with corresponding response matrices.
  - Flowcharts detailing responsibilities and contact points for each emergency level.

- Infrastructure and Resource Readiness
  - Stockpiling of sandbags, fill material, fuel, and maintenance tools.
  - Provision of essential services (medical, food, water) during emergencies.

- Training and Exercises
  - Regular drills and simulations to test EPRP effectiveness.
  - Documentation and evaluation of exercises in the Emergency Response Dossier.

- Risk Register and Review
  - Continuous update of risk assessments and residual risk evaluations.
  - Integration of findings into the EPRP and operational protocols.

These mitigation measures are designed to be scalable and adaptable, ensuring that the final EPRP reflects the operational realities and stakeholder inputs. The final EPRP will be legally binding and approved prior to reservoir impoundment

Fire risk

Regarding fire risks, the EIA mandates an Automatic Fire Alarm system to monitor fire indicators continuously and trigger an alarm upon detection. This system notifies on-duty personnel at a remote control center, who then alert emergency services. The system includes a fire control panel, smoke (optical) detectors, multi-sensor smoke detectors, thermal detectors, manual call points, sirens, flashers, power supply and signal cables, and auxiliary equipment, all conforming to the SRPS EN 54 standard. This addressable system ensures the precise identification of fire locations and activated detectors. Automatic fire detectors will be installed in fire-prone areas, while manual call points will be positioned near doors, staircases, corridors, and evacuation routes to ensure swift and effective responses.

Please see **ESIA Volume 2 – Emergency Preparedness and Response Plan** for full details.

Table 20 - Impact Assessment Table - Health and Safety

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
Occupational Health and Safety General Occupational Health and Safety Hazards	Risk to worker safety, unsafe work practices that could lead to serious injury or fatality Inadequate handling of working equipment, inadequate use of PPE, failure to follow working procedures, /methodologies that could lead to incidents and pose a health and safety risk to workers	Construction workers	Major	Moderate	Major	Develop and implement OHSMP which will define control and mitigation measures, as a standalone document or as a part the Project Specific ESMP. For all specific high-risk activities (such as work at height, blasting etc.), RAMS is expected to be developed. The OHSMP should include risk assessments and control measures for all identified risks (clearance of the vegetation, exposure to noise, dust, vibration, traffic, slips, trips, falls, electrical risk, fire, etc.). The Contractor to develop and implement Traffic Management Plan. TMP should identify transport routes, sensitive recipients (e.g. schools, kindergartens, medical facilities) along these routes, assess relevant risks, and define control and mitigation measures.	Minor
Occupational Health and Safety Vegetation clearance	Risk to worker safety, unsafe work practices that could lead to serious injury or fatality	Construction workers	Major	Moderate	Major	Develop and implement OHSMP. Include in OHSMP measures for vegetation clearance such as: • Use appropriate PPE (chainsaw gloves, chaps, helmet with face shield), • conduct daily equipment checks and maintenance, • establish safety zones and restrict access during tree cutting, • cut at proper angles to control debris direction, • ensure all workers are trained in vegetation clearing,	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
						• chainsaw use and emergency procedures, • maintain visual contact when working in teams, • Dust, noise, and vibration suppression through sound barriers, silencers, and water sprinkling.	
Occupational Health and Safety Excavation and blasting	Vibration, noise, flying debris Physical injuries, hearing loss, phycological effects such as stress effects, difficulty concentrating.	Construction workers	Major	Moderate	Major	Develop and implement OHSMP Implement permit to work system, ensure adequate PPE (hearing protection such as ear defenders or muffs), safe blasting procedures, training. Due to the potential harmful and dangerous effects resulting from the detonation of explosive charges, safety zones must be established to account for the following effects: seismic impact, the impact of the blast wave, and the dispersion of debris. For transportation of explosives, follow conditions for transportation of explosives.	Minor
Occupational Health and Safety Working in confined space	Risk from injury due to lack of oxygen, structure collapsing.	Construction workers	Major	High	Major	Implement permit to work system, ensure adequate PPE, communication system, emergency response, access and egress, Do not use petrol or diesel engines in excavations before making arrangements for the fumes to be ducted safely away or providing for forced ventilation.	Minor.
Occupational Health and Safety Working in or near open waterbodies	Slips and falls into water, drowning, adverse weather conditions. hypothermia, reduced visibility.	Construction workers	Moderate	High	Major	Use adequate PPE (life jackets, non-slip footwear, etc.) barriers, rescue equipment, training on water safety. Implement a buddy system to ensure that workers are never alone and can assist each other in case of emergencies.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
Occupational Health and Safety Falls from heights	Working at height; falling from high structures, ladders, scaffolding, etc. Improper safety practices leading to falls	Construction workers	Moderate	High	Major	Use of fall arrest systems (e.g., harnesses), guardrails, and safety nets Training on ladder use, securing ladders, non-slip footwear Weather monitoring, halt work in high winds or storms, proper PPE	Minor.
Occupational Health and Safety Manual handling operations	Mobilization of machinery and equipment Improper lifting technique while carrying construction equipment Heavy manual labour, awkward postures and previous or existing injuries can increase the risk of injury.	Construction workers	Minor	Moderate	Moderate	Where items are too heavy to be lifted by one person, team lifts are utilized to distribute the weight and reduce individual strain. Workers are rotated regularly to avoid overexertion and fatigue from repetitive manual handling tasks.	Negligible
Occupational Health and Safety Hazardous Substances	Safety management of hazardous substances The improper handling, storage, or disposal of hazardous substances such as chemicals, fuels, and lubricants during construction could lead to exposure, spills, or contamination.	Construction workers, local community, environment	Moderate	Major	Major	OHSMP should include mitigation measures for handling hazardous materials, but not limited to: • Use personal protective equipment (PPE) such as face mask respirators, protective overalls, and gloves. • Transfer liquids using a pump or siphon—never by mouth priming—and avoid spraying solvent-based substances whenever possible. • Use cutting, grinding, and blasting equipment fitted with local exhaust	Minor.

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
						ventilation to minimize airborne dust and fumes. • Maintain good ventilation in the work area, • Keep containers closed when not in use, and only open them during material transfer to limit exposure. • Apply hazardous substances with a brush rather than spraying, and use the minimum amount necessary for the task • Only workers that received appropriate training can handle hazardous substances. If hazardous substances are going to be used, manufacturers and suppliers of such substances have a legal duty to provide information. Read the label on the container and/or the safety data sheet. Approach the manufacturer or supplier directly for more information if necessary.	
Occupational Health and Safety Emergency Response	Risks and impacts on workers and community relevant for the emergency scenarios Emergency response in case of fire, earthquakes, spills, floods, working during extreme heat or cold, etc.	Construction workers	Major	High	Major	Develop and implement Emergency Preparedness and Response Plan during construction works, which will define control and mitigation measures, as a standalone document or as a part the Project Specific CESMP.	Minor.

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
Occupational Health and Safety Workers Accommodation	Poor accommodation conditions	Construction workers	Moderate	Moderate	Moderate	Worker accommodation conditions will be maintained to ensure a good standard of personal hygiene and hygiene in canteens need to be ensured to prevent contamination and the spread of diseases which result from inadequate sanitary facilities and may affect the community health and safety as well. The accommodation must comply with the requirements of the IFC and EBRD Workers' Accommodation Guidance Note.	Negligible
Occupational Health and Safety Community Health and Safety Dust Air Noise Vibrations	Nuisance from air, dust, vibration and noise emissions	Community members	Moderate	Moderate	Moderate	OHSMP or CESMP to include but not limited to vegetation clearance, dust, noise, and vibration suppression mitigation measures sound barriers, silencer, water sprinkling, construction work schedule and timely informing community in case of road closures, grievance mechanism, traffic management, identification of sensitive recipients. Monitoring of air, noise, dust vibration should be established prior start of construction and conducted on regular basis. Vibrations can be conducted as baseline prior to construction works and as per request.	Negligible .
Traffic Safety Construction traffic	Risks of traffic accidents due to Project activities during construction. Impact on traffic on the State Road IB 21 during execution of construction works	Workers and community during construction phase and community in the vicinity of the access roads	Major	High	Major	Develop and implement TMP, which will define control and mitigation measures, as a standalone document or a part of the OHSMP / CESMP. TMP to organize and control movement and interaction of pedestrians and vehicles in areas used and affected by ongoing works, inside and outside of the immediate construction site.	Minor.

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
	Missing out on specific risks relating to traffic					The Contractor to develop and implement Traffic Management Plan. It should identify transport routes, sensitive recipients (e.g. schools, kindergartens, medical facilities) along these routes, assess relevant risks, and define control and mitigation measures. Contractor will be responsible to further detail mitigation measures in the CESMP. Speed limits for heavy trucks and machinery will be enforced on all access roads to reduce risks to workers and local residents. Contractor to maintain quality of all used roads and promptly repair any damages. Construction work scheduling to minimize disturbances, with timely community notifications for road closures.	
Community Safety Security	Risk for violence in local communities arising from the actions of security personnel Risks to workers from security personnel, including non-compliance with the Code of Conduct	Workers and community during construction phase	Major	Moderate	Moderate	Management Plan for security personnel should be developed and implemented by the Contractor, as part of Community Health Safety and Security Management Plan or as a part of the CESMP. The Community Health, Safety and Security Management Plan shall include: Clear prescription of actions of security personnel in case of conflict situations; Regular trainings of security personnel on communication with local residents and	Negligible

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
						training of guiding principles on human rights; Measures of control of actions of security personnel; Envisage rewards and violations, including termination of working contracts;	
Community Safety Encroachment	Community members encroaching onto the construction site, exposing themselves to a range of potential risks.	Community members	Moderate	Moderate	Moderate	The Contractor to develop and implement Community Health, Safety and Security Management Plan, which will define control and mitigation measures, as a standalone document or a part of the CESMP.	Negligible
Occupational Health and Safety General Occupational Health and Safety Hazards	Risk to worker safety, unsafe work practices that could lead to serious injury or fatality Inadequate handling of working equipment, inadequate use of PPE, failure to follow working procedures, /methodologies that could lead to incidents and pose a health and safety risk to workers.	Workers appointed for operation and regular maintenance activities.	Major	Moderate	Major	Develop and implement OHSMP which will define control and mitigation measures, as a standalone document or as a part the Project Specific ESMP. Include impacts and all relevant mitigation measures for the construction of the phase 2 irrigation network.	Minor.
Occupational Health and Safety Working in confined space	Risk from injury due to lack of oxygen, structure collapsing.	Workers appointed for operation and regular maintenance activities.	Major	High	Major	Develop and implement OHSMP which will define control and mitigation measures, as a standalone document or as a part the Project Specific ESMP	Minor.

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
						Implement permit to work system, ensure adequate PPE, communication system, emergency response, access and egress, Do not use petrol or diesel engines in excavations before making arrangements for the fumes to be ducted safely away or providing for forced ventilation.	
Occupational Health and Safety Working near open waterbodies	Slips and falls into water, drowning, adverse weather conditions. hypothermia, reduced visibility.	Workers appointed for operation and regular maintenance activities.	Major	High	Major	Develop and implement OHSMP which will define control and mitigation measures, as a standalone document or as a part the Project Specific ESMP. Implement permit to work system, ensure adequate PPE such as life jackets, barriers,, rescue equipment, training on water safety. In case need of diving, ensure all diving equipment is regularly inspected and maintained, and workers receive adequate training. Use underwater communication systems.	Minor.
Community Safety Emergency Response	Potential impacts on community safety that can arise during operation of a dam	Community members	Major	High	Major	Develop and implement EPRP. Coordinate the implementation of EPRP with Ministry of Interior.	Minor
Community Safety Encroachment	Community members encroaching onto the dam area, exposing themselves to a range of potential risks.	Community members	Major	High	Major	Install clear and visible signage around the dam area to clearly inform the public of potential hazards. Regularly inspect signage and assess whether additional signs are needed. These measures should be included in the Community Health, Safety, and Security Management Plan.	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
Worker and Community Health and Safety	Potential impacts on workers and community safety that can arise during decommissioning of a dam	Workers appointed on decommissioning activities and Community members	Major	High	Major	Develop and implement Decommissioning Plan that includes Planning and risk assessment, with detailed procedures for dismantling and removal activities, Worker safety measures, including permit-to-work systems for all high-risk activities, Controls for air, noise, and dust emission. Provision of appropriate personal protective equipment, Traffic Safety management Waste Management activities, Community health and safety measures, including notification of local communities in advance of decommissioning activities; and Grievance Mechanism. The Decommissioning Plan should also incorporate training, supervision, and ongoing monitoring to maintain high health and safety standards during all phases of the decommissioning work. Planning and preparation for decommissioning would need to be initiated at least 5 years before targeted start of decommissioning	Minor
Community Safety Utilities	Relocation of utilities - lack of service provided due to works	Utilities	Moderate	Moderate	Moderate	Contractor to carry out the relocation of any affected infrastructure and utilities and provide advance notification to users of any disruption, alternatives for the period of	Minor

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
	Damage to utilities					disruption and full and prompt reestablishment of function. Construction work scheduling to minimize disturbances, with timely community notifications for road closures. Contractor to carry out prompt repairs of any accidentally affected utilities and provide information to local communities on how and when services will be re-established.	

Table 21 - Mitigation and Monitoring - Health and Safety

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Occupational Health and Safety General Occupational Health and Safety Hazards	Risk to worker safety, unsafe work practices that could lead to serious injury or fatality Inadequate handling of working equipment, inadequate use of PPE, failure to follow working procedures, /methodologies that could lead to incidents and pose a health and safety risk to workers. Excavation Working in confined space Near open water bodies Working near open waterbodies Falls from heights Manual handling operations	Construction workers	Develop and implement OHSMP. Implement permit to work system RAMS to be developed for high-risk works. Develop and implement Traffic Management Plan. Develop and implement Emergency Preparedness and Response Plan.	Prior start of the construction works

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
	Hazardous Substances Emergency Response Workers Accommodation			
Community Health and Safety Dust Air Noise Vibrations	Nuisance from air, dust, vibration and noise emissions	Community members	Develop and implement OHSMP. Conduct monitoring as recommended in Table 2 - Mitigation and Monitoring – Air Quality and Table 4 - Mitigation and Monitoring – Noise and Vibrations.	Prior start of the construction works
Traffic Safety Construction traffic	Risks of traffic accidents due to Project activities during pre-construction and construction. Impact on traffic on the State Road IB 21 during execution of construction works Missing out on specific risks relating to traffic	Workers and community during construction phase.	Develop and implement TMP.	Prior start of the construction works
Traffic Safety Construction traffic	Damage to local / access roads, safety risks due to conditions of the roads	Local / access roads	Undertake, prior to the start of construction, a pre-condition survey of all access roads to be used. The survey will be conducted by a civil engineer experienced in roads and will use photographic, video and other supporting materials to document the road condition in survey reports. Surveys will be undertaken together with responsible entities depending on the type of road and witnessed by the local municipality representatives.	Prior start of the construction works

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Community Safety Security	Risk for violence in local communities arising from the actions of security personnel Encroachment	Workers and community during construction phase	Develop and implement Community Health Safety and Security Management Plan	Prior start of the construction works
Occupational Health and Safety Occupational Health and Safety Hazards	Risk to worker safety, unsafe work practices that could lead to serious injury or fatality Inadequate handling of working equipment, inadequate use of PPE, failure to follow working procedures, /methodologies that could lead to incidents and pose a health and safety risk to workers.	Workers appointed for operation and regular maintenance activities.	Develop and implement OHSMP.	Prior start of the operation phase.
Community Safety Emergency Response	Potential impacts on community safety that can arise during operation of a dam	Community members	Develop and implement EPRP.	Prior start of the operation phase.
Community Safety Encroachment	Community members encroaching onto the dam area, exposing themselves to a range of potential risks.	Community members	Develop and implement Community Health, Safety and Security Management Plan.	Prior start of the operation phase.
OHS / Community Safety	Potential impacts on workers and community safety that can arise during decommissioning of a dam	Workers appointed on decommissioning activities and Community members	Develop and implement Decommissioning Plan.	Prior start of the decommissioning phase.

9. Landscape and Visual

Dams play a crucial role in water resource management, providing benefits such as water supply, flood control, hydropower generation, and irrigation. However, their construction and operation also bring significant environmental and social considerations that must be thoroughly assessed to ensure sustainable development. The Environmental and Social Impact Assessment (ESIA) process is fundamental in identifying, evaluating, and mitigating potential environmental and social impacts associated with large-scale infrastructure projects such as the Pambukovica Dam.

The Pambukovica Dam is planned on the Ub River, approximately 21 km upstream from its confluence with the Tamnava River and about 15 km west of the settlement of Ub. The project area spans the cadastral municipalities of Pambukovica, Radusa, and Gola Glava. The construction of the dam and associated infrastructure is expected to last three years, including the development of access roads, excavation of materials, river diversion, and extensive concreting works.

This ESIA is conducted to evaluate the potential environmental, social, and economic effects of the proposed dam construction and ensure compliance with national and international environmental standards. It will provide a comprehensive assessment of how the project interacts with various environmental components, including land use, water resources, biodiversity, air quality, and socio-economic conditions.

The ESIA follows international best practices, including those outlined by the International Finance Corporation (IFC) Performance Standards, the European Union Environmental Impact Assessment (EIA) Directive, and national regulations. The assessment considers both the construction and operational phases of the dam, identifying key impacts and proposing appropriate mitigation measures to minimize adverse effects and enhance positive outcomes.

The primary objectives of this ESIA include:

- Identifying and assessing potential environmental and social impacts associated with the construction and operation of the Pambukovica Dam.
- Ensuring compliance with relevant legislative and regulatory frameworks.
- Engaging stakeholders, including local communities, governmental authorities, and non-governmental organizations, in the assessment process.
- Recommending mitigation measures to minimize negative impacts and enhance environmental and social benefits.
- Providing a basis for decision-making to support sustainable development and responsible environmental management.

Through a systematic approach, the ESIA aims to ensure that the construction of the Pambukovica Dam aligns with sustainable development principles, minimizing environmental degradation while maximizing the project's benefits. The findings of this ESIA will contribute to the development of an Environmental and Social Management Plan (ESMP), which will guide project implementation in a way that balances development with environmental conservation and social responsibility.

9.1 Introduction and Purpose

The landscape and visual impact assessment is a critical component of the Environmental and Social Impact Assessment (ESIA), ensuring that the project's influence on the natural and visual environment is evaluated. Large-scale infrastructure projects, such as dams, alter the physical landscape, affecting visual aesthetics, landform character, and the perception of the surrounding environment.

The purpose of this assessment is to analyse the extent of landscape and visual changes resulting from the project and determine their significance. This involves evaluating changes to landform patterns, vegetation cover, and scenic quality, as well as assessing the project's visibility from key viewpoints, public areas, and nearby settlements.

A comprehensive landscape and visual impact assessment considers:

- Changes to the physical landscape, including modifications to topography and vegetation.
- The visual perception of the project from different viewpoints and receptors.
- The impact on the aesthetic and cultural value of the area.
- Potential mitigation measures to minimize visual disturbances and integrate the project into the surrounding landscape.

By systematically evaluating these factors, the assessment supports informed decision-making and promotes the responsible integration of the project into the existing landscape. The findings will contribute to the development of mitigation strategies that enhance visual harmony while maintaining the project's functional objectives.

9.2 Legislation and Standards

EBRD Performance Requirements

- PR 1: Environmental and Social Appraisal and Management
- PR 10: Information Disclosure and Stakeholder Engagement

National Legislation

National legislation

The main national legal framework considered, related to landscape and visual is:

- Nature Protection Law: Provides measures and standards for sustainable nature protection, including landscape and visual aspects 5.
- Law on Environmental Impact Assessment: Outlines the procedures for conducting EIAs in Serbia, including the assessment of landscape and visual impacts 6.
- Regulation on Criteria for Identification of Landscapes: Establishes criteria for identifying landscapes and assessing their significant features

Additionally, the assessment aligns with:

- The European Landscape Convention (ELC, 2000), which promotes the protection, management, and planning of landscapes, including both outstanding and everyday landscapes.
- National legislation on landscape and environmental protection, ensuring compliance with local regulatory frameworks governing visual and scenic impacts.
- Industry best practices and guidelines, including methodologies for Landscape and Visual Impact Assessment (LVIA) to evaluate and mitigate potential adverse effects.

This chapter establishes the regulatory and policy framework within which the landscape and visual impact assessment is conducted, ensuring that the project meets EBRD's sustainability criteria while minimizing negative visual effects on the environment and local communities.

This chapter establishes the regulatory and policy framework within which the landscape and visual impact assessment is conducted, ensuring that the project meets EBRD's sustainability criteria while minimizing negative visual effects on the environment and local communities.

Full list of relevant legislation and standards (Project Standards) is provided in the **Book 1 Introduction.**

9.3 Methodology

The methodology of the Landscape and Visual Impact Assessment (LVIA) has been developed in line with overarching ESIA methodology to ensure it considers receptors and the likelihood of significant landscape and visual impacts. The LVIA methodology has been adopted from the Guidelines for Landscape and Visual Impacts Assessment (The Landscape Institute and the Institute of Environmental Management & Assessment, 2013).

Assessment Approach

The assessment considers both direct and indirect effects on landscape character and visual receptors. Landscape effects encompass changes to topography, vegetation, and land use, while visual effects involve alterations to views from key receptors. Sensitivity assessments for these receptors are conducted to gauge the significance of potential impacts.

Methods used in the assessment integrate desk studies and field surveys in an iterative manner. Satellite imagery and digital elevation model serve as the initial reference points. This approach ensures a comprehensive understanding of how the Pambukovica Dam Project may alter the landscape and visual environment.

While certain aspects of landscape and visual changes can be measured objectively, much of the assessment relies on qualitative judgments. The evaluation of landscape and visual impacts follows two interconnected processes. Landscape is assessed as an environmental resource, while visual effects are considered as part of the broader impacts on the population.

9.4 Assumptions and limitations

Assumptions and limitations presented in the **Book 1 Introduction** are relevant for this topic.

Landscape and visual specific assumption and/or limitations:

- Assumptions include determining existing landscape characteristics and visual baseline using site visits, satellite imagery, and land use data, assuming no significant landscape changes before construction.
- Visibility modelling assumes clear atmospheric conditions and a standard observer height.
- Receptor sensitivity is based on existing land use, local planning policies, and stakeholder input. The assessment also assumes that the dam and associated infrastructure will be constructed as per design specifications, including planned mitigation measures such as vegetation screening and landform restoration.
- Public and stakeholder views on landscape and visual impacts have been inferred based on general consultation principles.
- Seasonal variations in vegetation cover, water levels, and weather conditions may influence the actual visual impact.
- Visual representations of the project, such as photomontages, are based on available project design data and may not fully capture on-site perspectives or future landscape modifications.

- Temporary visual impacts during construction have been estimated based on standard practices but may vary due to unforeseen logistical and scheduling changes.

9.5 Baseline

The Pambukovica Dam is planned on the Ub River, approximately 21 km upstream from its confluence with the Tamnava River and about 15 km west of the settlement of Ub. The project area spans the cadastral municipalities of Pambukovica, Raduša, and Gola Glava. The construction and associated works, including access roads, excavation, river diversion, and concreting, are expected to last three years.

The reservoir will be positioned within the Ub River valley, following the natural contours of the terrain, with its water surface reaching an elevation of approximately 145.5 masl, while the dam crest will be constructed at approximately 150.5 meters above sea level.

The surrounding landscape is characterized by gently rolling hills, with altitudes ranging from 140 to 160 meters, interspersed with agricultural fields, scattered rural settlements, and patches of deciduous forest (Figure 29**).** The area is dominated by gravelly-sandy materials of various granulations, occasionally with clay fractions. These sediments form confined aquifers with good hydraulic connectivity to the river. Vegetation includes deciduous forest communities along the Ub River, featuring species such as black alder, grey alder, willows, and poplars. Land cover in the project area is a mix of agricultural land, forests, and built-up areas, with agricultural land being predominant. It consists of arable fields, pastures, and meadows, while forests are sparsely distributed, mainly as natural coppice stands. A detailed land cover map will be presented in the following section to illustrate the spatial distribution of these land categories **(**Figure 30**).**

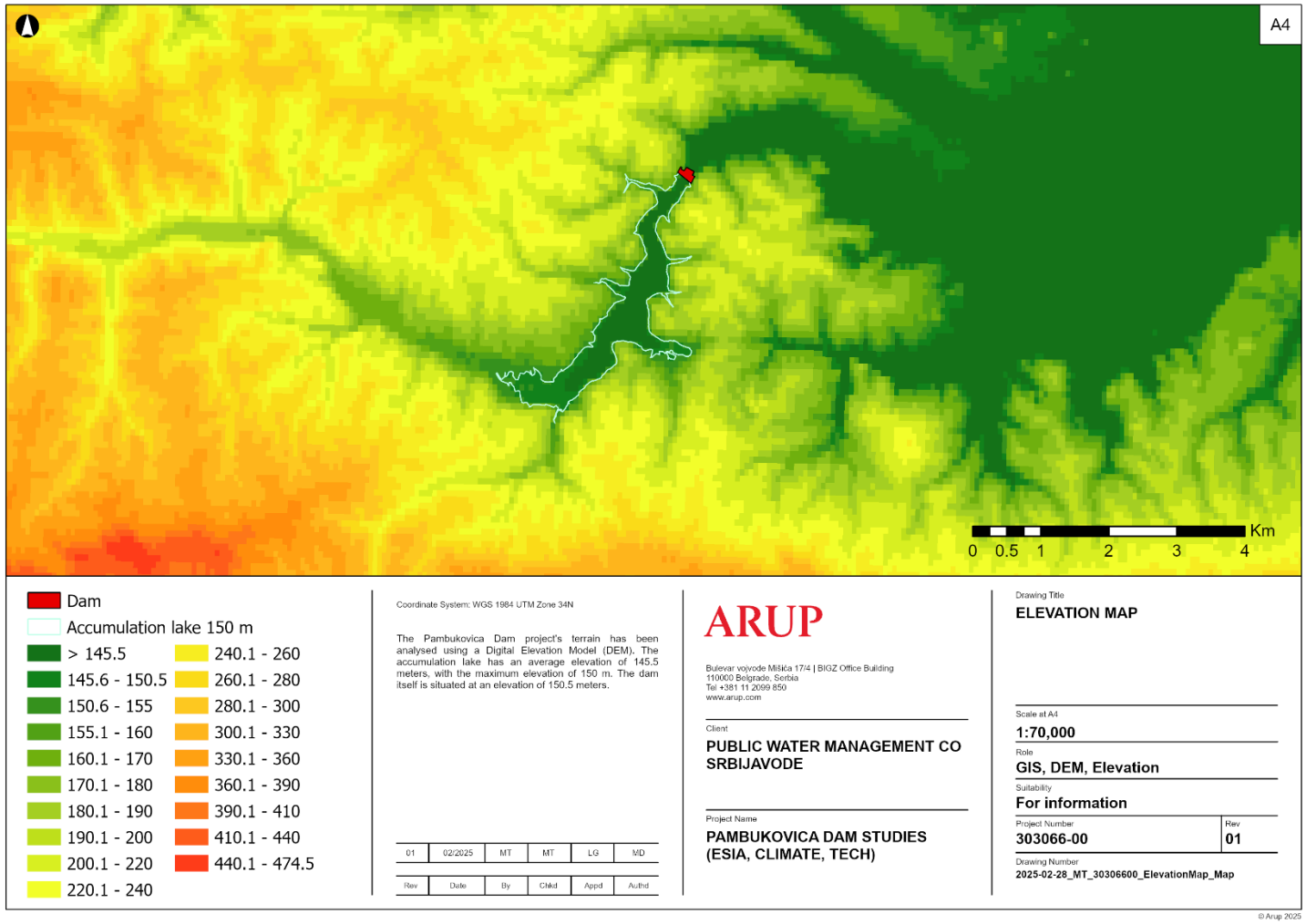

Figure 29 - Elevation map of the Project area and surrounding

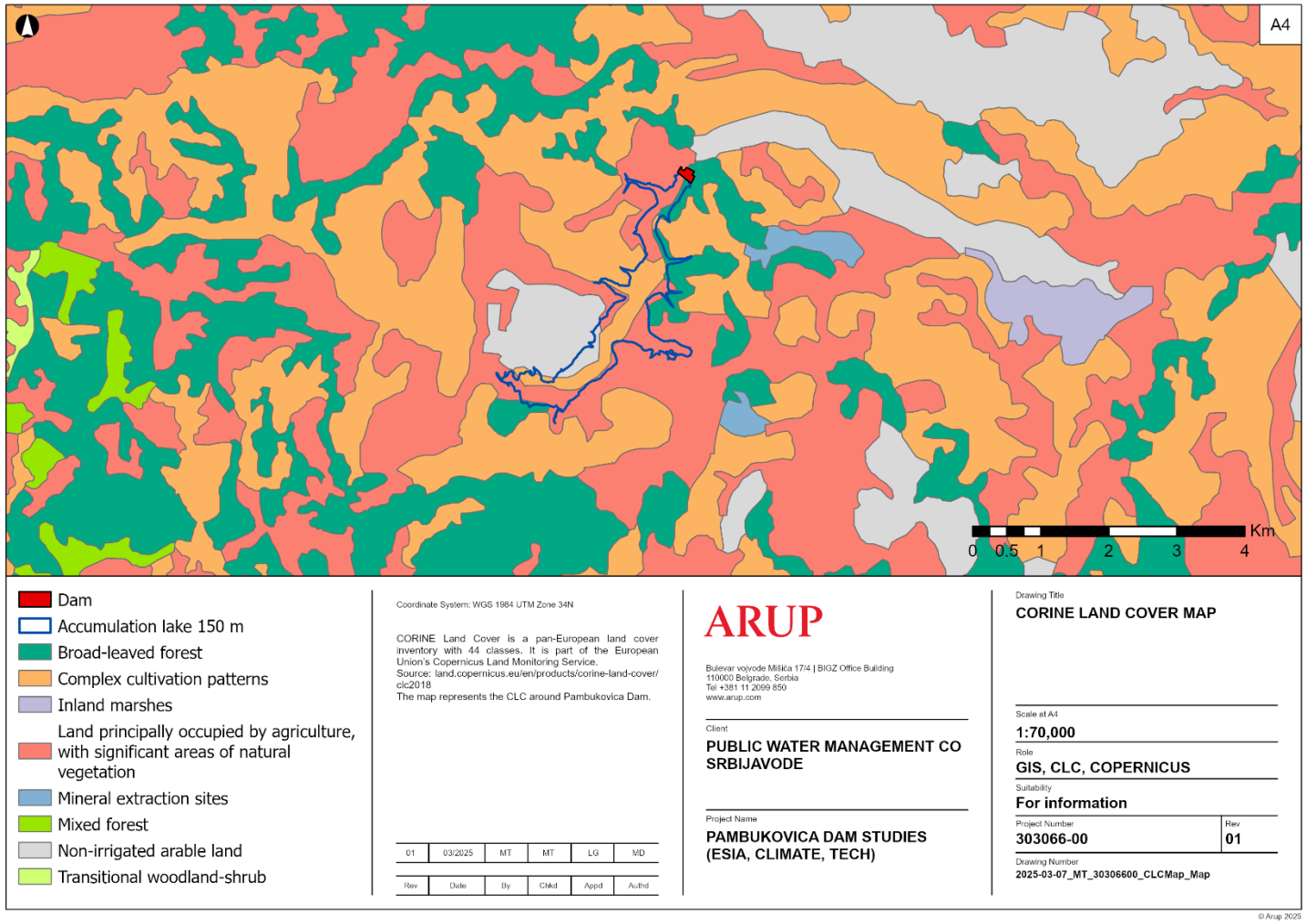

Figure 30 - Corine land cover map of Project location

In order to understand the geographical location, elevation of the area from different viewpoints we have taken into consideration multiple elevation profiles along dominant viewsheds towards Project area.

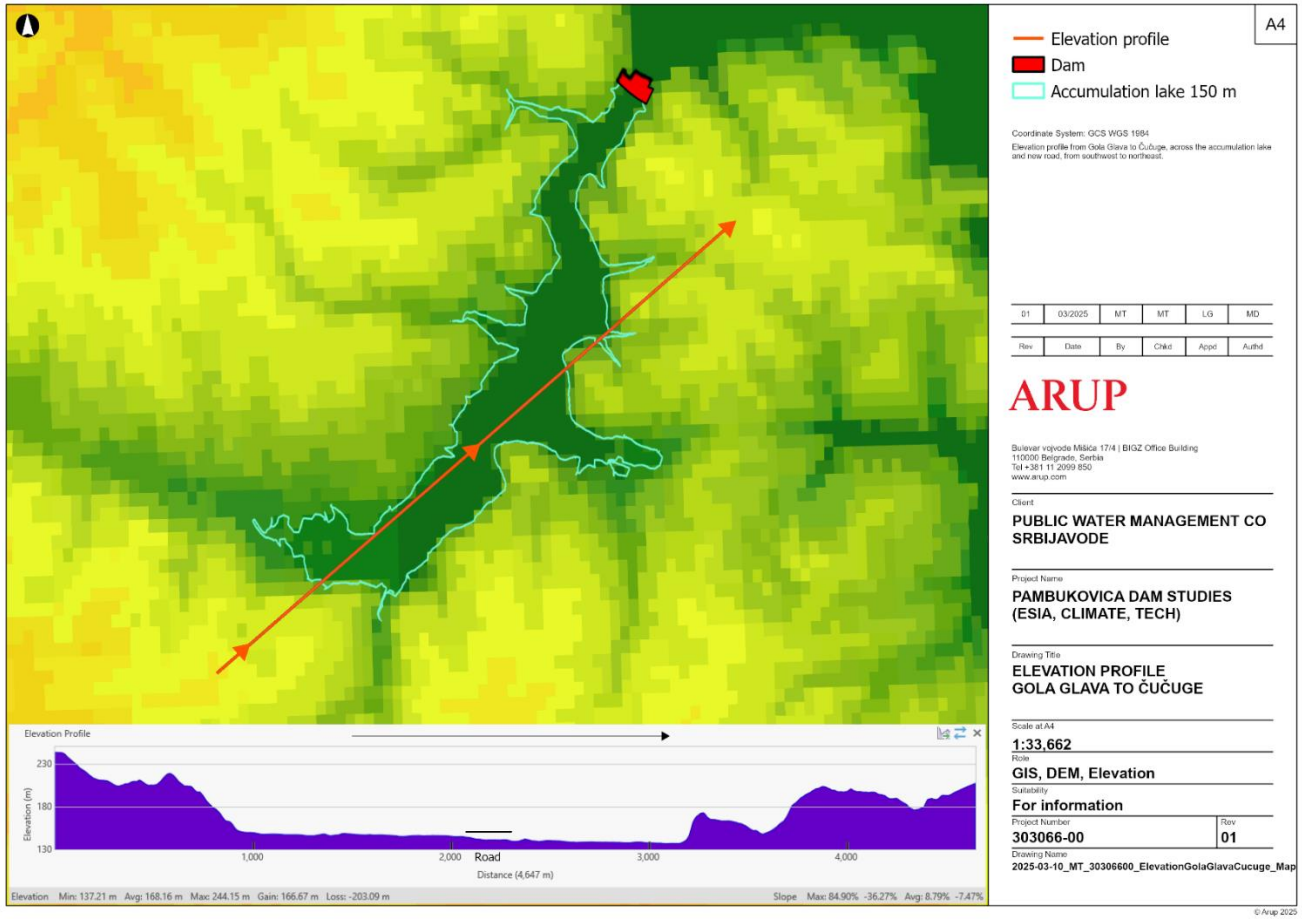

Figure 31 - Elevation profile – Gola Glava to Čučuge

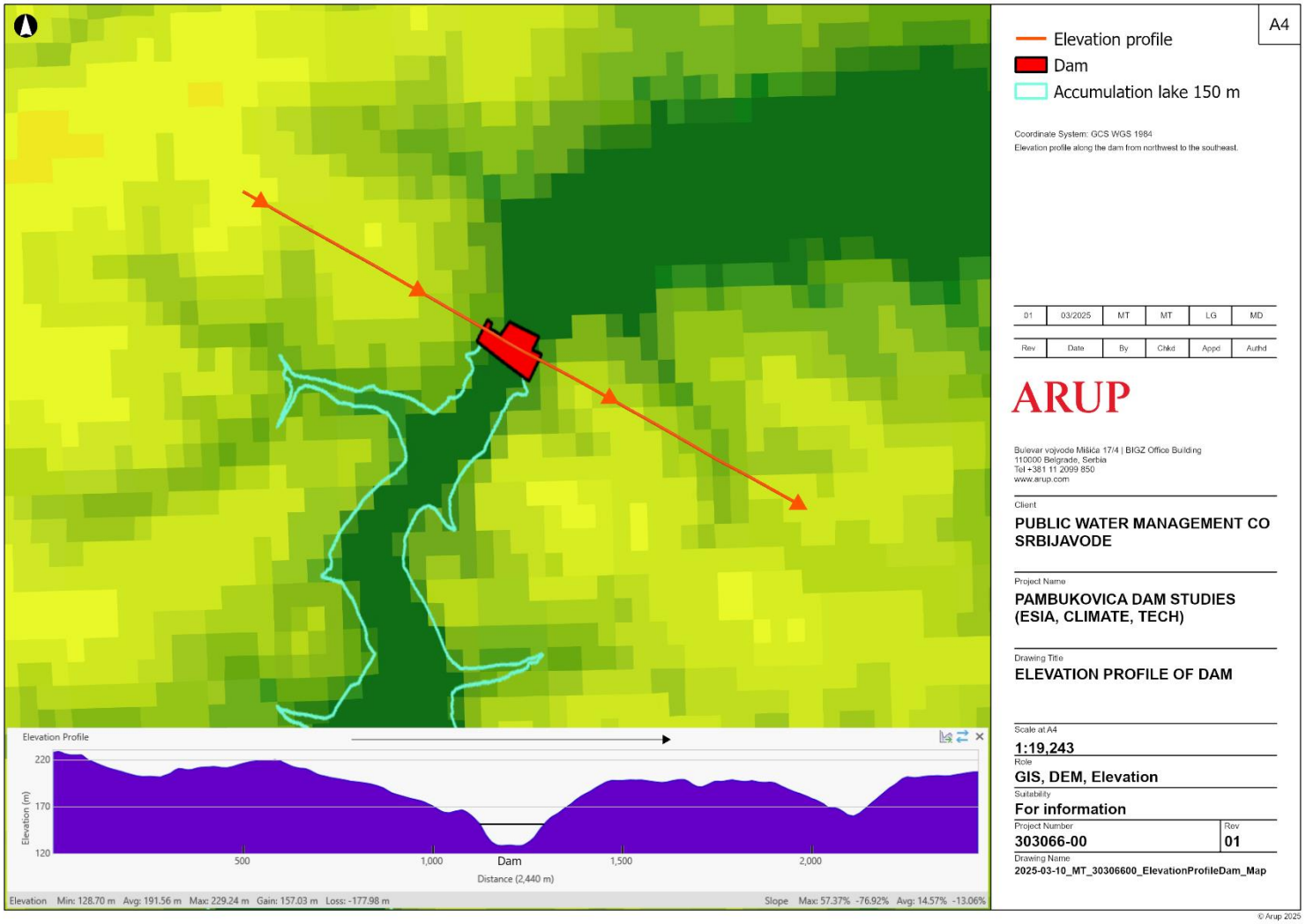

Figure 32 - Elevation profile of the DAM

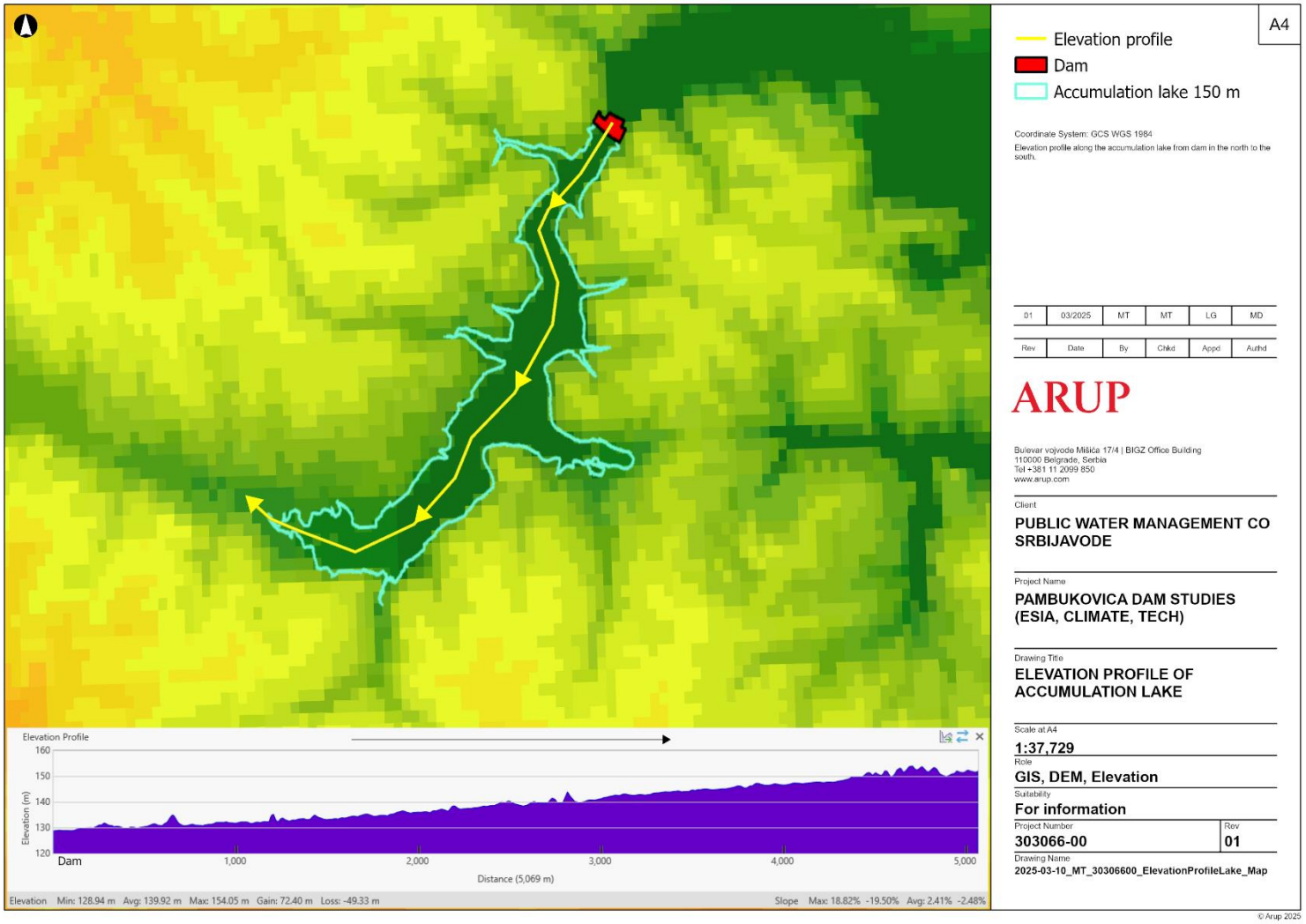

Figure 33 - Elevation profile of accumulation lake

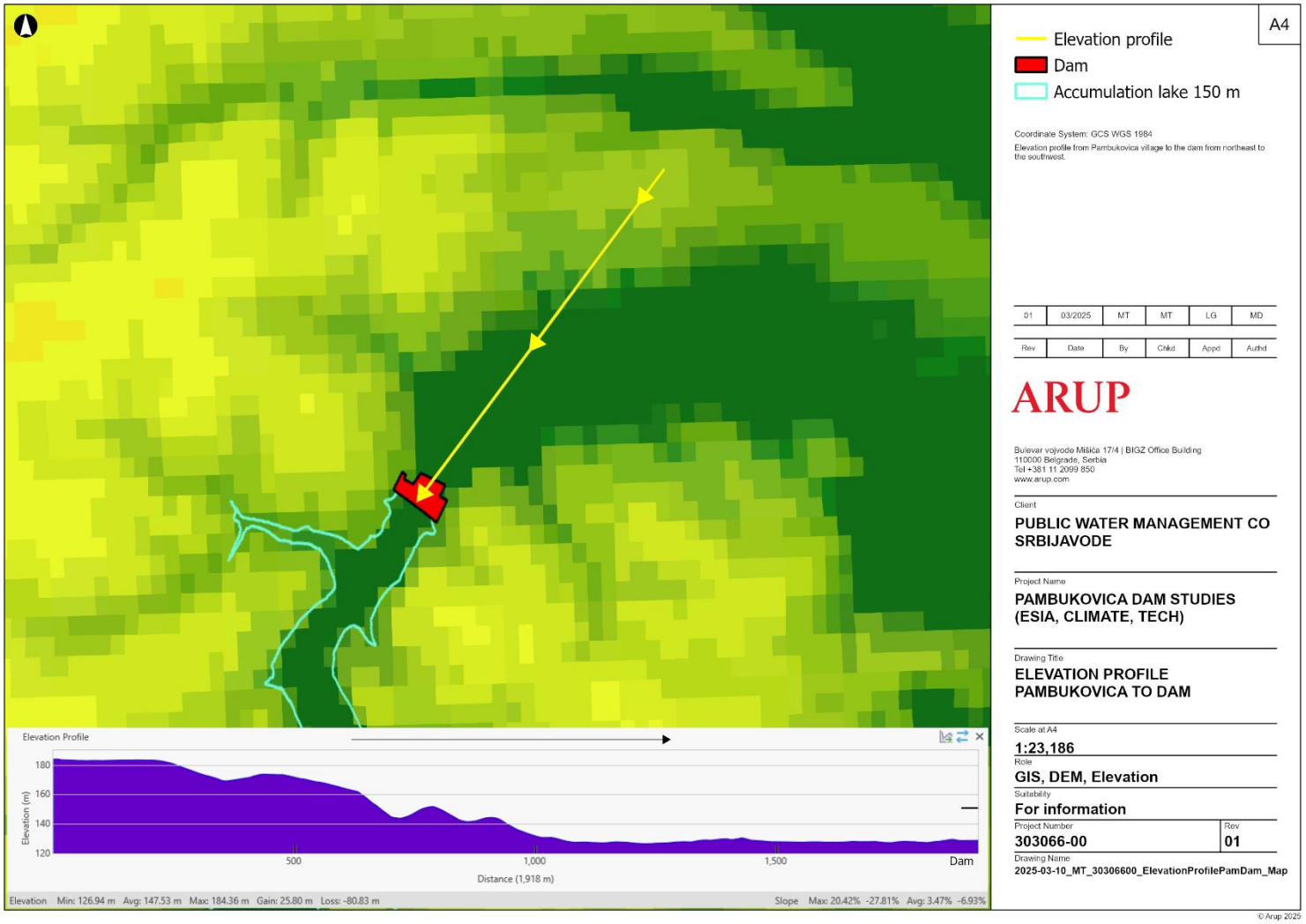

Figure 34 - Elevation profile – from Pambukovica to DAM

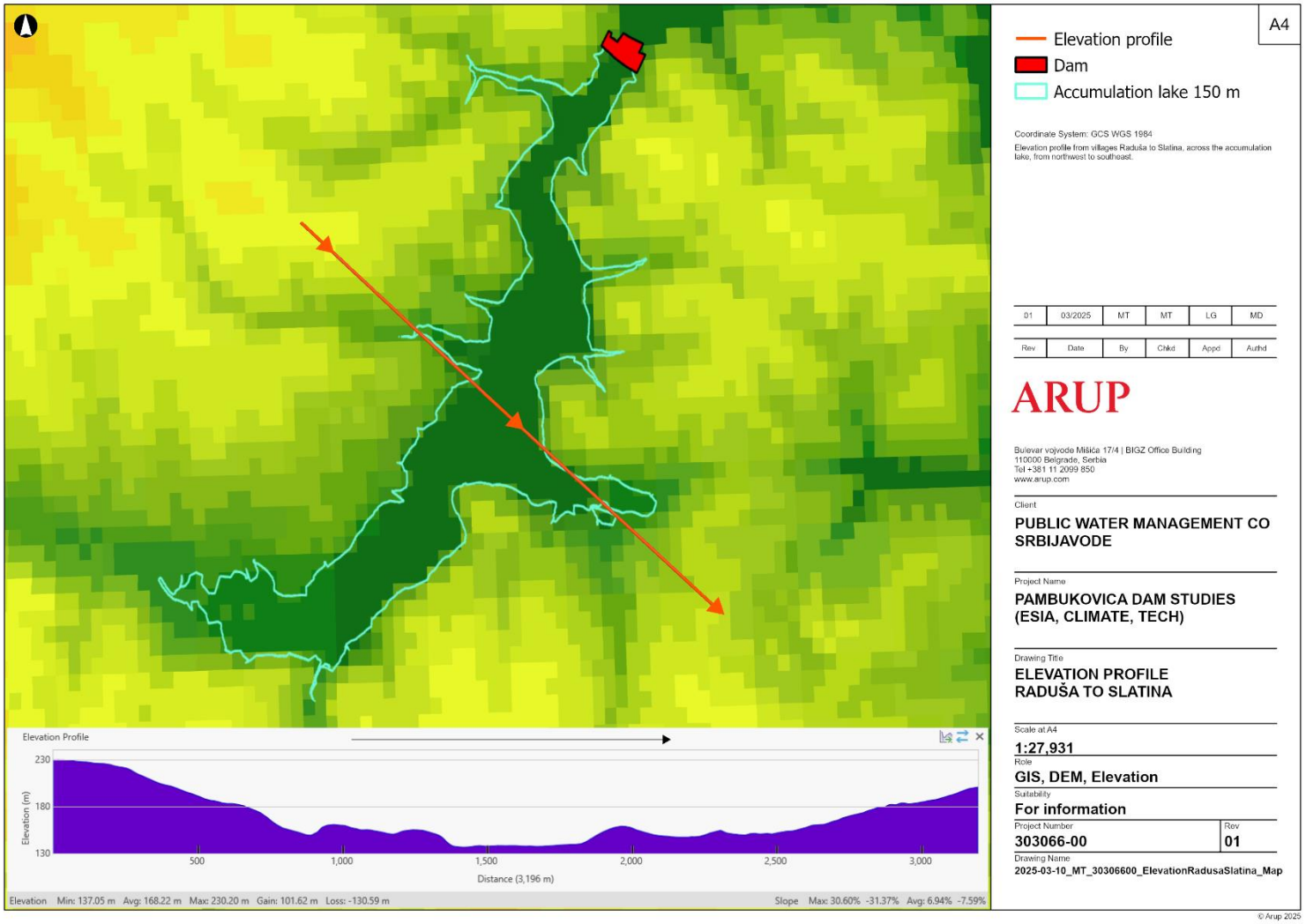

Figure 35 - Elevation profile – from Raduša to Slatina

The project area includes several cultural heritage sites, such as churches, monasteries, and archaeological locations of historical significance. Notable sites within Ub Municipality include the 15th-century Dokmir Monastery and various archaeological findings from the Vinča, Roman, and medieval periods. The Detailed Regulation Plan for the Pambukovica Dam also recognizes remains of a medieval Orthodox church in Raduša, an Eneolithic settlement in Slatina, and two medieval *stećak* tombstones on the river's left bank.

The second phase of the project involves the construction of an irrigation network to support agricultural development within Ub Municipality, following the completion of the dam and reservoir.

Figure 36 below shows the irrigation network that will be developed after the completion of Phase 1.

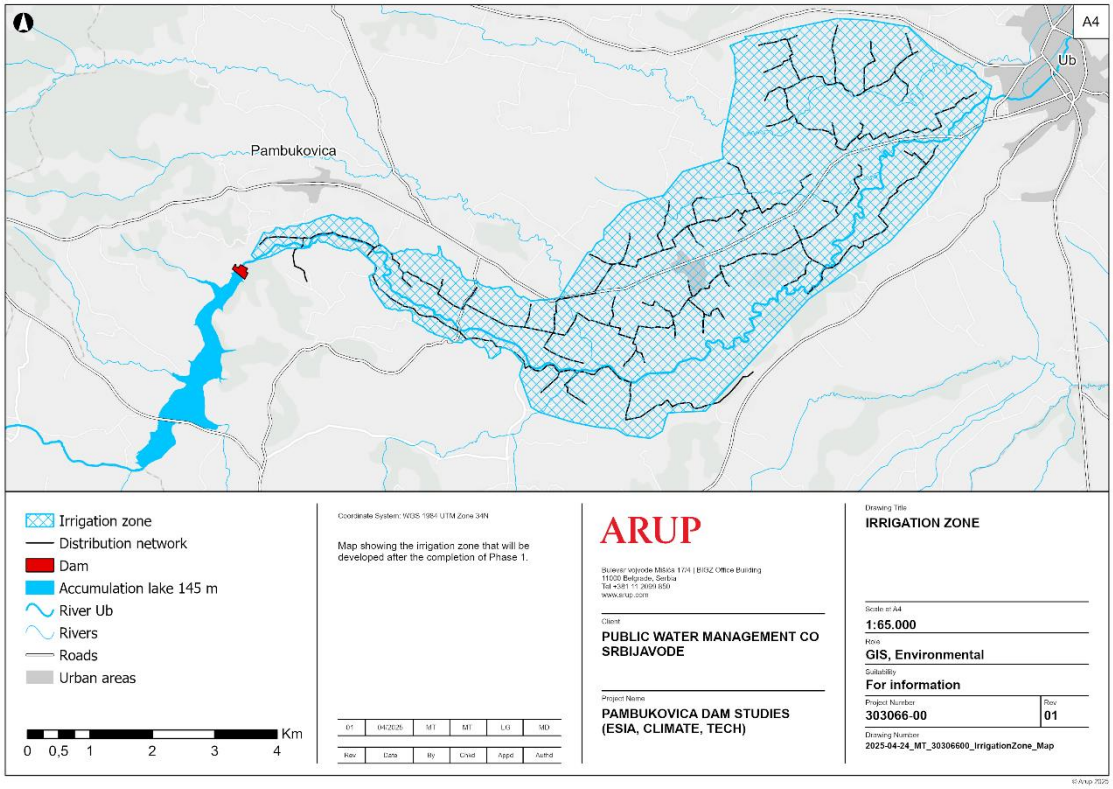

Figure 36 - Phase 2 of the project, irrigation zone

9.6 Receptors

The surrounding landscape of Project area consists of a river valley setting with agricultural fields, scattered settlements, and transport infrastructure. The project will transform the existing landscape, introducing new landscape receptors, including the reservoir, embankments, access roads, and irrigation network. These changes will impact not only individual elements, such as rivers and buildings, but also broader aesthetic characteristics like tranquillity, openness, and rural character.

In addition to physical landscape changes, the dam and its reservoir will significantly alter visual receptors' experiences. These receptors include:

- Residents of nearby settlements such as Pambukovica, Radusa, and Gola Glava, who will experience changes in their visual environment.

- Users of transport routes, including travelers on State Road No. 21 and local roads, who will encounter new visual features along their routes.
- Recreational users in the area, such as walkers, cyclists, and visitors, whose perception of the landscape may be influenced by the presence of the dam and reservoir.
- Workers in agricultural areas, where the irrigation network and associated infrastructure will introduce additional industrial and engineered elements into the landscape.

9.7 Project Activities and Identification of Impacts

In the context of the Pambukovica dam project, it is essential to consider the visual and landscape impacts of the planned activities. This chapter outlines the key project activities and identifies their potential effects on the surrounding environment, focusing on the construction of the dam, the formation of the reservoir, and the associated infrastructure developments.

9.7.1 Pre-construction

During the pre-construction only limited activities will be executed, including land surveying and site marking to establish construction boundaries and mark key locations for project infrastructure, including the dam site, access roads, and temporary facilities. These are expected to have negligible impact.

9.7.2 Construction

The dam will be an earth-fill embankment with a central clay core, filter zones, and supporting bodies made from mixed coarse and fine-grained materials. The dam's crest elevation will be 150.50 meters above sea level, with a length of 208 meters and a width of 8 meters at the crest.

The construction of the Pambukovica dam will involve significant earthworks and the creation of a large embankment structure.

Initial land clearance, particularly in areas designated for construction activities and reservoir flooding, will lead to the first noticeable visual alterations in the landscape.

Conducting geological and geotechnical investigations that may temporarily disturb the visual appearance of the terrain are also expected in the early phases of construction.

The construction of access roads will be necessary for the movement of machinery and transport vehicles, leading to changes in the terrain and vegetation.

The diversion of the Ub River during the construction of the dam will temporarily alter the river's natural flow and landscape.

The formation of the reservoir will have a normal water level at an elevation of 145.50 meters, covering an area of 129 hectares and extending approximately 4 kilometers upstream. Before the area is flooded, vegetation and topsoil will be removed, so the landscape will already be changed before the reservoir is filled. These changes will result in significant and permanent alterations to the visual and ecological landscape.

The formation of the dam structure will also result in permanent and significant visual and landscape changes in the area. The presence of a large built structure in a predominantly natural or rural setting will alter the character of the landscape and affect its visual perception from various viewpoints.

The relocation of a portion of the state road Valjevo - Šabac, approximately 900 meters long, will involve significant earthworks and will cause permanent changes to the existing road infrastructure, further causing visual and landscape impact.

The regulation of the riverbed downstream of the dam will ensure proper water flow after the dam's construction, involving excavation and the creation of a trapezoidal channel lined with stone, altering the natural riverbed.

Some deposit areas and quarries are located within the future reservoir footprint, meaning they will be submerged and no longer visible after the project's completion. However, other deposit sites and quarries that might be used for the project purpose are situated in the surrounding landscape. Their potential use might be resulting in longer-term visual and landscape effects. The selection and restoration (after use) of these sites will be crucial in minimizing potential impacts.

9.7.3 Operation

During the operational phase, the most significant landscape and visual impacts will be associated with the presence of the dam, the newly formed reservoir, and the associated infrastructure, including the elevated roadway crossing over the reservoir.

Although operation phase activities itself does not result in any impacts, completion of the construction and formation of the reservoir introduces long-term alterations to the landscape.

9.7.4 Decommissioning

The Pambukovica Dam and its associated infrastructure are designed for long-term operation. However, if the dam were to be decommissioned in the future, the process would involve the removal or modification of key structures, including the dam itself, the reservoir, access roads, and any auxiliary facilities.

9.8 Impact Assessment and Mitigation

The Project activities and the Project itself will produce both temporary and permanent impacts.

Temporary impacts during the construction can be actively limited and mitigated.

However, completion of the construction (the Project itself) will result in permanent landscape and visual changes, with significant modifications to the area's topography and visibility from key receptors. This will redefine the visual character of the area, previously predominantly natural and agricultural surroundings, influencing significantly how key receptors, such as residents, road users, and recreational visitors, perceive the transformed environment.

The transformation of the valley into a water body will create a reflective surface that contrasts with the existing land cover, making it a visually dominant feature in the area.

The most pronounced visual changes will be experienced from elevated locations and open vantage points where the reservoir and dam will be clearly visible.

To assess the extent of these changes, specific viewpoints have been selected based on the topographical characteristics and receptor locations, ensuring a comprehensive evaluation of the project's visual impact.

The Zone of Theoretical Visibility (ZTV)

The Zone of Theoretical Visibility (ZTV) represents the area from which a structure or landscape modification is theoretically visible, based on terrain elevation and observer height, without considering vegetation or built obstructions. It is a key tool in visual impact assessments, helping to determine how prominently a project will be perceived from different locations.

For the Pambukovica Dam visual impact analysis, five reference points were selected for the ZTV model development to evaluate visibility from key receptors, considering the terrain characteristics and elevation of both the dam and the future reservoir. These points were selected to capture the main visual changes introduced by the project, particularly the formation of the reservoir and the new vertical structures. The selection process was informed by site visits, terrain analysis, and the identification of key receptors likely to

experience significant visual changes. Reference points are distributed to cover whole project: three points at the future reservoir elevation 145.5 m (which is expected to be the designed water level of the accumulation), one at the planned dam crest, and one at the section of the existing road that will be elevated as part of the project. Based on these points, ZTV maps were developed to illustrate the terrain's topology and spatial relationships, identifying locations from which the planned structures will be visible.

In the analysis, a buffer of 5 km and 10 km from the selected reference points was marked, representing the average distance within which the project is expected to have a significant impact on the landscape and visual characteristics of the surroundings. This approach allows for an assessment of how the construction of the dam and the formation of the reservoir will alter the perception of the landscape from different viewpoints and for key visual receptors. The following pictures present ZTV maps, providing a detailed insight into the potential visibility of the project from various locations within the broader area.

In accordance with the expected visual impacts and topographic analysis, reference viewpoints have been selected to compare the existing terrain and visual perspectives with projections of the post-construction landscape. These viewpoints serve as a basis for assessing how the dam structure, the reservoir, and the elevated roadway integrate into the surrounding environment.

- **Dam Structure** – As a dominant feature in the valley, the dam introduces a significant vertical and horizontal element, altering views from multiple locations. Its visibility will be most pronounced from elevated areas and open viewpoints along nearby roads and settlements. The visual assessment considers how the dam contrasts with the surrounding natural terrain and whether mitigation measures, such as vegetation buffers, can help integrate it into the landscape.
- **Reservoir** – The formation of the reservoir will lead to a fundamental transformation of the valley's visual characteristics. The existing mosaic of agricultural land, riparian vegetation, and natural riverbanks will be replaced by an expansive water surface. Seasonal water level fluctuations may expose transitional shorelines, which could contrast with surrounding land cover. The visual assessment evaluates how these changes are perceived from key observation points and whether natural vegetation or landform adaptation can help soften the transition.
- **Elevated Roadway** – The modification of the existing road and its extension across the reservoir will introduce a linear infrastructure element, changing how movement through the landscape is experienced. This will be particularly noticeable from higher elevations and along road corridors where the road's continuity and visibility across the water are prominent. The potential impact of vehicle movement, guardrails, and any nighttime lighting is also considered in the context of maintaining the rural character of the area.

To systematically assess the extent of these visual changes, five key reference points were selected: one at the dam location, one at the site of the future elevated roadway, and three distributed across the reservoir surface at an elevation of 145.5 m, which represents the expected maximum water level. ZTV maps have been developed to illustrate the topography and identify the areas from which these reference points are visible.

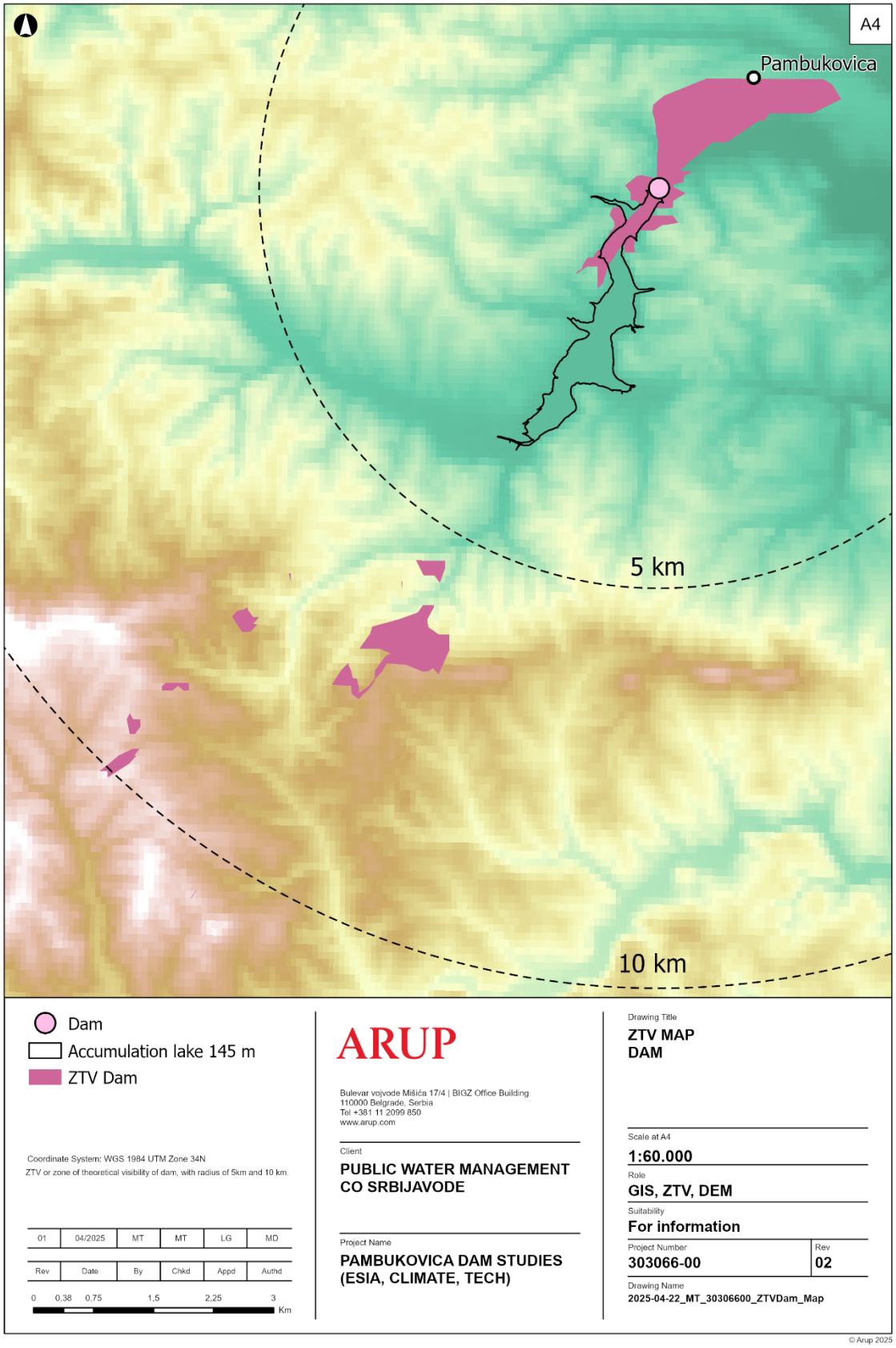

Figure 37 - ZTV Map – Dam / Dam crest

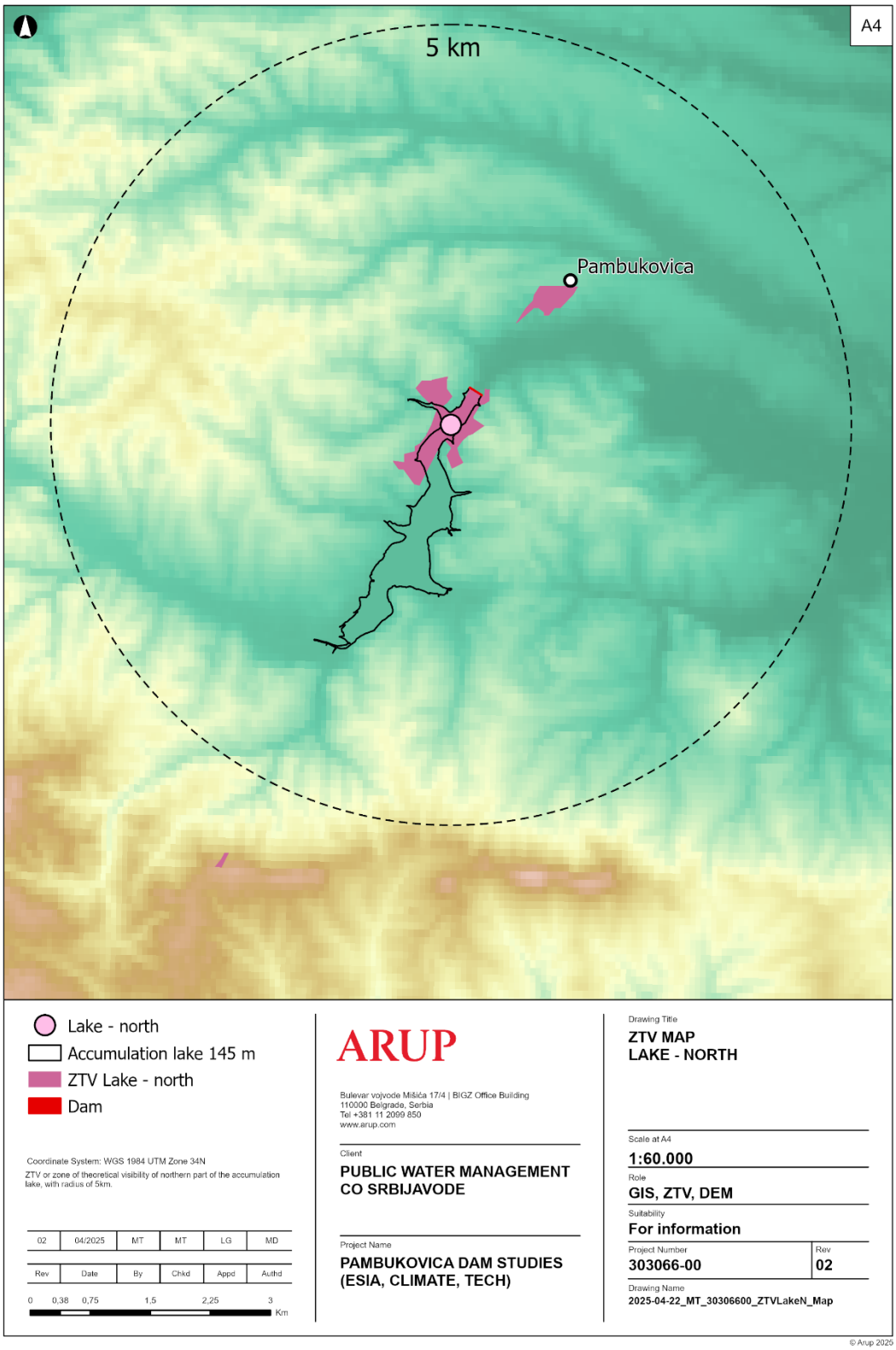

Figure 38 - ZTV Map – Lake North

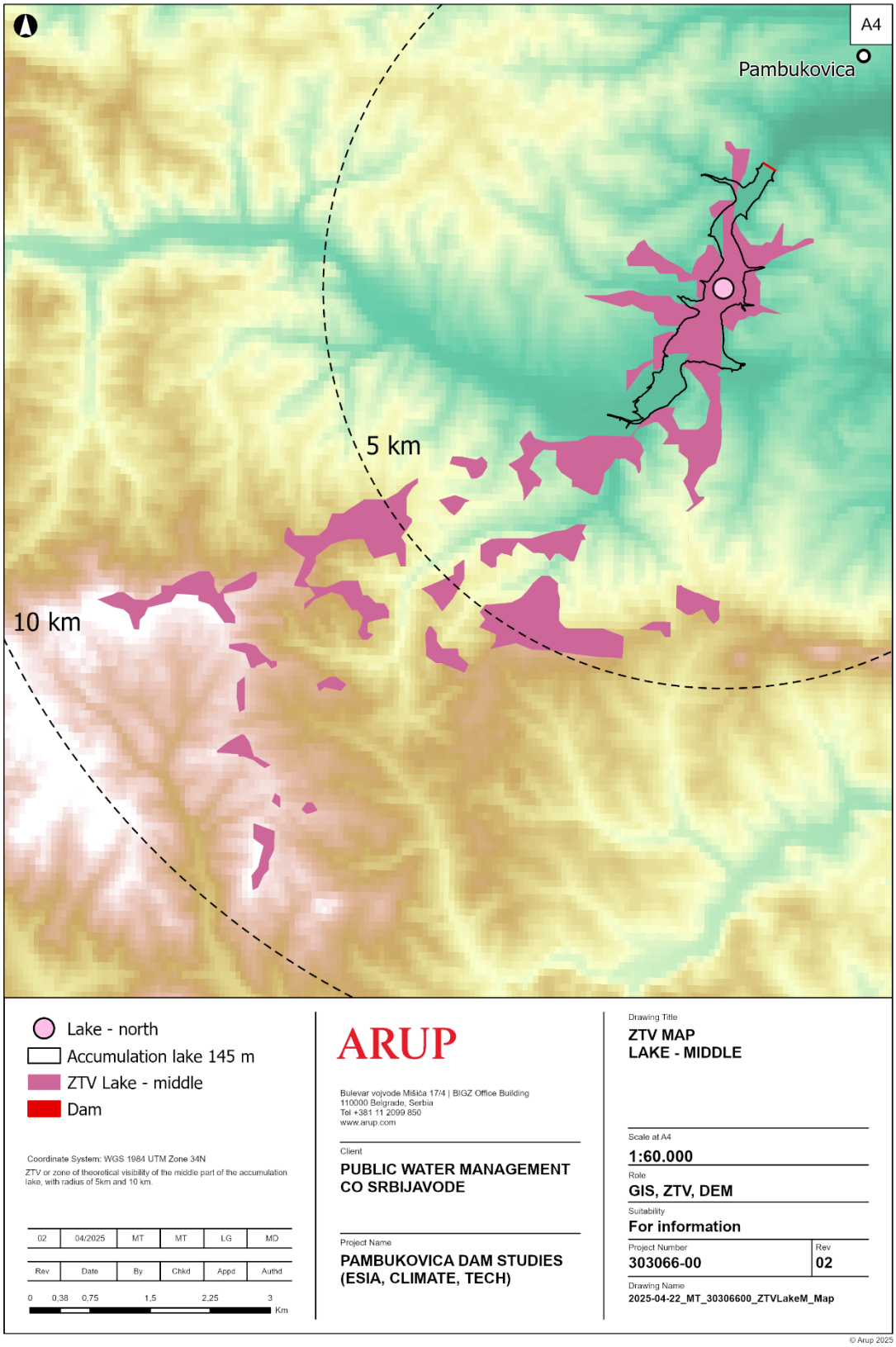

Figure 39 - ZTV Map – Lake Middle

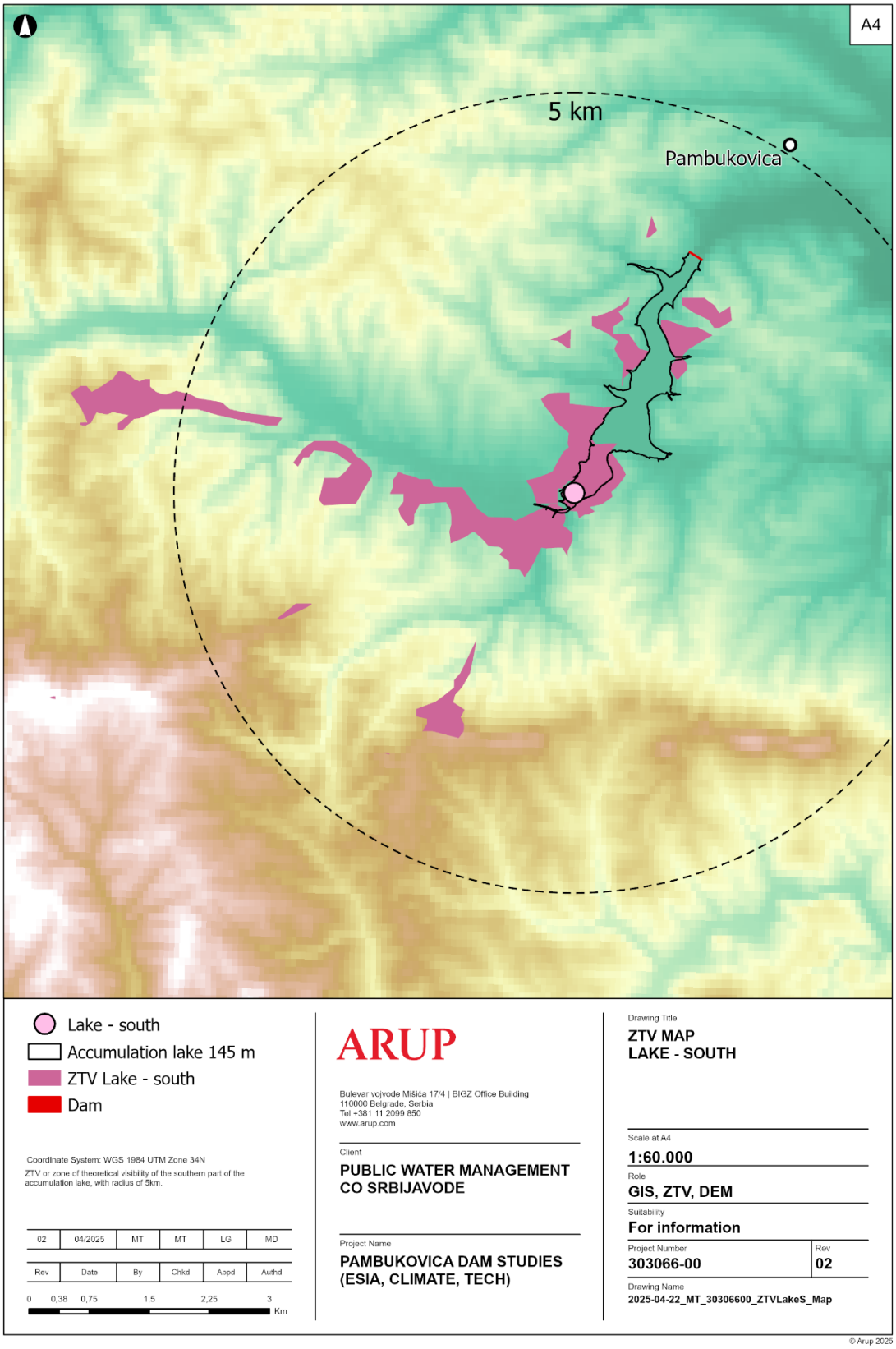

Figure 40 - ZTV Map – Lake South

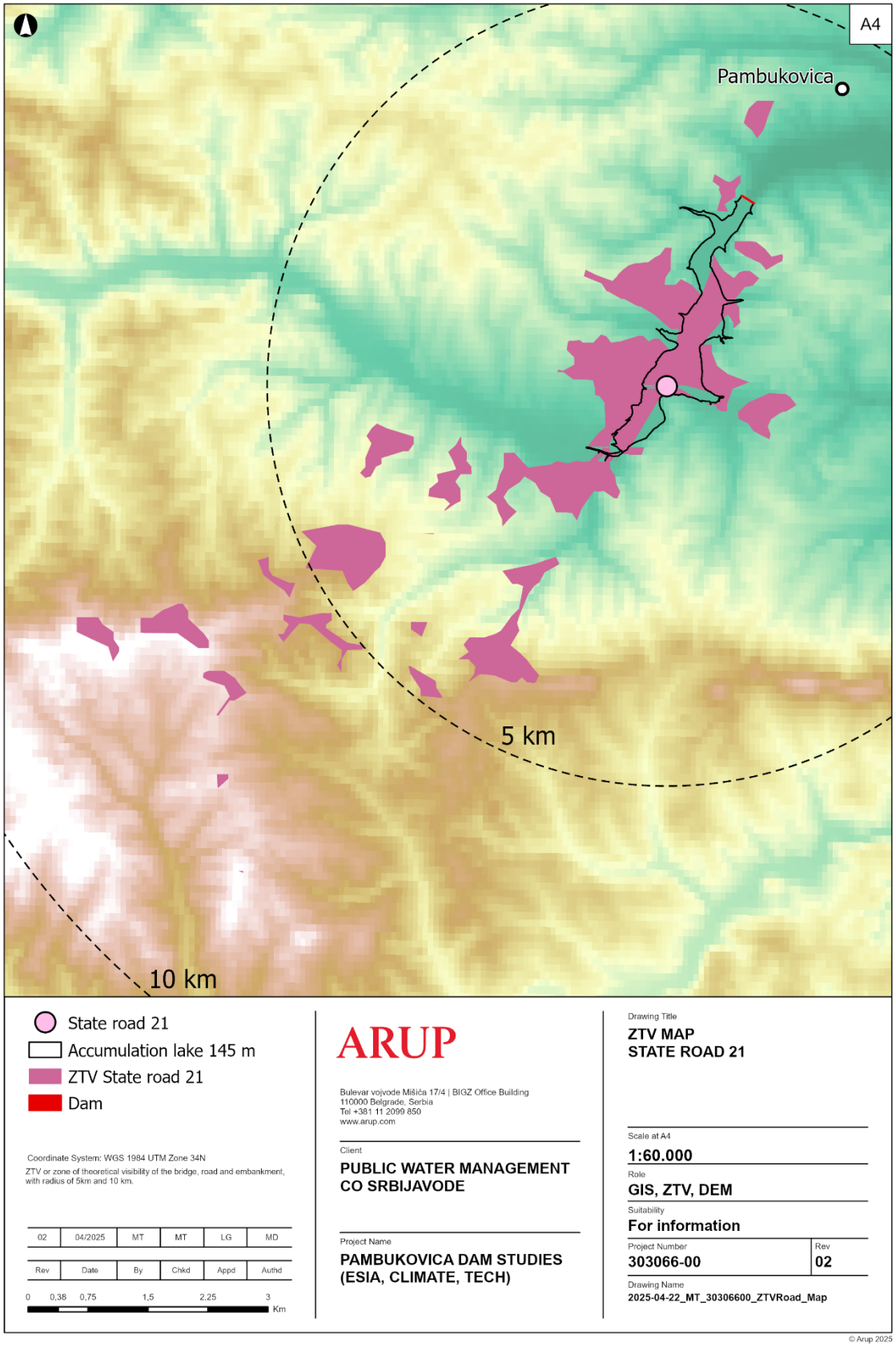

Figure 41 - ZTV Map – State Road IB no. 21

A buffer of 5 km and 10 km around the selected reference points has been considered as a representative range for evaluating the project's visual influence. This range aligns with typical visibility assessments for infrastructure projects of this scale and reflects the average distances within which the dam and reservoir will have a noticeable impact on the landscape.

The following conclusions can be drawn from the ZTV results:

- The dam crest and intake tower will be the most visually prominent elements due to their elevation and contrast with the natural landscape. These structures will be visible from elevated viewpoints in the surrounding hills and from certain sections of access roads.
- The reservoir, as a large reflective water surface, will be visible from multiple locations along the valley, particularly from higher elevations. However, its visual prominence will be influenced by seasonal water level variations and surrounding vegetation cover.
- Lower-lying areas within the project vicinity, particularly within the river valley, will have limited views of the dam structure itself due to topographical screening, though parts of the reservoir may still be visible.
- The presence of existing landforms, vegetation, and built structures will play a role in filtering views from some receptors, reducing the perceived extent of visual change.

The ZTV results provide an essential basis for selecting representative viewpoints for further assessment. These viewpoints enable a more detailed evaluation of how the project integrates into the landscape and the extent of potential mitigation measures required to minimize visual intrusion. The following map presents the cumulative ZTV for the previously selected points and will be considered the area of interest for further assessment.

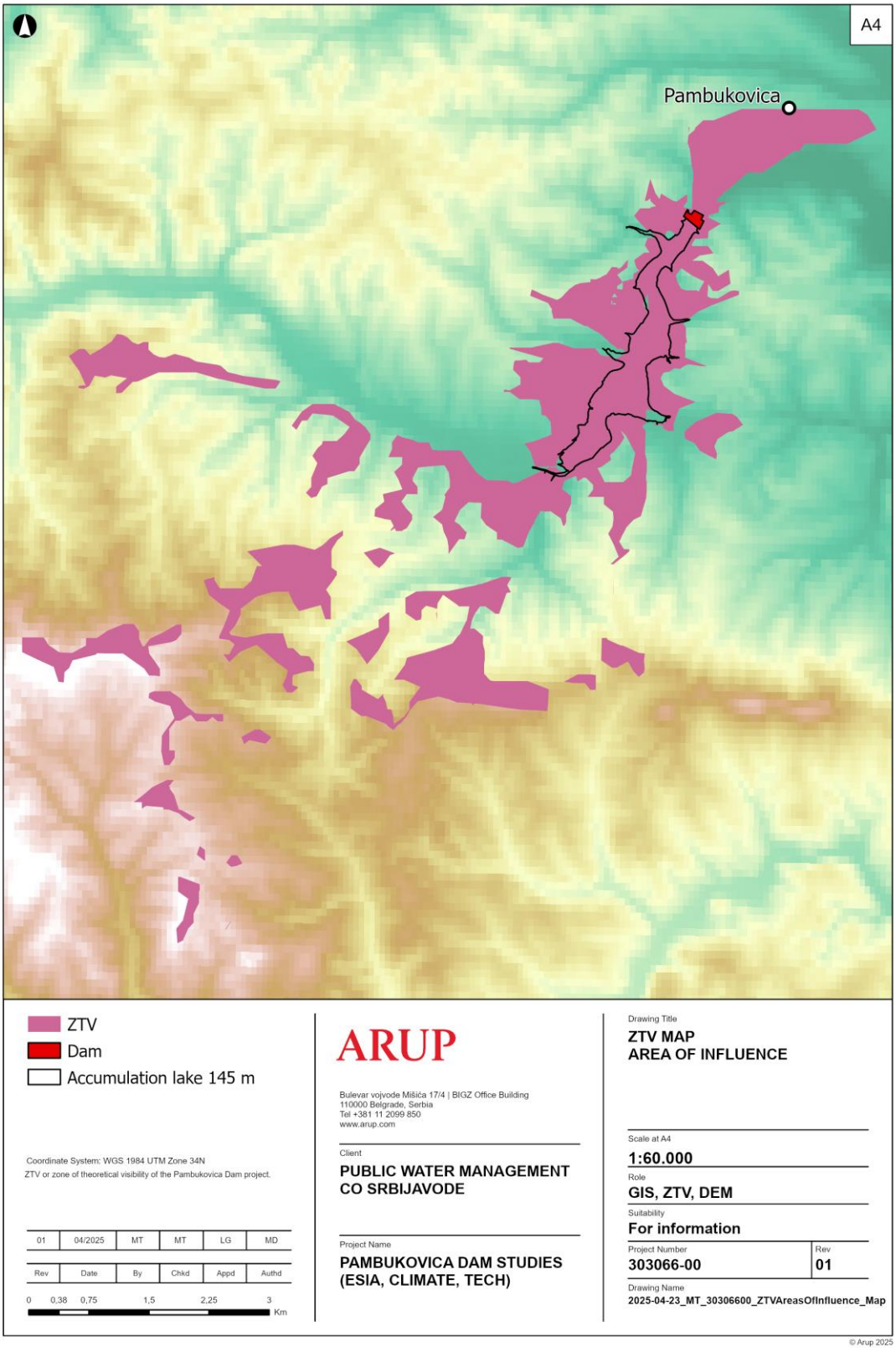

Figure 42 - Cumulative ZTV map (Area of influence)

Viewpoints – Landscape and Visual

Viewpoints relevant to the landscape and visual assessment have been selected based on site investigations and their significance to key visual receptors. The primary factors considered in this selection include the visibility of the project components, the distance from the dam and reservoir, the sensitivity of the affected landscape, and the presence of key receptors such as residential areas, cultural heritage sites, transportation corridors, and agricultural land.

The viewpoints were chosen to represent a range of perspectives, including those from elevated positions overlooking the project site, locations at mid-range distances where the dam and reservoir will be partially visible, and closer viewpoints where construction activities and permanent structures will have the most significant visual impact. Particular attention was given to locations where the project may alter the visual character of the landscape, such as river valleys, forested areas, and agricultural land. In selecting viewpoints, actual on-site conditions were considered, with emphasis on areas expected to experience greater visual change. Natural barriers such as forests and buildings, often not visible on elevation maps, were also considered during the site investigation, which may reduce the actual level of visual impact from Project experienced from certain areas. A map below illustrates selected viewpoints and their position in relation to project facilities.

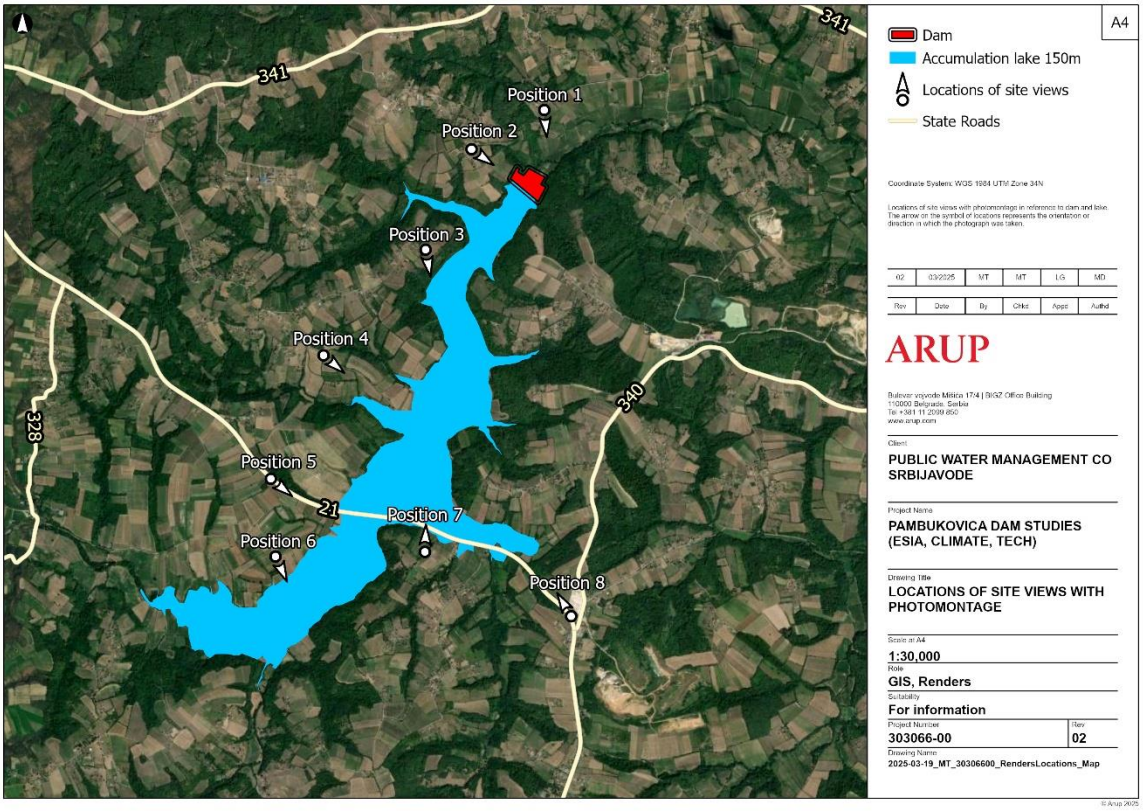

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Figure 43 - Map of the viewpoint taken into consideration during the impact assessment

Points were selected based on the combination of the spatial distribution of relevant receptors within the Area of Interest (AoI), as defined by the outputs of the ZTV modelling. Relevant model is presented at the following map:

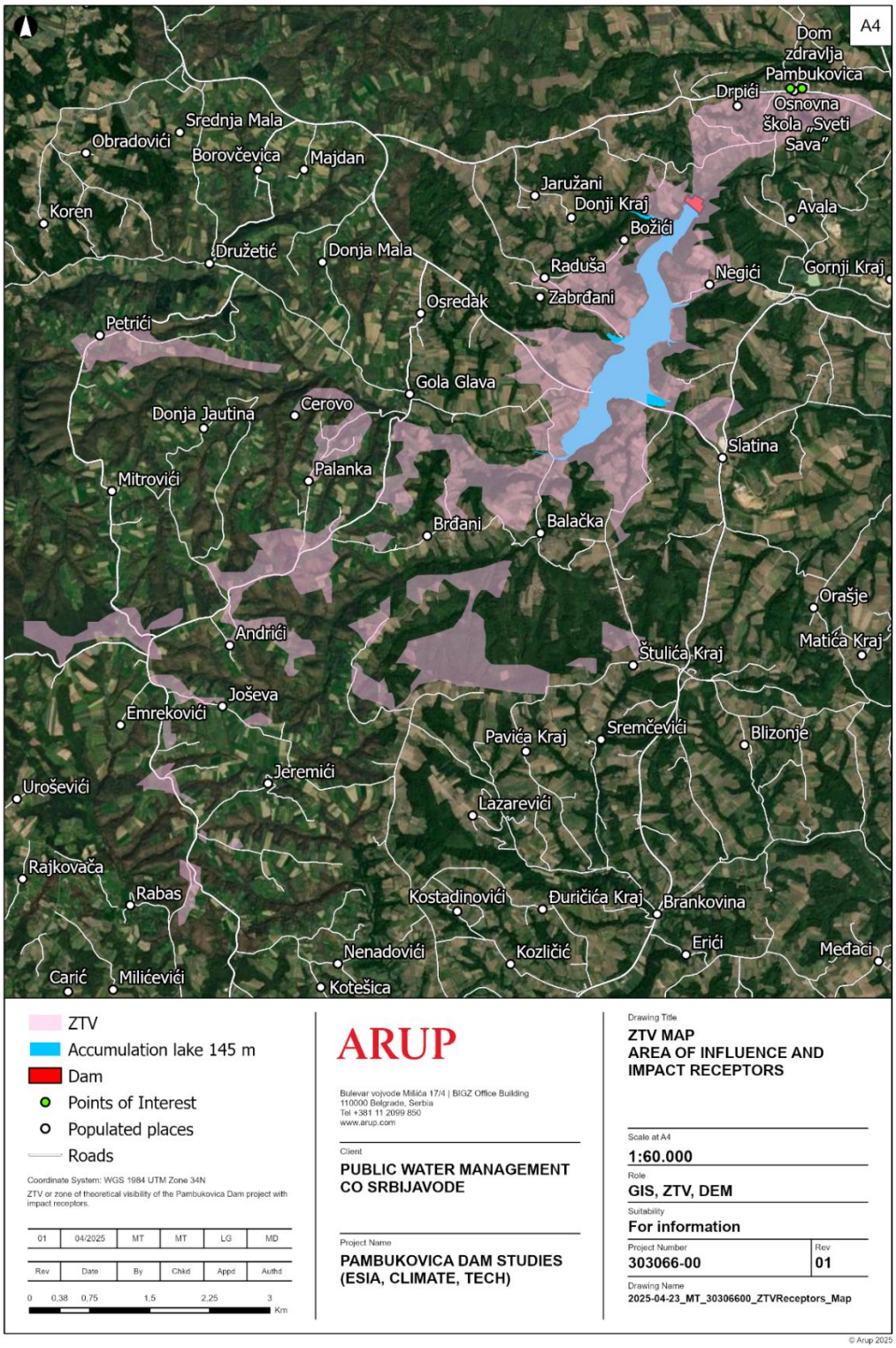

Figure 44 - Map of L&V Area of influence with impact receptors

In the following section, baseline imagery from the selected viewpoints will be presented to establish a reference for the existing visual characteristics of the landscape. These baseline conditions will provide a foundation for assessing potential modifications to visibility and landscape composition resulting from the project. Additionally, predictive visual simulations will be included to illustrate anticipated changes in views

from these locations upon project completion. These visual projections will support the evaluation of potential impacts and the effectiveness of proposed mitigation strategies.

Picture 2 - Position 1-Baseline

Picture 3 - Position 1 - Photomontage

Picture 4 - Position 2 – Baseline

Picture 5 - Position 2 – Photomontage

Picture 6 - Position 3 – Baseline

Picture 7 - Position 3 – Photomontage

Picture 8 - Position 4 – Baseline

Picture 9 - Position 4 – Photomontage

Picture 10 - Position 5 – Baseline

Picture 11 - Position 5 – Photomontage

Picture 12 - Position 6 – Baseline

Picture 13 - Position 6 - Photomontage

Picture 14 - Position 7 - Baseline

Picture 15 - Position 7 – Photomontage

Picture 16 - Position 8 – Baseline

Picture 17 - Position 8 - Photomontage

Decommissioning

The impacts of potential decommissioning would be similar in magnitude to those experienced during the construction phase, primarily due to large-scale earthworks, material removal, and landscape alterations.

The most significant impact would be the controlled release or redirection of stored water, which would drastically alter the valley's visual and ecological character. The former reservoir area would transition into a new landform, with sediment deposition patterns shaping the terrain. The removal or modification of the dam structure would restore natural river flow, though the surrounding landscape would take time to stabilize.

Access roads constructed for the project may either be removed or repurposed for public or private use, depending on regional infrastructure needs. Any remaining structures, such as intake facilities and spillways, would be either dismantled or integrated into a post-decommissioning land-use plan.

Temporary disruptions due to machinery, excavation, and dust generation would be managed through mitigation measures like those applied during the construction phase.

Following the completion of decommissioning activities, the area would undergo a restoration process aimed at reintegrating it into the natural environment.

This may involve reforestation, soil stabilization, and the reintroduction of native vegetation to support ecological recovery. Upon full restoration, impacts on landscape character would diminish, ultimately returning the area to a state resembling its pre-dam condition.

Mitigation measures

Proposed mitigation measures include:

- Final dam design to blend with the surrounding natural gradients and elevations, ensuring that the dam integrates smoothly with the existing topography.
- Consideration of final slopes and exposed rock faces in quarries (if used) may be essential, as selective blasting and slope grading can help create a more natural appearance and support the establishment of vegetation, thereby reducing the prominence of these landscape alterations.
- Restoring areas affected during construction with native trees and shrubs, along with appropriate ground cover such as grass or wildflower mixes, will help soften the visual impact and promote long-term landscape recovery.
- Planting of trees in the buffer zone may reduce the level of visual and landscape impact for some receptors, while also provide opportunity for restoring habitat loss.

By implementing these measures, the project can better integrate affected areas into the existing landscape, reducing its long-term visual and landscape impact while working towards the ecological integrity of the surrounding environment.

Table 22 - Impact Assessment Table – Landscape and Visual

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
Modification of valley landscape due to dam construction	The dam will introduce a large vertical and horizontal structure, altering the natural valley setting and becoming a dominant landscape feature.	Residents in nearby settlements, road users, and visitors	High	Medium	Major	Visual integration through landscaping and vegetation buffers at the base of the dam	Medium (Permanent)
Transformation of the valley due to reservoir formation	The replacement of natural riverbanks, agricultural land, and vegetation with a large water body will significantly alter the landscape's visual character.	Local communities, landowners, recreational users	High	Medium	Major	Preservation of existing vegetation along the reservoir edges, controlled shore stabilization, and design measures to maintain visual harmony with surrounding landforms	Medium (Permanent)
Change in visibility of project elements (dam, reservoir, roadway)	Long-range visual impact due to elevated structures and open water surface, particularly from higher terrain and road networks.	Viewpoints from settlements, road networks, and hills	High	Medium	Major	Use of natural materials for final dam design, adaptive design for road infrastructure, and strategic placement of reforested areas to reduce contrasts	Medium (Permanent)
Elevated roadway introducing a linear infrastructure element	The road crossing the reservoir will be a noticeable new element in the landscape, altering	Road users, nearby residents	Medium	Medium	Moderate	Design adjustments to blend the roadway into the landscape,	Minor (Permanent)

Type of Impact	Impact Description	Receptor	Impact Magnitude	Sensitivity of the Receptor	Impact Significance (pre – mitigation)	Mitigation	Residual Impact Significance
	perceptions of movement through the area.					use of minimalistic lighting	
Seasonal fluctuations in reservoir water level	Exposure of transitional shorelines during dry periods may create visually contrasting features.	Local communities, recreational users	Medium	Medium	Moderate	Natural shoreline restoration, stabilization with native vegetation, and adaptive land-use planning	Minor
Nighttime visibility of infrastructure	Artificial lighting on the roadway, dam facilities and dam structure could introduce visual disturbance in an otherwise low-light environment.	Residents in proximity, wildlife	Medium	Medium	Moderate	Use of downward-shielded lighting to reduce glare and visual impact	Minor (Permanent)

Table 23 - Mitigation and Monitoring – Landscape and visual

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Landscape Impact	The dam construction will alter the valley's landscape, adding significant vertical and horizontal structures. The reservoir formation will replace agricultural land, vegetation, and riverbanks with a large water body.	Local communities, road users, recreational users	- Dam design integration with natural surroundings (colour, texture) - Vegetation buffers at the dam base - Preservation of existing vegetation where possible - Controlled stabilization of reservoir shoreline	Design (Definition) Construction (Implementation) Operation (Maintenance)

Type of Impact	Impact Description	Receptor	Mitigation, Management or Monitoring Measure	Timeframe / Frequency / Deadline / Phase
Visual Impact	Visibility changes in project elements (dam, reservoir, roadway) cause visual impact due to elevated structures and open water surfaces.	Viewpoints from settlements, road networks, and hills	- Use of natural materials in dam design (landscaping) - Adaptive road infrastructure design - Reforestation to minimize visual contrast	Design (Definition) Construction (Implementation) Operation (Maintenance)
Visual and Landscape Impact	The elevated roadway will introduce a linear infrastructure element. The road crossing the reservoir will change the way movement through the area is perceived.	Road users, nearby residents	- Roadside landscaping with native species - Minimalistic light-reflecting materials - Regular monitoring of infrastructure condition	Design (Definition) Construction Phase (implementation) Operation (Maintenance)
Visual and Landscape Impact	Seasonal changes in reservoir water levels can expose shorelines, creating visually contrasting features.	Local communities, recreational users	- Natural shoreline restoration with native plants - Adaptive land-use planning to integrate fluctuating shorelines - Regular monitoring of the impact of fluctuation on shoreline damage/impact	Design (Definition, land-use planning) Operation Phase (Monitoring & Restoration)
Visual Impact	Artificial lighting on the roadway and dam may cause visual disturbance.	Residents in proximity, wildlife	- Use of downward-shielded lighting	Design Phase (Definition) Construction Phase (Installation) Operation (Maintenance)