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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

Project Description

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Abbreviatons

Abbreviation	Definition
CIA	Cumulative Impact Assessment
CRO	Climate Resilience Outcomes
E&S	Environmental and Social
EBRD	European Bank for Reconstruction and Development
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FIDIC	Fédération Internationale Des Ingénieurs-Conseils
FSL	Full Supply Level
GEP	Guaranteed National (Serbian) Ecological Flow
GET	Green Economy Transition
GHG	Greenhouse Gas
GMS	Ground Meteorological Station
IPCC	Intergovernmental Panel on Climate Change
MBTS	Metal-enclosed Box-type Transformer Station
NDC	Nationally Determined Contribution
PGD	Design for Construction Permit
PMF	Probable Maximum Flood
PWMC	Public Water Management Company
RHMS	Republic Hydrometeorological Service
WMD	Water Management Directorate

1. Overview

1.1 Project history

The Kolubara River basin in northwest Serbia is characterized by unfavourable water regimes and consequently has a long history of flood occurrences. Flood protection for the valley areas within the basin has always been a pressing issue, which has been confirmed through the Preliminary Flood Risk Assessment undertaken in 2012, in which the Kolubara basin was identified as significant at the national level in Serbia. The seriousness of the problem was highlighted by the flood in May 2014, when the population, economy, infrastructure, and natural resources along the Kolubara basin suffered significant damage. As a further step in the attempt to find a solution for this long-term issue, the Kolubara River Basin Catchment Study was prepared by Institute for Water Management Jaroslav Cerni in 2018, and it proposed Pambukovica dam as one of the retention dams.

PWMC proceeded with commissioning of relevant studies for the realisation of the Pambukovica Dam Project and the Design for the Construction Permit for Pambukovica Dam was prepared by "Energoprojekt-Hidroinženjering" in October 2023 in accordance with the Location Conditions issued by the Ministry of Construction, Transport, and Infrastructure in January 2023. The next step in the development of the Project design is preparation of the Design for Construction Execution (Projekat za izvođenje as per Serbian legislation. Closest equivalent level is Detailed Design). Design for Construction Execution is expected to be prepared by the future Contractor on the basis of the design and build contract (e.g. Yellow FIDIC). As per the information available at the moment, high level estimate for Design for Construction Execution to be completed in 2026.

Feasibility Study 2018 for the Pambukovica dam with a reservoir on the Ub river was developed by "Energoprojekt-Hidroinženjering". It elaborated technical solutions for the dam and accompanying structures and defined the estimated investment value required for project realization.

Conceptual Design has been revised in 2020 for the Pambukovica dam by "Energoprojekt-Hidroinženjering", Belgrade. This design analysed the proposed dam profile and defined its parameters and those of the future reservoir. Preliminary analyses confirmed the suitability of the proposed profile for the construction of the dam and the formation of the reservoir, taking into account all existing constraints and adhering to the set criteria.

Environmental Impact Assessment (Serbian legislation) has been issued in May 2020 and approved by Ministry of Environmental Protection in June 2020. EIA was publicly disclosed in November and December 2019, in line with requirements of the Serbian legislation. The assessment provides a detailed analysis of the baseline environmental conditions, including hydrological, geological, and ecological aspects. It also considers the socio-economic conditions of the local communities. The EIA also identifies and evaluates the potential impacts on various environmental components such as water quality, air quality, noise levels, biodiversity, and land use. It also assesses the social impacts on local communities, including potential displacement and changes in livelihoods. The ESMP (Environmental and Social Management Plan) is a crucial part of the EIA, detailing the implementation of mitigation measures, monitoring programs, and responsibilities of various stakeholders. It ensures that the project complies with environmental regulations and standards.

The Design for the Construction Permit has been developed by "Energoprojekt-Hidroinženjering" in 2023. It has been aligned with the measures from the Report on the Performed Expert Control of the Feasibility Study and Preliminary Design for the "Phased Construction of the Multipurpose Pambukovica Dam with Accumulation", issued by the State's Revision Committee for the control of technical documentation. Design for Construction Permit has been approved by the State’s Revision Committee (Technical Expert Control) in October 2023.

Baseline Biodiversity Surveys with Preliminary Critical Habitat Assessment have been prepared by Arup in May 2024.

Table 1 - Relevant previous studies

Name of the Study	Developed by	Date of Issue
Study of Improvement of Water Protection in the Kolubara River Basin	Institute for Water Management "Jaroslav Černi"	2018
Construction of "Ub" Irrigation System, Feasibility Study	Energoprojekt-Hidroinženjering a.d.,	December 2018
Expropriation of a reservoir dam	Energoprojekt-Hidroinženjering a.d.,	February 2020
Environmental Impact Assessment Study of the Multi-Purpose Reservoir Project Pambukovica Dam	Energoprojekt-Hidroinženjering a.d.	May 2020
Hydrological study for Pambukovica Dam with accumulation on the Ub river	Energoprojekt-Hidroinženjering a.d.,	August 2020
Conceptual Design of the dam	Energoprojekt-Hidroinženjering a.d.	October 2020
Koceljeva and Pambukovica Dams Project Technical, Environmental and Social Due Diligence – Gap Analysis	Arup	December 2020
Conceptual Design of the DP 21 road	Tangram projekt d.o.o.	November 2022
Design for Construction Permit for the Construction of Pambukovica Dam with Reservoir	Energoprojekt-Hidroinženjering a.d.	October 2023
Baseline Biodiversity Surveys – Final Report **Baseline Biodiversity Surveys – Preliminary Critical Habitat Assessment**	Arup	May 2024

1.2 Location

Pambukovica Dam is envisaged to be on river Ub approximately 21km upstream from the confluence to Tamnava River, which is 15km west from the settlement of Ub. Location of the Dam belongs to cadastral municipalities of Pambukovica, Radusa and Gola Glava. Location of Pambukovica dam is shown in Figures 1, 2 and 3.

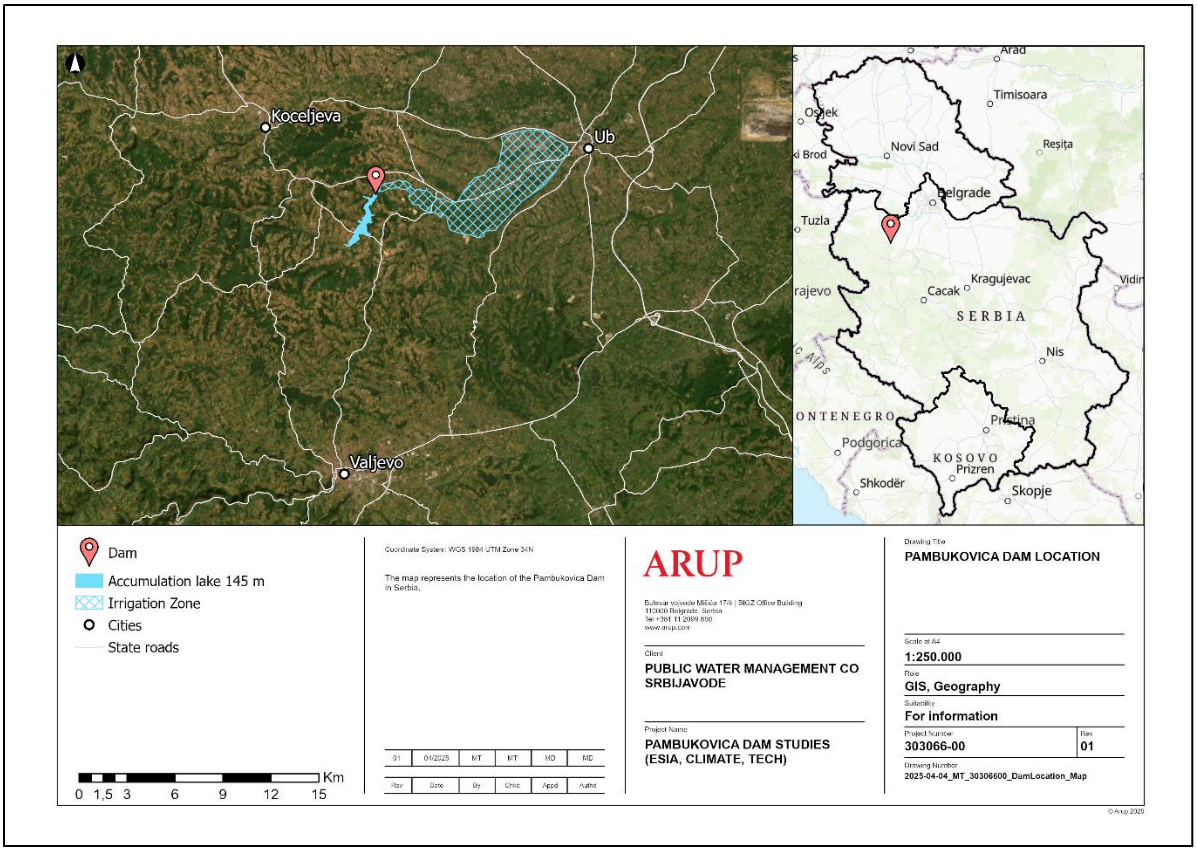

Figure 1 - Pambukovica Dam location (regional view)

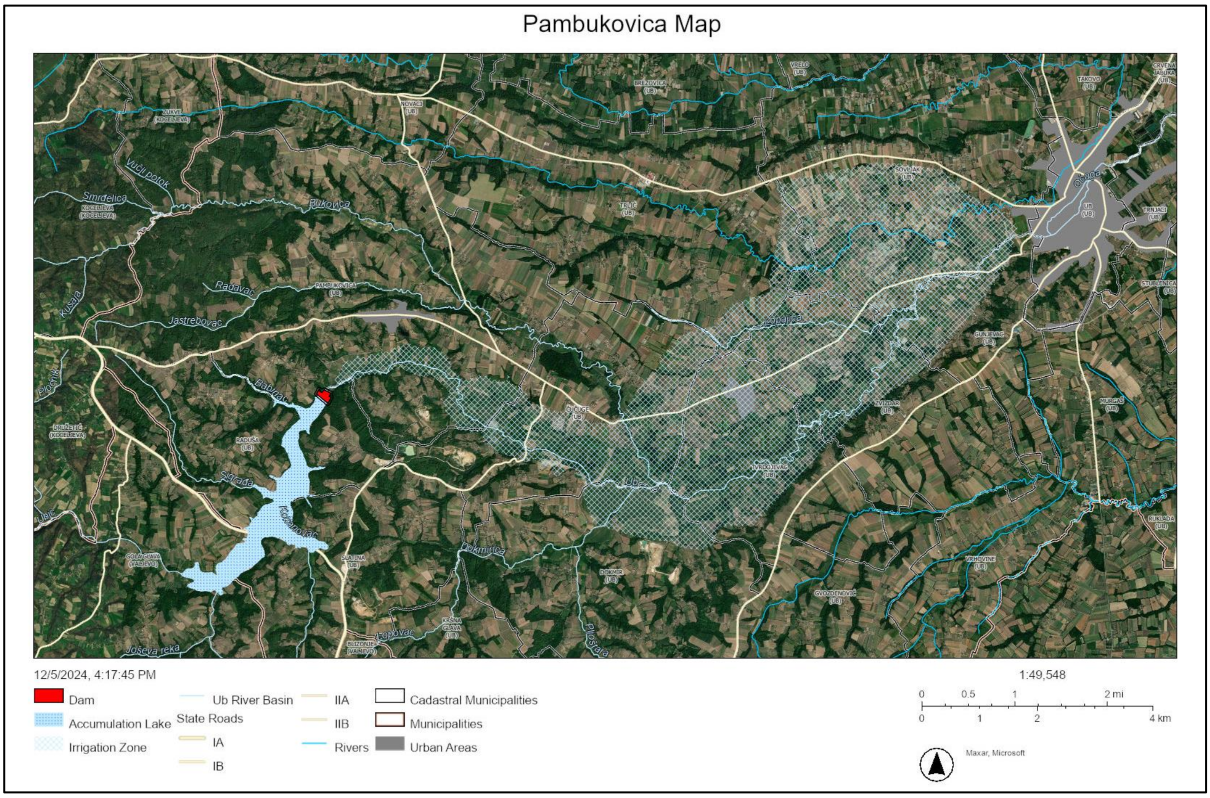

Figure 2 - Pambukovica Dam – Reservoir location with potential irrigation area

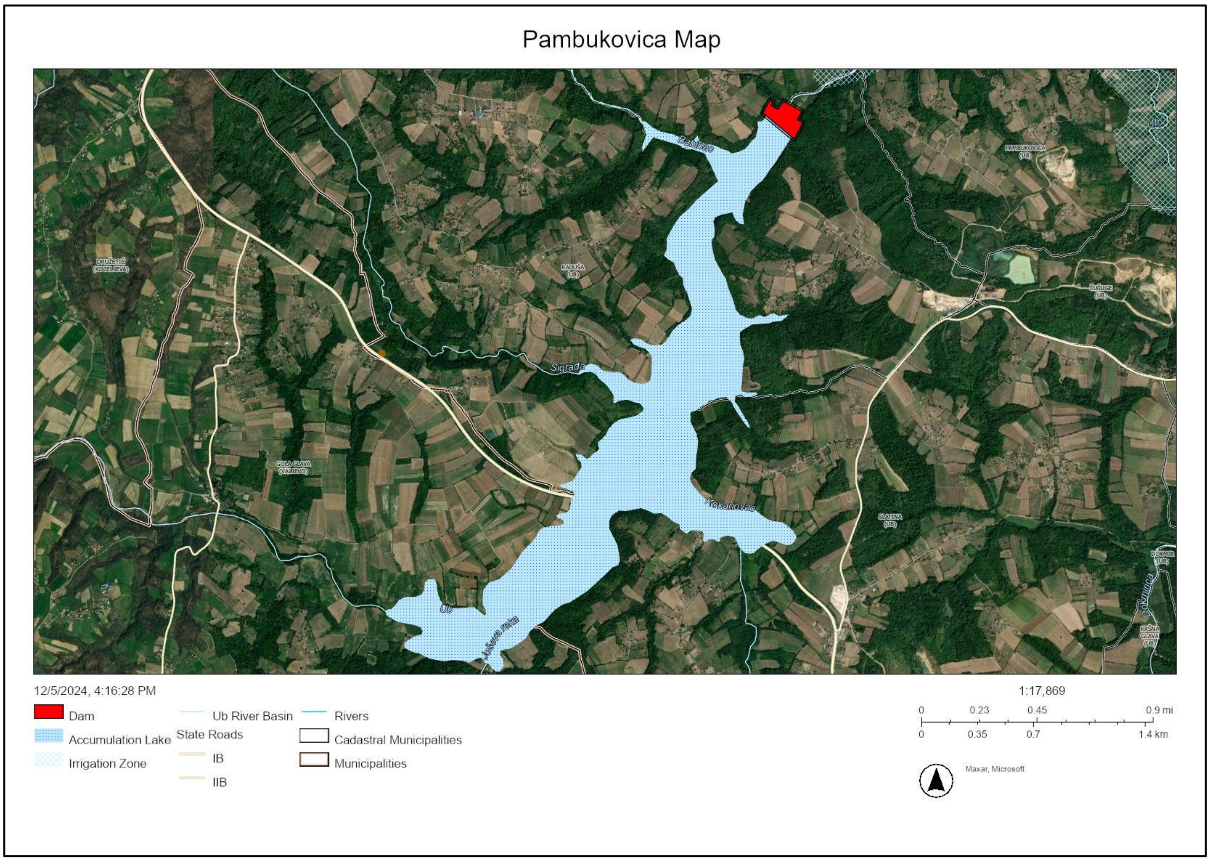

Figure 3 - Reservoir location - inundation area

The inundation area of the considered profile is characterized mainly by hilly terrain. The width of the river valley is quite variable, ranging from 100 meters to over 600 meters. At the location of the dam profile, the width of the river valley is about 150 meters.

A full description of the habitats within the project area is included in ESIA Volume I Book 4 Biodiversity Impact Assessment. The inundation would mostly occupy agricultural land. Within the inundation area itself approximately 53% of is arable land and market gardens. Of the remaining habitat 29% represent natural and semi-natural habitats including; mesic grasslands, sparsely wooded grasslands, Balkan riverine willow scrub, Fagetum moesiace submontanum typicum woodland, Quercetum frainetto-cerris woodland, riparian and gallery woodland, with dominant Alnus glutinosa/Populus nigra/Salix alba, and lines of trees (with small anthropogenic woodlands, with dominant Populus nigra cv. italica. As for the population, there are a small number of households in the retention area, mostly located along local rural roads.

1.3 Structure of this document

- Section 2 – Description of the Scheme
- Section 3 – Associated Facilities
- Section 4 – Analysis of Alternatives
- Section 5 – Project Activities
- Section 6 – Climate
- Section 7 – Climate Change / Green Assessment
- Section 8 – Hydrology / Ecological Flow

2. Description of the Scheme

2.1 General information

Design developed by "Energoprojekt" envisages development of a 30.5 m high earth embankment dam, the Pambukovica dam, on the Ub River and an irrigation network within the Ub River Valley. The dam will be a multipurpose dam impounding a total reservoir volume of 8.15 Mm3. Its intended functions are:

- Flood protection,
- Irrigation of about 2,225ha,
- Maintaining a guaranteed ecological flow in reservoir and downstream river,
- Retention of sediments.

Estimated time needed for construction of the dam is two to three years, considering the amount of work and defining the dynamics of execution of work.

Assumed dam lifetime is 80 years.

Construction and preparation of technical documentation for Pambukovica dam is planned in two phases:

- Phase 1 - Construction and operation of Pambukovica dam for flood defence purposes. For construction of the dam, and before impoundment, a 900m long section of the State Road No.21 will need to be raised above the maximum water level of the reservoir, and additional services located in the reservoir footprint relocated. Phase 1 will complete with the impoundment of the river and formation of the reservoir. Design of the dam has been prepared up to the level of Design for the Construction Permit (PGD) as defined in national legislation.
- Phase 2 - Construction and operation of an irrigation system within Ub Municipality is now planned to begin in parallel with finalisation of Phase 1 works. This phase involves the dam and reservoir operating for both flood defence and irrigation purposes. Irrigation construction works will involve construction of the key facilities of the irrigation system primary distribution network which include pump stations, pressure pipelines and the tanks for daily balancing of the inflow. The rest of the distribution network infrastructure is planned to be developed to full capacity in the subsequent years.

Construction of upstream sediment traps is planned as part of the overall Pambukovica Dam Project, as part of the Phase 1. PWMC Srbijavode confirmed that the plan is to construct sediment traps in parallel with the construction of the dam. Completion is planned before start of reservoir operation.

The primary purpose of Pambukovica dam is flood protection / alleviation.

Secondary purpose of the system is to be used for irrigation of surrounding agricultural areas, benefaction of small waters and retention of sediment from upstream areas.

Both primary and secondary purpose will integrate requirements and considerations of the guaranteed ecological flow.

2.2 Project implementation timeline

Timeline below has been developed based on:

- Project documentation provided,
- Information provided during project meetings by the PWMC Srbijavode and EBRD

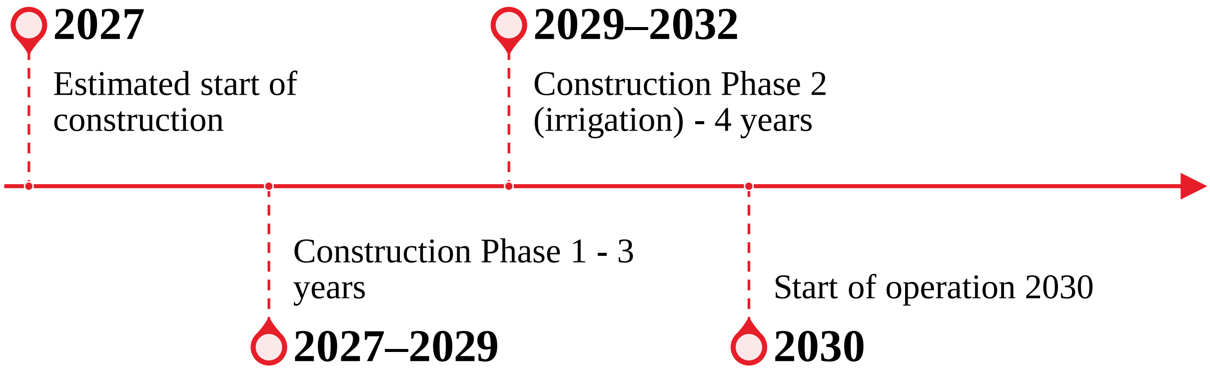

Figure 4 - Provisional project timeline

2.3 Technical description of the scheme

The dam will be constructed with earth material, with a central clay core that will ensure the dam is waterproof. The elevation of the dam crest is envisaged to be 150.50 masl, while the maximum height of the dam is envisaged to be 30.5 m. Length of the dam in crest will be 212.6 m, from the point of transitional section of the side spillway to the access platform on the left side of the dam. Upstream and downstream cofferdams that will be constructed for the construction phase will be incorporated into the dam cross section.

Floods will be evacuated by a free overflow spillway with a weir and a chute and a bottom outlet. These facilities are envisaged to be on the right bank of the dam. The bottom outlet during the construction of the dam will serve as a diversion gallery, meaning the gallery of the bottom outlet is designed for both the construction phase and the operational phase of the dam.

For ecological flow releases two pipes will be installed (DN200) which will practically be outlets from the bottom outlet gallery and from the intake pipe for irrigation. Release of ecological flow will be conducted mostly from pipe DN200 which is derived from outlet/drain and that in case when bottom outlet is closed. Second, reserve pipe would be used only in cases of repairing of bottom outlet.

Outlet/drain and water intake for the needs of irrigation will be equipped with suitable valves. At the upstream end of these structures, a water intake tower is planned, with a platform at the crest elevation of the dam where a crane will be installed for handling maintenance shut-off valves of the discharge outlet. At the upstream end of the irrigation intake pipe, an emergency shut-off valve will be installed, accessible from a dry gallery at the downstream end.

At valve chamber, at the end of discharge outlet, there will be placed operational-regulation gates, and upstream from them, and emergency shut-off valve. A flow meter will be installed on the irrigation intake pipeline DN1000. Within the scope of valve chamber there will be valves that will regulate discharge of ecological flow in the downstream of the dam. There will be access to dry gallery from valve chamber.

Immediately next to the dam, on its downstream side, there will be platform at level 130.20 masl on which the spillway gate will be placed, command building and electrical system connection point facility will be located. Electrical connection facility is not part of this Project but will be the subject of the technical documentation for the Project connecting the dam to the electrical power system.

Current state implies presence of rapids which are flowing into the river Ub from the left side in level of downstream forebay. In order to enable uninterrupted construction of the dam and operation, concrete gallery is envisaged that will represent a passage that connects stream bed and the main riverbed downstream of the structure. Through this gallery, entrances will be available to the crown of the dam and to downstream platform.

Immediately downstream of the dam, riverbed will be regulated with the goal of adequately evacuating water coming from stream in the left bank of the dam, as well as the hydraulically right connection of the calm water in the stilling basins of the foundation outlet and overflow with the downstream riverbed.

To access the crest of the dam at level 150.50 masl, as well as to access downstream platform with command building, there are two envisaged access roads which will be separated from the local road that is located on the left shore in the zone downstream of the Pambukovica Dam. The layout of the Pambukovica Dam and its accompanying facilities is shown in the following Figure 5.

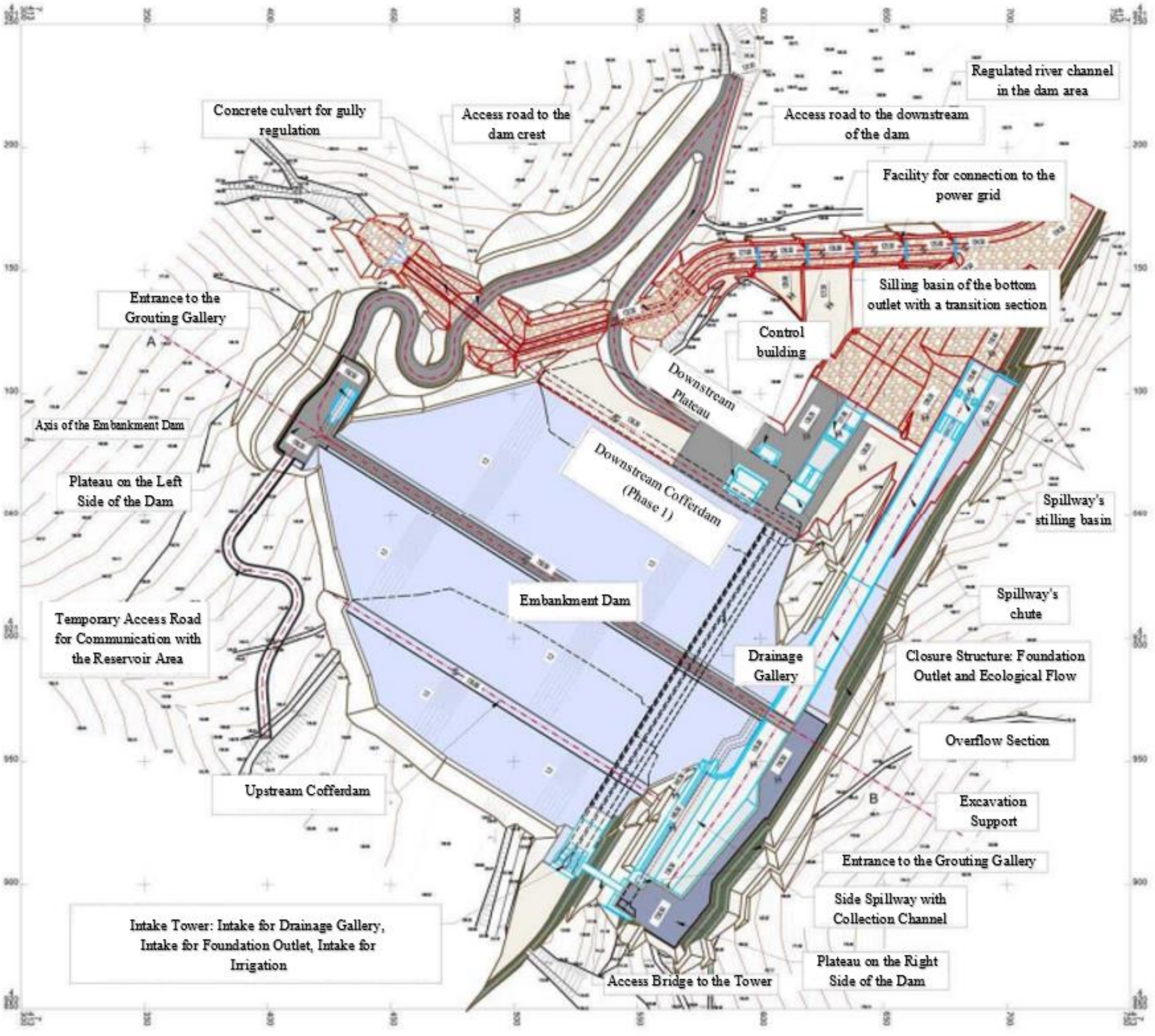

Figure 5 Layout of the Pambukovica Dam with key structural elements (Source: Design for Construction Permit)

2.4 Basic elements

The Pambukovica dam is designed as an embankment dam with a central clay core and a supporting body composed mainly of excavation material.

The auxiliary structures that are an integral part of the dam's hydro complex and form a unified whole with the dam are as follows:

- Structures for the evacuation of large waters during the operation of the facility, consisting of the following components:
  - Side spillway with a collection channel,
  - Transition section between the collection channel and the chute,
  - Chute,
  - Still basin,
  - Discharge channel.
- Structures for the evacuation of water during the construction of the facility:
  - Bypass gallery with intake,
  - Chute with transition section,
  - Discharge channel,
  - Upstream cofferdam which is part of the main dam body,
  - Downstream cofferdam which is part of the main dam body.
- Structures for controlled water intake during the operation of the facility:
  - Bottom outlet with downstream gate,
  - Intake for irrigation,
  - Intake for releasing environmentally acceptable flow,
  - Chute of the bottom outlet with transition section which is also the chute in the bypass gallery,
  - Injection gallery.
- Downstream platform where the following structures are located:
  - Command building,
  - Downstream gate,
  - Structure for connecting the dam to the power grid (not part of the dam and reservoir project, but part of a separate project "Connecting the Pambukovica dam to the power grid"),
  - Service roads for access and communication with the dam crest and the platform on the right bank in the area of the side spillway and with the downstream platform,
  - System for technical monitoring of the facility,
  - Regulated riverbed in the dam area, within the boundaries of the Detailed Regulation Plan.

2.5 Upstream sediment traps

Construction of upstream sediment traps is planned as part of the overall Pambukovica Dam Project, as part of the Phase 1. PWMC Srbijavode confirmed that the plan is to construct sediment traps in parallel with the construction of the dam. Completion is planned before start of reservoir operation.

The purpose of these sediment traps is to control the amount of sediment reaching the dam reservoir.

Seven upstream sediment traps planned are:

- Sediment Trap Dam 1 - Babinac Stream: Located in the Babinac Stream area.
- Sediment Trap Dam 2 - Babinac Stream: Also located in the Babinac Stream area.
- Sediment Trap Dam 3 - Joševa River: Located in the area of the Joševa River.
- Sediment Trap Dam 4 - Joševa River: Also located in the area of the Joševa River.
- Sediment Trap Dam 5 - Jasenovac Stream: Located in the Jasenovac Stream area.
- Sediment Trap Dam 6 - Medvednjak Stream: Located in the Medvednjak Stream area 1.
- Sediment Trap Dam 7 - Oglađenovačka River: Located in the area of the Oglađenovačka River

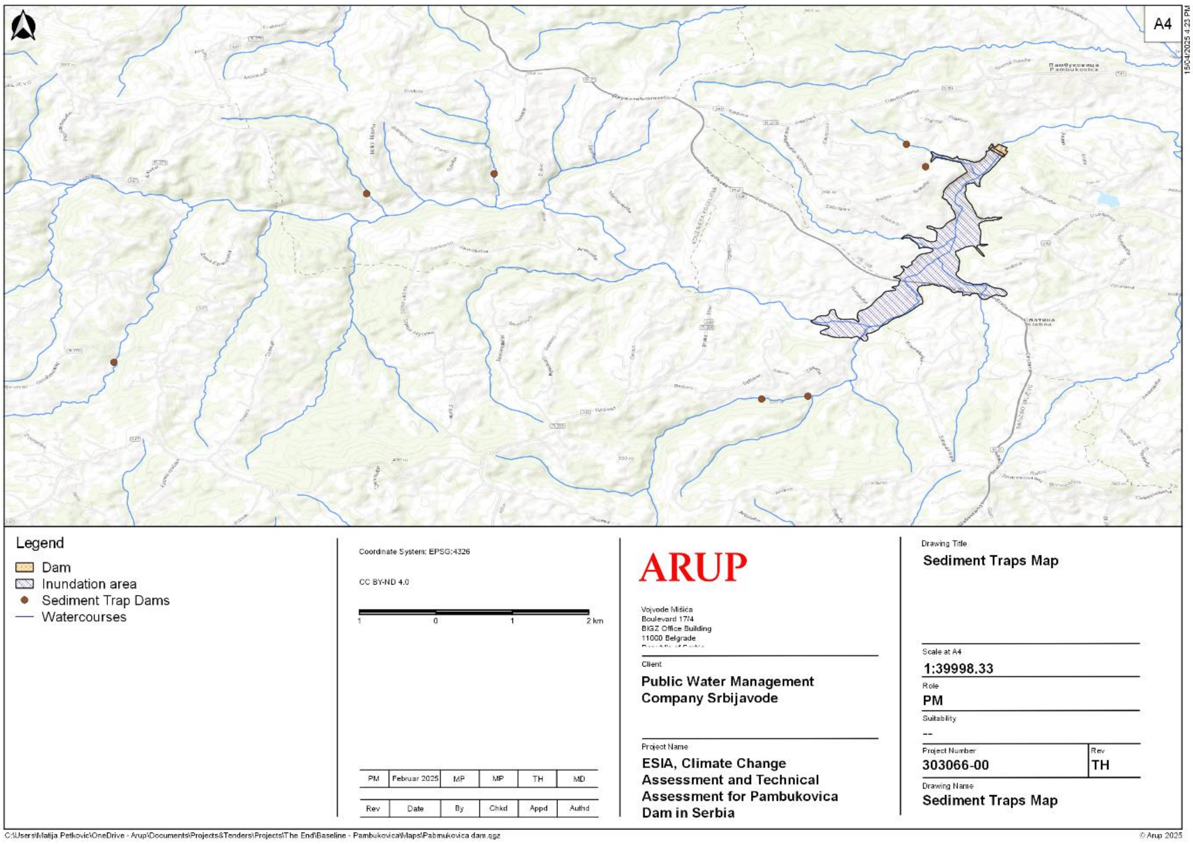

Figure 6 Location of upstream sediment traps

2.6 Brief description of the reconstruction of the State Road IB number 21

Due to inundation of the area and the future level of water in the reservoir being above the current level of the state road IB No. 21, construction of the reservoir requires reconstruction of the road, its elevation and adjustment of the alignment.

Within the future reservoir area lies State Road IB No. 21 Šabac-Valjevo (formerly the main road Valjevo-Šabac M-21), section 02122 from interchange number 2121 Gola Glava (km 114+800) to interchange number 2122 Slatina (km 119+452), which crosses the River Ub by a bridge.

The state road IB-21 connects northern, western, and southwestern Serbia. It starts in Novi Sad, passes through Ruma, Šabac, Valjevo, Kosjerić, Požega, Arilje, Ivanjica, and ends in Sjenica.

Works are planned as a part of the separate Project titled "Conceptual Project for the Reconstruction and Construction of a Section of State Road IB No. 21, as part of the construction of the Pambukovica Dam with a reservoir on the River Ub." Based on the available information PWMC Srbijavode will be investor for this separate Project, which is planned to be financed by the loan from the EBRD.

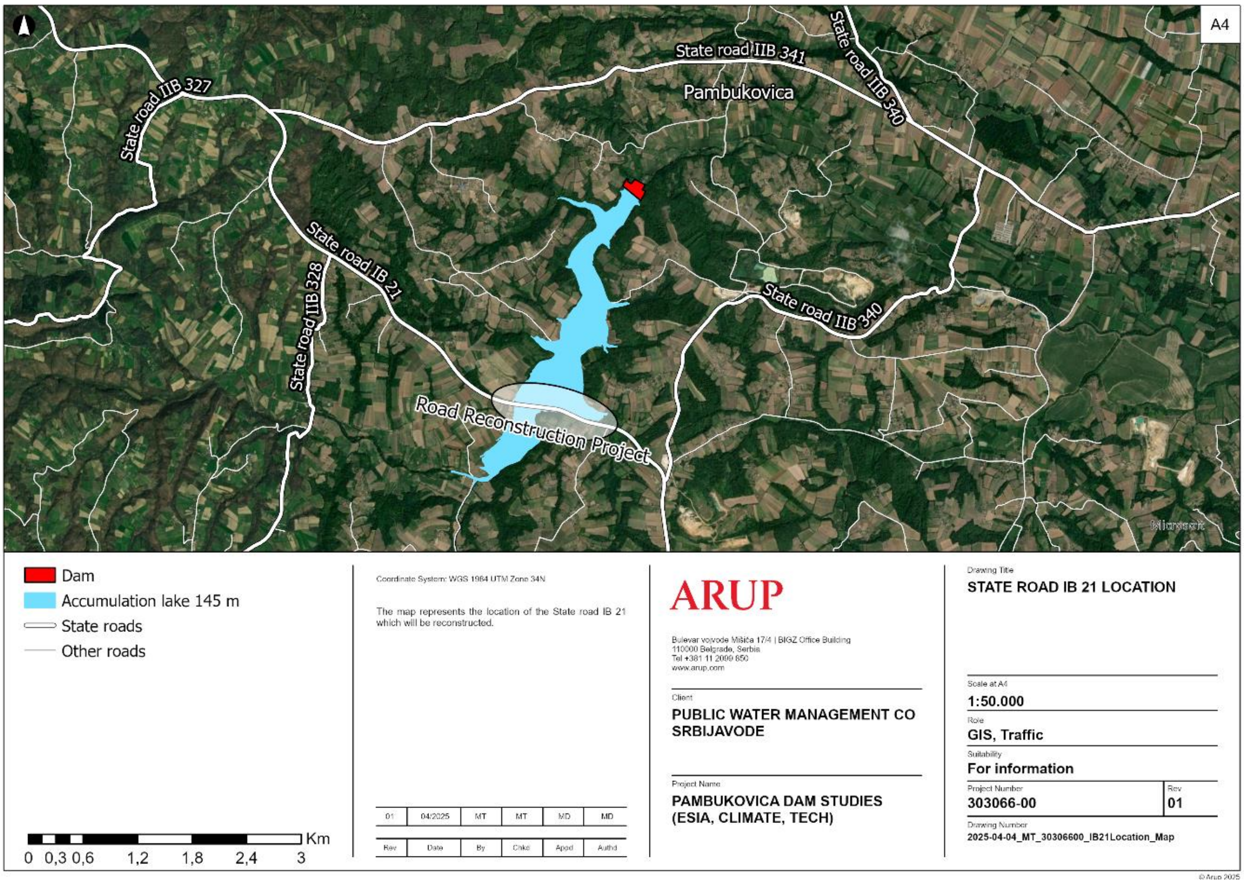

Figure 7 Location of the State Road IB number 21

Considering the requirements of the road manager to ensure traffic flow on the section of the State Road IB-21 during the construction works, the newly designed solution involves the construction of a section that deviates from the existing road geometry, meaning the road is relocated from the current route.

In accordance with the overall realignment of the state road route, the project includes a new bridge at km 117+635.50, whose construction will be aligned with the newly designed route and road levels.

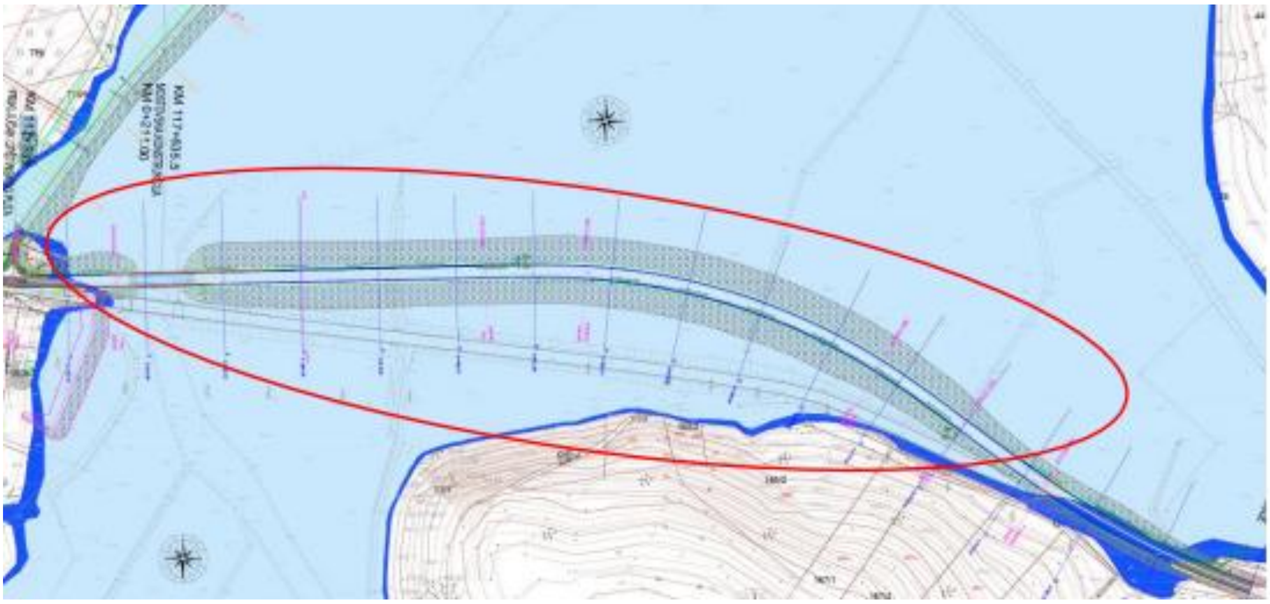

Figure 8 Location of the old and new alignment of the State Road IB-21 (Source: Conceptual Design for the State Road IB No.21)

3. Associated Facilities

Taking into consideration the definition of Associated Facilities[1] defined in the EBRD E&S Policy 2019 following facilities have considered as part of the Project assessment.

3.1 Transformer Station and connection to 10kV line

Designed to supply power to the dam and is planned to be constructed as a 10/0.4 kV transformer station connected to a separate 10 kV line. The planned transformer station will be built as either a free-standing unit (MBTS) or a pole-mounted unit. The exact location of the transformer station and separate 10 kV line will be determined by the next stages of project documentation and the requirements of the relevant power distribution company. If necessary, the external appearance of the transformer station should be harmonized with the surrounding environment. Currently available information about the scheme connection to power supply is provided in the Chapter 7.2.

3.2 Telecommunication installations

The relocation works of the existing Telekom Srbija cable.

3.3 Irrigation system

- Primary Irrigation Network - Construction includes pump stations, pressure pipelines, and tanks for daily balancing of inflows. The primary network will be developed over three years, with 30% investment in the first year and 35% in each of the next two years.
- Secondary Irrigation Network - This involves the development of the irrigation network on agricultural plots. The goal is to equip 20% of the irrigated area in the first year, 40% in the second year, and the remaining 40% in the third year.

[1] Associated facilities - facilities or activities that are not financed by EBRD as part of the project but which in the view of EBRD are significant in determining the success of the project or in producing agreed project outcomes. These are new facilities or activities: (i) without which the project would not be viable, and (ii) would not be constructed, expanded, carried out or planned to be constructed or carried out if the project did not exist.

- Implementation Timeline – Based on the information available from meetings with representatives of the PWMC Srbijavode, the construction of the irrigation system will begin during finalisation of the Phase 1 or immediately after the completion of the dam and reservoir. Entire system expected to be operational within four years.
- Expansion Possibilities - The system is designed to allow future expansion, potentially connecting more parcels and increasing the irrigated area to about 2,225 hectares.

3.3.1 Irrigation system description

One of the water management functions of the Pambukovica dam with its reservoir is the irrigation of agricultural land in the municipality of Ub. The subject of this project is to define the structures and equipment within the Pambukovica dam necessary for water intake for irrigation. To assess the technical characteristics of the irrigation system that would be supplied with water from the Pambukovica reservoir, a conceptual design of the "Ub" irrigation system was realized by Energoprojekt-Hidroinženjering. This project is based on the technical solution of the Pambukovica dam with its reservoir from the conceptual design of the "Pambukovica" dam on the Ub river. Below is a brief description of the irrigation system defined by the mentioned project documentation.

According to the conceptual design of the irrigation system, the Pambukovica reservoir could irrigate 2,225 hectares of net agricultural land with sufficient reliability.

The components of such a system are as follows:

- Water intake within the Pambukovica dam with a supply pipe
- Pumping station
- Pressure pipeline
- Reservoir for daily flow equalization
- Distribution network

Water intake for irrigation is planned within the water intake structure located at the upstream part of the Pambukovica dam's bypass gallery. The captured water is distributed from the reservoir to the pumping station located on the downstream plateau of the dam using a steel pipe with a diameter of Ø1000 mm. The pumping station houses three working pumps with a total installed flow rate of 1100 l/s and a lifting height ranging from 67 to 88 m, depending on the state of the Pambukovica reservoir and the reservoir. From the pumping station, water is pumped at a constant flow rate into a pressure pipeline with a diameter of Ø1000 mm and a total length of approximately 1730 m. After crossing under the old bed of the Ub river downstream of the future foundation outlet of the Pambukovica dam, the pressure pipeline follows the river's course along its left bank for approximately 950 m, after which the pipeline passes under the river and its route turns uphill towards the reservoir for daily flow equalization.

Water is delivered to the reservoir from the pressure pipeline through an outlet structure integrated into the slope of the reservoir embankment. The reservoir is designed as a geotechnical structure, partly in excavation and partly in embankment. The reservoir's waterproofing is ensured by an HDPE geomembrane at the bottom of the reservoir. The working levels of the reservoir range from 207.50 to 211.50 meters above sea level. At an axial distance of 5 m from the axis of the pressure pipeline, the intake structure of the irrigation system's distribution network is located, from which a valve chamber with an emergency valve and a flow meter is located. The reservoir's drainage after the irrigation season, as well as the water discharge in case of excessive reservoir filling, is provided by a single structure placed in line with the outlet and intake structures. From the structure, a pipeline route for water discharge to the nearest recipient, which in the case of this reservoir is approximately 230 m northeast of the reservoir overflow, starts.

4. Analysis of Alternatives

4.1 Introduction

As part of the systematic solution to flooding problems in the Kolubara basin, the "Study for the Improvement of Water Protection in the Kolubara River Basin" proposed the construction of the Pambukovica Dam on the Ub River, a right tributary of Tamnava, in the Ub municipality. The primary idea behind building this dam, which would create a multifunctional reservoir, is to provide space to accommodate the flood wave during high water conditions, thereby contributing to the protection of the downstream area. In addition to this primary role, the possibility of using the accumulated water for other purposes such as irrigation, and enriching the watercourse during low water periods is also considered.

4.2 Purpose

The Analysis of Alternatives chapter outlines how, among others, environmental and social (E&S) considerations were integrated into planning process of the proposed Pambukovica Dam:

- Describing alternatives and options discussed during project preparation.
- Analysis of the location, concept (operational), dam type and size.
- Comparison of the optioneering of relevant scheme aspects (such as fish paths solution, sediment management, regional road impact).
- Addressing the no-project/do-nothing scenario.
- Identifying criteria defined at the strategic level and outside of the client's control.
- Findings from the 2018 Kolubara River Basin Catchment Study.

4.3 Previous studies

4.3.1 Legislation and planning context

The Pambukovica Dam has been included in multiple tiers of spatial and strategic planning documentation, confirming its long-standing recognition as a priority intervention for flood risk management and water resource development in the Kolubara River Basin.

The following spatial plans reference the Pambukovica Dam:

- Water Management Foundation for the Kolubara River Basin (1977) – This foundational document identified the need for multipurpose water management infrastructure in the Kolubara Basin, including the Pambukovica Dam.
- Regional Spatial Plan for the Kolubara and Mačva Administrative Districts (2015) – This plan confirms the strategic importance of the dam and its alignment with regional development goals. It remains valid and in force.
- Spatial Plan of the Municipality of Ub (2012) – The dam is included in the current municipal spatial plan, which remains valid. The plan also references the associated infrastructure, including the road realignment and irrigation system.

In addition to the above, the General Regulation Plan (2016) and the Detailed Regulation Plan for the Pambukovica Dam Area (2016) provide further zoning and land use guidance. These plans are considered valid at the time of this assessment.

Following is relevant when it comes to Strategic Environmental Assessment (SEA):

- The Regional Spatial Plan (2015) was subject to a Strategic Environmental Assessment (SEA), as required under Serbian legislation.

- The Spatial Plan of the Municipality of Ub was also subject to SEA.
- The Kolubara River Basin Catchment Study (2018) was not officially subject to SEA, as it is a technical study and not a formal planning document under the SEA Law.

The Environmental Impact Assessment (EIA) for the Pambukovica Dam was completed in May 2020. The EIA was publicly disclosed in November and December 2019, in accordance with Serbian legal requirements. The EIA was approved by the technical commission of the Ministry of Environmental Protection on June 10, 2020. with the obligation to start the construction within the two-year period. Srbijavode is expected to initiate the EIA renewal procedure as a prerequisite to proceeding to the Construction Phase of the Project.

4.3.2 Summary of Analysis Social Impacts of proposed solution as provided in the 2018 Kolubara Basin Study

In Book 3 of the 2018 Kolubara Basin Study: Improvement of Flood Protection in the Kolubara Basin, Volume 3.6 Impact of the Proposed Solution on Social Factors, the methodology and criteria for impact assessment, the assessment of the proposed solution's social impacts, the main results of the survey conducted for the Study, the proposal for a continuous monitoring program of the planned solutions' impact on social factors, and the proposal of incentive measures to mitigate the adverse impacts of the Study on social factors have been presented.

The criteria used for assessing the impact of the proposed solution on social factors is given in the following table.

Table 2 Criteria for Evaluating the Magnitude of Impact

Magnitude of Impact	Score	Description
Greater	-2	Significantly threatens or impacts social recipients
Medium	-1	Slightly threatens or impacts social recipients
None	0	No direct impact social recipients or negligible impact
Positive	+1	Positive impact on social recipients
Very positive	+2	Very positive impact on social recipients

Table 3 Criteria for Evaluating the Spatial Scale of Impact

Spatial Scale of Impact	Score	Description
Local	L	Possible impact on micro location level
Municipal	O	Possible impact on municipal level
Regional	**R**	Possible impact on regional level

Table 4 Assessment of the Magnitude of Social Impacts

Probability(%)	Score	Description
100%	S	Certain
>50%	V	Possible
<50%	M	Probable

Table 5 Assessment of the Magnitude of Social Impacts

Planned solutions	Social impact significance of the planned solutions			
	Magnitude	**Spatial Scale**	**Probability**	**Duration**
Construction of accumulation / retentions				
Pambukovica	+2	R	S	D

Table 6 Planned solution

Planned solution	Impact Level	Rationale of the social impact assessment
Accumulation construction	R+2/S/P	Најзначајнији друштвени утицај у оквиру студије односи се на изградњу ретенционих базена, јер ове зоне за акумулацију или испуштање воде током прекомерног дотока представљају једну од најважнијих активних мера за спречавање поплава. Акумулације дуж водотока, где се вода намерно испушта у случају поплава како би се спречило оштећење насипа услед преливања и смањио врх поплавног таласа у низводном подручју, успешно спречавају већу штету на непокретној имовини у насељима. Оне се углавном формирају на пољопривредним површинама са мање вредним културама, избегавајући инфраструктурне објекте, индустрију и рударство.

4.3.3 Summary of Analysis of Environmental Impacts of proposed solution as provided in the 2018 Kolubara Basin Study

In Book 3 of the 2018 Kolubara Basin Study: Improvement of Flood Protection in the Kolubara Basin, Volume 3.7: Impact of the Proposed Solution on the Environment, an overview of the area where the planned works and measures have an impact on the environment has been provided, along with the methodologies and criteria for environmental impact assessment, the assessment of the environmental impact (on the regime and quality of surface and groundwater, soil, ecosystems, biodiversity, ambient values, etc.), a description of measures to prevent and reduce harmful impacts, and a program for monitoring environmental impacts.

The environmental impact includes a qualitative and quantitative overview of possible changes in the environment during the project execution, regular operation, and in case of accidents, as well as an assessment of whether the changes are temporary or permanent, particularly regarding: the regime and quality of surface and groundwater, air, ecosystems, biodiversity, ambient values, etc.; soil, land use and utilization (built and unbuilt areas, use of agricultural, forest, and water land, etc.); natural resources of special value and immovable cultural goods, their surroundings, and landscape characteristics of the area, etc.

Regarding the impact of the proposed solution on the regime and quality of surface and groundwater, it has been noted that the planned operation – permanently open bottom outlets and the retention space emptying time of 10-15 days positively affects the surface water regime as it reduces floods and does not affect the regime of medium and low waters. The impact on groundwater has been assessed as localized.

As for the impact of constructed facilities on the ecosystem, biodiversity, and ambient values, it is concluded that it is positive, as the planned facilities improve flood protection conditions and thus protect the ecosystem, biodiversity, and ambient values.

The impact of the planned facilities on roads, infrastructure facilities, and the population has been assessed as positive, as well as on cultural and historical heritage. This impact was considered when selecting dam location.

Regarding measures to prevent and reduce harmful impacts, this part of the study defines measures to prevent and reduce harmful impacts during construction, as well as measures to preserve habitats and biological diversity.

4.4 Alternatives Considered for Flood Risk Alleviation for the Ub and Kolubara River Basins

As a part of the 2018 Kolubara Basin Study a broader set of potential flood protection measures for providing flood alleviation in the Ub and Kolubara River Basins have been considered. The selection of dam (retention basin) as a main solution/alternative followed evaluation of both structural and non-structural options for managing flood risks.

Overview of Alternatives

Structural Measures (Non-Dam):

- Embankments and levees.
- Riverbed regulation.
- Anti-erosion works.
- Controlled retention basins.
- Diversion channels and canal systems.

Non-Structural Measures:

- Land use planning and zoning.
- Mobile flood barriers.
- Upgrading existing flood infrastructure.
- Flood forecasting and early warning systems.

These options were evaluated individually and in combination, with attention to their applicability to the catchment's hydrological, environmental and socio-economic context.

Comparative Assessment of Alternatives

The following table provides a structured comparison of the alternatives:

Table 7 - Comparative Assessment of Flood Protection Alternatives

Alternative	Effectiveness	Feasibility	Environmental Benefits & Impacts	Social Benefits & Impacts	Safety Benefits & Impacts
Retention Basins (Dams)	• Very High – Effective at reducing peak flood waves and downstream risk	• Moderate – Requires land acquisition, engineering and high level of investment	• Potential to improve resilience to drought and flood damage to the river • May affect habitats, protected areas, and archaeological sites	• Long-term protection • Potential displacement and land acquisition issues • Requires expropriation	• High structural protection • Requires maintenance and emergency planning
Embankments & Levees	• High – Effective in urban and industrial areas	• High – Existing infrastructure can be reinforced	• Prevents erosion • Alters river hydrology and may fragment habitats	• Immediate protection for critical areas • May transfer risk downstream	• Immediate benefit • Can fail under extreme conditions
Anti-Erosion Works	• Moderate – Reduces runoff and sediment transport	• High – Low-tech, locally implementable	• Improves soil stability and water quality • Limited impact on peak floods	• Boosts rural resilience • Minimal social disruption	• Reduces erosion and landslide risks
Urban Drainage Improvements	• Moderate – Targets urban flash floods	• High – Especially effective in towns	• Improves urban water quality • No riverine impact	• Enhances urban living standards • May cause temporary construction nuisance	• Reduces local urban flood risks
Land Use Planning / Zoning	• High (Long-Term) – Prevents exposure	• Moderate – Depends on enforcement and governance	• Preserves natural flood zones • No immediate flood protection	• Reduces future vulnerability • Politically sensitive	• No direct structural benefit • Indirect long-term risk reduction
Early Warning Systems	• Low (Direct Protection) – Supports preparedness	• Very High – Scalable and cost-effective	• No ecological footprint	• Saves lives via timely alerts • Dependent on public response	• Improves response readiness • No structural risk reduction

Discussion and Key Insights

- Pambukovica Dam as a multipurpose reservoir (also considered as retention basin) are most effective at controlling extreme flood events and providing downstream protection. While they entail moderate feasibility challenges—particularly land acquisition and ecological trade-offs—they offer multi-purpose utility (irrigation, environmental flow support) that other measures do not.
- Embankments and levees are highly feasible and effective for specific urban and industrial zones. However, their inability to adapt to extreme flood scenarios and the potential for transferring risk downstream limits their standalone application.
- Anti-erosion works are environmentally and socially favourable, especially in upstream or erosion-prone areas, but have limited effect on large-scale flooding and are best used as complementary measures.
- Urban drainage improvements and early warning systems are critical to local preparedness and resilience, particularly in densely populated or economically vital areas, but are not substitutes for basin-wide hydrological management.
- Land use planning offers long-term resilience and supports sustainable development goals, however lacks immediacy and can face political and regulatory hurdles.

Conclusion

The selection of the Pambukovica Dam as the preferred alternative is based on a multi-criteria evaluation that balances hydrological efficiency, engineering feasibility, long-term benefits, and social and environmental sustainability. While no single measure offers a universal solution, the dam-based retention approach provides the highest level of flood protection for downstream communities and infrastructure, supports secondary functions, and aligns with national strategies on climate adaptation and water resource management.

To optimize outcomes, the dam should be integrated with complementary measures—such as anti-erosion works, early warning systems, and land use control—to ensure a resilient, inclusive, and environmentally responsible flood risk management strategy.

4.5 Analysis of alternative locations

As a part of the 2018 Kolubara Basin Study, concept design and feasibility phase, high level assessment of dam location has been undertaken.

Existing planning documentation suggested current location as a part of the river valley that is relatively narrow and significantly widens both upstream and downstream from this zone.

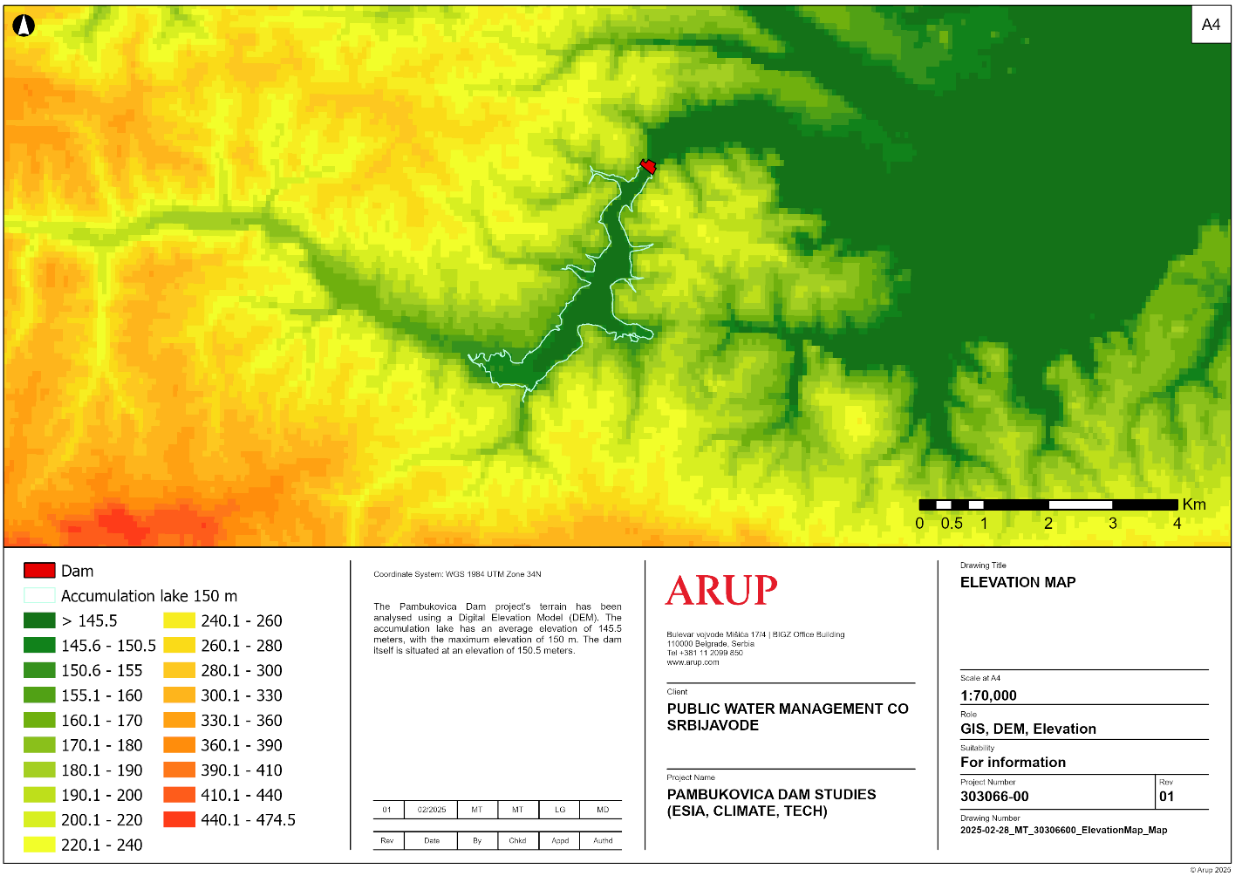

Figure 9 – Elevation map of the River Ub valley, showing selected location

Detailed analysis, which took into account data on the geological structure of the terrain, selected the profile in the downstream part of the considered section. Immediately after this profile, the river valley significantly widens, and placing the profile in the zone downstream from the proposed would require the construction of a barrier object of much larger dimensions, and consequently, the material needed for its construction.

Locating the profile in the most downstream part of the acceptable section of the river valley aligns with the aim to ensure the largest possible volume to meet all the requirements set for this multifunctional reservoir, maximizing benefits while minimizing construction and operation costs.

High level comparison of environmental and social impacts has been made with downstream locations, where the river valley is wider.

Table 8 - Comparison of the Selected Location vs Wider River Valley location

Impacts	Current/Initial Location	Wider River Valley Downstream
Environmental	• Chosen for its geographical and hydrological suitability. • The narrowness of the river valley allows for economical construction due to reduced material and logistical costs. • Geological conditions are favourable, with stable rock formations providing a solid foundation. • Minimal disruption to the local ecosystem. • Minimizes deforestation and habitats disruption, preserving local biodiversity.	• More expensive dam structures to achieve the same water storage capacity. • Less favourable geological conditions, such as unstable soil or rock formations • Greater habitat loss. • Bigger construction site leading to larger footprint.

Impacts	Current/Initial Location	Wider River Valley Downstream
Social	• Minimizes displacement of local communities, primarily affecting agricultural lands rather than residential areas. • Includes raising a section of State Road No. 21 and implementing infrastructure improvements.	• Greater impact on local communities, including the need for more extensive land acquisition and displacement of households. • Longer transport routes affecting higher number of recipients. • Potentially does not impact State Road No.21 (location dependent), however would probably impact other

Conclusion

- The initial location was determined to be the most suitable due to its technical feasibility, cost-effectiveness, and lower environmental and social impacts.
- Current solution supports the project's goals of flood control, irrigation, and water quality improvement while minimizing adverse effects on local communities and the environment.

4.6 Analysis of alternative concepts (multipurpose vs. retention)

2018 Kolubara Basin Study further provides high-level analysis of the alternative concepts comparing multipurpose reservoir with retention structure.

Multipurpose Reservoir:

Multipurpose reservoirs are designed to serve multiple functions beyond flood control. They can provide water supply, irrigation, and support economic development. However, they require more time for planning and construction, and greater operational capabilities.

Retention Structure:

Retention structures are primarily focused on flood control. They are designed to temporarily hold excess water during peak flows to prevent downstream flooding. These structures require less time for planning and construction and lower operational capacity.

Table 9 - Comparison of the Multipurpose Reservoir vs Retention Structure

Impacts	Multipurpose Reservoir	Retention Structure
Environmental Impacts	• Offer a broader range of benefits, including flood control, water supply for irrigation, and control of minimal ecological flow. • Support ecological balance by enhancing water retention capacity. • Contribute to afforestation and soil stabilization. • Help maintain groundwater levels. • Provide habitats for various aquatic species.	• Retention structures focus solely on flood control, providing temporary storage during peak flows. • Limited functionality of retention structures does not support long-term ecological sustainability.
Social Impacts	• Support economic development by providing water for agriculture, industry, and domestic use. • Create recreational opportunities, boosting local tourism and economy. • Support fish farming and other livelihood activities, enhancing food security and income generation for local communities.	• Focus on flood control, with lower investment value and less impact on regional development. • Do not provide the same level of social benefits as multipurpose reservoirs, limiting contribution to community prosperity.

Conclusion

- Multipurpose reservoirs are more sustainable, offering comprehensive benefits beyond flood control, including control of minimal ecological flow.
- Multipurpose reservoirs provide higher economic and social benefits.
- Retention structures, while effective for flood management, do not offer the same level of ecological sustainability, multifunctionality and regional development support.

4.7 Analysis of dam type

As a part of the 2018 Kolubara Basin Study, concept design and feasibility phase, high level assessment has been undertaken between:

1. Earth-fill Dam with Central Clay Core
2. Concrete Gravity Dam

Table 10 - Comparison of considered main dam types

Impacts	Earth-fill dam	Concrete gravity dam
Environmental Impacts	• Earth-fill dams with central clay cores blend naturally with their surroundings. • Cause less disruption to the ecosystem. • Provide good stability and seepage control, contributing to long-term environmental sustainability. • Support vegetation growth on their slopes, enhancing aesthetic value and reducing erosion.	• Concrete gravity dams require more materials and have a higher environmental footprint. • Extensive excavation and concrete production lead to higher carbon emissions and resource consumption. • Have higher impact on surrounding environment, especially vegetation on its borders.
Social Impacts	• Earth-fill dams are cost-effective and utilize locally sourced materials. • Reduce transportation costs and support local economies. • Offer opportunities for local labour involvement, boosting employment and skill development in the region. • Construction and maintenance are relatively simpler.	• Concrete dams involve higher construction costs and greater technical complexity. • Reliance on specialized labor and equipment can limit local participation and benefit sharing. • Visual impact of large concrete structures may not align with aesthetic preferences of local communities.

Conclusion

- Earth-fill dams with central clay cores are the most suitable option due to their cost-effectiveness, environmental integration, and compatibility with the site's geological conditions.
- Concrete gravity dams were rejected due to higher costs and less favourable environmental and social impacts.

4.8 Analysis of height and volume

As a part of the 2018 Kolubara Basin Study, concept design and feasibility phase, high level assessment of the height and volume of the future dam and reservoir have been explained. Summary of discussion about potential impact is provided below.

4.8.1 Environmental Impact

- Higher dam heights and larger reservoir volumes would require more extensive land acquisition.
- Increased land acquisition leads to higher environmental and social impacts.
- Larger reservoirs would inundate more land, affecting terrestrial habitats and biodiversity.

- Smaller dams may not provide sufficient flood control and water storage capacity.
- Limitations of smaller dams could compromise the project's effectiveness and long-term sustainability.
- Selected height and volume ensure a balance between environmental preservation and project goals.

4.8.2 Social Impacts

- Selected height and volume ensure effective flood control while maintaining cost-effectiveness. Designed to handle a 100-year flood volume, reducing flood risks.
- Supporting agricultural productivity through reliable water storage for irrigation.
- Ensures availability of water for irrigation, contributing to regional development.
- Higher dam heights and larger volumes could displace more people and disrupt local communities.
- Higher dam heights require more extensive resettlement and compensation programs, increasing social costs and challenges.
- Smaller dams may not provide adequate benefits, limiting positive impact on community livelihoods.

4.8.3 Conclusion

- Chosen height of 30.5 meters and reservoir volume of around 8.0 million cubic meters provide an optimal balance for flood control, water storage, and optimal environmental and social impacts.
- Higher or lower alternatives were found to be less viable due to increased costs or insufficient flood control capacity.

4.9 Analysis of fish path / no fish path solution

Detailed note on analysis of the fish passage solution is in provided in the **ESIA Book 4 Biodiversity Impact Assessment – Appendix Fish Passage Technical Note.** Summary of the conclusions made in the note are provided below.

4.9.1 Context and Previous Studies

A fish pass, also known as a fish ladder, is a structure built on, in, or alongside a river barrier (e.g. a weir or dam) to help fish navigate around or over obstacles, allowing them to move freely up and down the river.

4.9.1.1 Decision of the Institute for Nature Protection of Serbia

In 2018, the Institute for Nature Protection of Serbia’s decision to approve the project included the requirement for the dam to include a fish pass (Decision of the Institute for Nature Protection of Serbia, 3 No. 020-320/2).

The condition (10) is written in Serbian but can be translated as follows:

‘(10) in accordance with the provisions of the Regulation on special technical and technological solutions that enable unhindered and safe communication of wild animals ("Official Gazette of the Republic of Serbia", No. 72/2010), the construction of a fish pass, the type and construction of which should depend on the hydrobiological characteristics of the Ub River, and which will enable upstream and downstream migrations of fish species and other aquatic organisms, shall be mandatory’.

4.9.1.2 Technical and Environmental and Social Due Diligence 2020

In 2020 a technical, environmental and social due diligence report was undertaken of the proposed project. This report noted that the potential for a fish pass at Pambukovica Dam is discussed and a reasonable rationale for not including a fish pass is included.

Table A4.7 stated that: ‘The potential for a fish pass is discussed and a reasonable rationale for not including a fish pass is included. Despite the installation of a fish pass being a condition of the Institute for Nature

Protection of Serbia decision to approve the project, the EIA states that's construction of a fish pass is not technically feasible for either the Kamenica or Pambukovica dams due to the fluctuating water level in the reservoirs. The EIA states that no signification migrations or aquatic organisms are expected, however, without an aquatic ecology baseline, this statement cannot be substantiated. It should be noted that European barbel (Barbus barbus1) (referenced in the EIAs) are known to migrate hundreds of kilometres so populations could be severed. Alternative non-conventional fish passage solutions, such as a bypass channel have not been investigated as part of optioneering (although EBRD should note that such options are not generally adopted on similar schemes across Europe).

4.9.1.3 Explanation of Technical Unfeasibility

Considering the goal of fulfilling the intended functions of the Pambukovica accumulation, it has been concluded that the realization of the technical solution for the fish passage is not possible. The reason for omitting the fish passage is that its functionality cannot be achieved while fulfilling the primary tasks of the dam at the Pambukovica accumulation. If a simple intake near the bottom of the accumulation were to be installed—submerged during changes in the accumulation level—and connected to the fish passage tract (or other conduit), water speeds of up to 1 m/s would occur. At these speeds, the migration of aquatic organisms is not possible.

To ensure suitable speeds for aquatic organism migration, it would theoretically be necessary to construct a selective intake at over 20 different levels. The construction, operation, and maintenance of such a facility are practically impossible."

4.9.1.4 Biodiversity baseline 2023/2024

All species recorded in the study area are indicative of gravel bed streams, but many can also inhabit stillwater and reservoir environments. Spawning typically occurs on gravel substrate, with some species more adaptable, spawning on gravel and/or vegetation. All fish in the project area are late spring/summer spawning species. Cold water / winter spawners (e.g. tout) are considered absence from the project area.

Whilst some species may make minor migrations from larger rivers to tributaries, or from lakes/reservoirs into rivers to spawn none are considered to migrate large distances and would typically be described as 'resident' or 'non-migratory' fish. Resident fish are fish species that complete all stages of its life cycle within freshwater and frequently within a local area. Most notable species of conservation value recorded are the loaches: Balkan loach, spined loach and golden spined loach. These are small, benthic (bottom dwelling) species and are non-migratory. Other species are all common species.

4.9.2 Conclusion

Whilst the proposed dam will sever connectivity in the River Ub, creating a barrier to migration for fish, habitats suitable to support the life-cycles of the fish assemblage (including spawning and nursery habitats) are present both upstream and downstream of the dam. It is therefore considered that the fish population of the River Ub can be adequately supported, both upstream and downstream of the dam, and a fish pass is therefore not critical to the health of the fish community.

4.10 Analysis of alternative water management

Technical assessment of the water management solutions has been detailed in the Technical Assessment Report, developed as a separate part of this Assignment. Summary is provided below.

Phase 1

For **Phase 1**, the typical operation level will be 138.5 masl, which represents the water level required to provide enough capacity to ensure ecological flow throughout the year. For Phase 2 the water level will fluctuate between 138.5 masl and 145.5 masl, with the introduction of the need for irrigation.

An alternative Phase 1 operations whereby no water is stored and all water entering the reservoir is released would mean that during dry summer periods less than the Serbian minimum flow (a legal requirement) could not be released from the reservoir. Delivery of the Serbian minimum flow during dryer summer months will result in higher than baseline flows downstream of the proposed dam offering increased drought resilience for aquatic communities. This increased drought resilience is considered a key aquatic biodiversity benefit of the scheme and if this waw to be removed. Aquatic and riparian species and habitat downstream of the dam would be impacted by future droughts.

Phase 2

During Phase 2, once the irrigation component is operational, the reservoir is intended to be maintained at Full Supply Level (FSL) of 145.5 masl during the irrigation season, with a commitment to draw down before flood events. This approach is based on the following rationale:

- **Prioritization**: Operational rules and modes prioritize flood control as primary purpose, while irrigation and ecological flow are considered secondary purpose. However, scenarios for operation in Operational Rules (part of the Technical Assessment) integrates all functions through adaptive reservoir management, in the low-flood risk periods. Regular storms and un-forecasted events are handled via the uncontrolled spillway, which mimics natural flood responses without compromising dam safety.
- **Irrigation Demand**: The volume between full supply level (FSL) of 145.5 and 138.5 masl is designated for irrigation use. Maintaining FSL ensures that sufficient water is available to meet peak irrigation demands during the dry summer months (June–August), considering also system losses and variability in annual rainfall.
- **Flood Control**: The operational rules require that the reservoir be drawn down within two days of a forecasted major storm. This drawdown restores the flood storage capacity, ensuring that flood protection standards are not compromised. While keeping the reservoir at lower level(s) would allow for faster drawdown, in a long term it would affect availability of water for irrigation, removing one of the key benefits of the multipurpose reservoir.
- **Environmental Safeguards**: Environmental flows are continuously maintained, and in drought conditions, releases can be made from reserves below 138.5 masl, ensuring ecological integrity is not sacrificed for irrigation or flood control.

4.11 Analysis of alternative sediment management solutions

Technical assessment of the sediment management solutions has been detailed in the Technical Assessment Report, developed as a separate part of this Assignment. Summary is provided below.

4.11.1 Context and Available Management Alternatives

Sediment management is essential for ensuring the functionality and longevity of reservoirs. Sedimentation can negatively impact water quality, reduce storage capacity, obstruct outlets, and increase loads on dams. It also disrupts habitats, decreases biodiversity, and impairs ecosystem services. To mitigate these environmental effects, effective sediment management involves reducing sediment inflow through watershed management and constructing upstream sediment traps. Addressing sedimentation is a key objective of the Pambukovica Dam project, which seeks to enhance water quality, preserve aquatic habitats, and promote the sustainability of the reservoir and its surrounding ecosystems.

Managing reservoir sedimentation can be achieved through various methods, including:

- Reducing sediment inflows: Implementing watershed management and constructing upstream check structures.
- Managing sediments within the reservoir: Creating operating rules and conducting tactical dredging.
- Evacuating sediments from the reservoir: Using flushing, sluicing, density current venting, and mechanical removal techniques.
- Replacing lost storage: Increasing dam height or constructing a new dam.
- Decommissioning: Ending the reservoir's use.

For the Pambukovica Reservoir, techniques such as reducing sediment inflows, managing sediments within the reservoir, and evacuating sediments are considered appropriate and discussed in detail in the Technical Assessment Report.

4.11.2 Comparison between Solution with Sediment Traps and without Sediment Traps

The sediment yield for the Pambukovica Reservoir was independently assessed with and without upstream sediment traps.

4.11.2.1 Longevity and Maintenance

- Without sediment traps, the specific yield is 221.9 $m^3/yr/km^2$, resulting in an estimated 2.1 million m^3 of accumulated sediments over 80 years.
- With sediment traps, the specific yield is reduced to 149.3 $m^3/yr/km^2$, leading to an estimated 1.4 million m^3 of accumulated sediments over the same period.
- Therefore, it has been concluded that sediment traps significantly reduce sediment inflow, decreasing the sedimentation rate by approximately 34%.

4.11.2.2 Environmental Impacts

Sediment traps reduce the volume of sediments entering the reservoir, thereby preserving water quality and reducing the need for frequent maintenance.

This solution also supports biodiversity by maintaining a more stable aquatic habitat in the main reservoir, while having a relatively minor impact on River Ub tributaries where sediment traps are planned to be installed.

In contrast, the solution without sediment traps results in higher sediment accumulation, which can negatively impact water quality, aquatic habitats, and the overall ecosystem, but avoid impact on river Ub tributaries.

4.11.2.3 Social Impacts

Implementing sediment traps can have positive social impacts by enhancing water quality and ensuring a reliable water supply for irrigation and other uses for longer period.

This contributes to improved agricultural productivity and economic benefits for local communities.

The solution without sediment traps may lead to more frequent interruptions in water supply for irrigation due to sediment blockage, reducing the reliability of irrigation and impacting community livelihoods.

The solution without sediment traps would require more frequent removal of sediment from the main reservoir and probably lead to additional land requirements for management of removed sediment.

4.11.3 Comparison between Flushing and Dredging Options

Flushing and dredging are two methods for sediment removal proposed for the sediment management of the Pambukovica Dam during operation.

4.11.3.1 Environmental Impact

- Flushing involves releasing water to carry sediments out of the reservoir, which should be timed to minimize impacts on downstream biodiversity. This method can be effective but may temporarily increase sediment loads in downstream ecosystems.
- Dredging, while more controlled, requires designated areas for storing dredged sediments and can disturb aquatic habitats during the operation.
- Both methods have distinct environmental trade-offs, with flushing generally impacting downstream ecosystems more, while dredging affects the reservoir area directly.

4.11.3.2 Social Impact

- The social impacts of flushing include temporary disruptions to water availability and potential conflicts with downstream water users.
- Proper coordination is needed to align flushing schedules with community needs.
- Dredging, although less disruptive to water availability, can have temporary noise and air pollution impacts on nearby communities.
- At the same time, dredging poses higher health and safety risks for the workers, as dredging is considered a high-risk activity.
- Additionally, finding suitable sites for sediment disposal can be challenging and may require land acquisition or usage changes.

4.11.4 Overall Conclusion

Based on the environmental and social impacts, the use of sediment traps is the most favourable option for reducing sediment inflow into the Pambukovica Reservoir. It offers significant environmental benefits by maintaining water quality and supporting biodiversity while also providing social advantages such as reliable water supply for irrigation and enhanced agricultural productivity.

A balanced and integrated sediment management strategy that combines sediment traps, selective flushing in specific periods of the year and selective dredging when necessary is recommended to optimize both environmental and social outcomes. Development of detailed methodology for sediment management once the final operational management system and design solution is accepted, would ensure minimization of environmental and social impacts.

4.12 Analysis of alternatives for the State Road IB no. 21

Project for reconstruction/relocation of the State Road IB 21 is a result of the decision to implement Pambukovica Reservoir Project and the need for the current road to be elevated above the maximum water level in the future reservoir.

Due to existing road and its general use on the state level, no relocation of the road has been taken into consideration as part of the development of the conceptual design, as it would:

- Require significant change in state level planning documents,
- Lead to significant additional land take requirement,
- Increase environmental impacts, including further impact on biodiversity and ecosystems,
- Impact on travel and transport on local and regional level, for both individual and business users.

Following key considerations were taken into consideration at the conceptual design stage:

- **Geometric Adjustments**: Due to the requirement to maintain traffic flow during construction, the geometry of the road section was altered. This led to the construction of a new road section that deviates from the existing road geometry.
- **New Bridge Construction**: The new design includes the construction of a new bridge within the state road, near the existing bridge. The existing bridge and the part of the road that will be out of function and demolished once new road becomes operational.
- **Connection Adjustments**: The new design also required the reconstruction of the existing connection between the municipal road Pambukovica-Raduša-Slatina and the state road, as well as a part of the municipal road in the connection zone. This was necessary to ensure adequate conditions for connecting the two roads, leading to limited environmental impacts and land acquisition requirements. This ensures that the local communities remain well-connected.

- **Traffic Management**: The project ensures that traffic will continue to flow through the affected area via the new road section and the newly constructed bridge, as well as through a new road planned in the spatial plan of the municipality of Ub. This will reduce the environmental footprint of the project. This is particularly important for ensuring access to essential service.
- **Resilience to environmental changes:** the new road section and bridge are designed to be more resilient to future environmental changes, such as flooding, which reduces the long-term environmental impact.

Overall, proposed design solution for the Stater Road IB 21, has been assessed as having a limited localized temporary impact (construction works), and limited localized permanent impacts (land take, environmental impact along the access of adjusted alignment). However, considering overall benefits of the scheme, these impacts are considered minor.

4.13 No-project alternative

The Kolubara River basin has experienced severe flooding over the years, with one of the most notable events occurring in May 2014. This catastrophic flood caused extensive damage to the population, economy, infrastructure, and natural resources. The region would continue to face significant flood risks, particularly during extreme weather events, if no action is taken.

The no-action alternative would indeed avoid the environmental impacts associated with the construction and operation of the dam. However, it would also mean that the ecological benefits of controlled water flow, sediment retention, and improved water quality during low-flow periods would not be realized. Additionally, the lack of flood control measures would leave the area vulnerable to future floods, leading to recurring damage to residential properties, agricultural lands, and public infrastructure.

Without the project, there would also be no improvement in water availability for irrigation. This would perpetuate the existing issues of water scarcity during dry periods, severely affecting agricultural productivity and overall economic development in the area. The local communities and the government would continue to bear the high economic and social costs associated with flood damage and water scarcity.

Moreover, the high economic and social costs associated with flood damage and water scarcity would persist, with local communities enduring repeated losses and hardships. The no-action alternative represents a missed opportunity for local and potentially regional development, as the potential benefits of flood control and improved water management would remain unrealized.

On the other hand, the proposed project presents potential long-term ecological and economic benefits. By implementing effective flood control measures and enhancing water availability for irrigation, the project could significantly mitigate the risks and costs associated with floods and droughts. This would not only safeguard the region's agricultural productivity but also promote broader economic development and resilience.

4.13.1 Summary of Environmental Impacts (Project vs No-Project)

- The area would continue to face significant flood risks, particularly during extreme weather events.
- No-action alternative would avoid the environmental impacts associated with the construction and operation of the dam.
- However, the ecological benefits of controlled water flow, sediment retention, and improved water quality during low-flow periods would not be realized.

4.13.2 Summary of Social Impacts (Project vs No-Project)

- The economic and social costs of flood damage would remain extremely high.
- The no-action alternative would mean that these costs would continue to burden the local communities and the government.
- Without the Project, there would be no improvement in water availability for irrigation.

- Without the Project, the region would continue to experience water scarcity during dry periods, affecting agricultural productivity and the overall economic development of the area.
- No-project alternative would miss opportunities for local and regional development.

4.13.3 Conclusion

In summary, the No-project alternative would result in continued flood risks, high economic and social costs, lack of water management for irrigation, and missed opportunities for local and potentially regional development. While it would avoid the environmental impacts of dam construction, it would also forgo the potential ecological and economic benefits of the project.

5. Scope of the ESIA in Relation to the Project and Associated Facilities

This chapter provides a definition of the scope of the Environmental and Social Impact Assessment (ESIA) for the Pambukovica Dam Project, specifically in relation to the main project components and the associated facilities (AF), as defined under the EBRD Environmental and Social Policy (2019). It addresses the delineation between the ESIA and the Cumulative Impact Assessment (CIA) and identifies where each associated facility has been assessed within the ESIA Package documentation. This chapter is a continuation of the Chapter 1.5 Scope of ESIA in the ESIA Volume I Book 1 Introduction and should be considered together.

The ESIA Volume I has assessed the environmental and social impacts of the main project components, including the dam, reservoir, sediment traps, and road realignment. In addition, it has also assessed the irrigation system, which, although categorized as an associated facility, has been included due to its integral role in the project's multipurpose function. Assessment of the irrigation system has been done based on the information available at the time of the assessment.

The ESIA Volume 3 Cumulative Impact Assessment considers the broader environmental and social impacts of the project in combination with other developments in the area, including the associated facilities not covered in detail in the ESIA Volume I.

Table 11 - Scope of the ESIA and CIA in Relation to the Project and Associated Facilities

Component	Category	Assessed in ESIA	Assessed in CIA	Relevant Books/Chapters
Pambukovica Dam & Reservoir	Core Project	Yes	Yes	ESIA Volume I -all Books
Irrigation System	Associated Facility	Yes	Yes	ESIA Volume I – all Books
Transformer Station & 10kV Line	Associated Facility	No	Yes	ESIA Volume III Cumulative Impact Assessment
Telecommunication Installations	Associated Facility	No	Yes	ESIA Volume III Cumulative Impact Assessment

6. Project Activities

For the purpose of assessing environmental and social impacts of activities in each of the phases of the Project, activities have assigned to following phases:

- **Pre-Construction Phase -** This phase encompasses all preparatory activities undertaken prior to the commencement of physical construction works. It includes site-specific environmental and social monitoring, detailed technical and geotechnical surveys, design development, land acquisition (if applicable), stakeholder engagement, regulatory approvals, and procurement of contractors and materials.
- **Construction Phase -** This includes initial site clearance, earthworks, and the mobilization of contractors, including the establishment of construction camps, access roads, and temporary infrastructure. All civil engineering works associated with the dam are executed during this period in accordance with the approved design, environmental, and safety standards.
- **Operation Phase -** This phase begins upon the completion and commissioning of the constructed infrastructure. It includes the routine operation and maintenance of the dam, reservoir, and irrigation network (when commissioned).
- **Decommissioning Phase -** Although not expected in the immediate future, this phase accounts for the potential long-term decommissioning of the project infrastructure. It includes all activities related to the safe dismantling, removal, or repurposing of structures, as well as the rehabilitation of the project site, where applicable. Decommissioning planning will be developed in alignment with national regulations and best environmental practices if and when this phase becomes relevant.

Further details for the construction, operation and decommissioning phase are presented in the text below.

6.1 Construction

6.1.1 Brief description of anticipated construction works

Following construction works are anticipated:

- Excavation and terrain preparation:
  - Excavation in soft material (Categories II and III): This excavation involves 90,000 m³ of material. The material is excavated at the dam site and associated structures. Excavation is carried out using machinery (excavators, bulldozers, etc.).
  - Excavation in rock mass without blasting (Categories IV and V): For this phase, 31,000 m³ of material needs to be excavated. Rock mass is typically found in hilly and mountainous areas. Excavation is performed with heavy machinery and manually.
  - - Excavation in rock mass with blasting (Categories IV, V, and VI): Here, 3,500 m³ of material needs to be excavated. Blasting is used to break down rock mass into smaller pieces. After blasting, the material is removed using machinery.
- Concrete work for the spillway gallery: The spillway gallery is part of the dam that allows for controlled drainage of the reservoir. Concrete work is done in segments (blocks) of 6 meters in length. It takes 36 working days to set up reinforcement and formwork. The inlet structure, transition section, and the base outlet spillway require a total of 3,000 m³ of concrete and 250 tons of reinforcement.
- Embankment construction: The main part of the dam consists of a clay core. Clay is added layer by layer to achieve impermeability. An injection-drainage gallery is formed to reduce seepage water. Filling is done carefully to maintain the stability of the dam.
- Final works: Adaptation of the spillway gallery into the base outlet and dry gallery. Construction of access roads and service roads. These works facilitate access and maintenance of the dam.

- Execution of construction work is expected to generate construction traffic, movement of machines and transport of significant amount of material within the immediate zone of reservoir, as well as potential traffic to and from the borrow pit / quarry Čučuge.

Quarry Čučuge

Quarry for stone and filer material Čučuge is an existing quarry. Available documentation defines Čučuge as a quartz sand and non-metallic mineral deposit in the municipality of Ub exploited by the company “Rudnici nemetala Valjevo”. Currently there are no activities at this site and quarry is not active. No official confirmation about the status has been received.

Čučuge quarry may potentially be used during the Project implementation, as it has been recognized and recommended as part of the design as a possible location for obtaining of material. Quarry is located downstream from the dam profile.

The required quantity of material for constructing the retaining body of the embankment is approximately 132,000 m3. About 53,000 m3 can be obtained from the excavation within the construction area (dam location). The remaining material for the retaining body is planned be sourced from borrow pits of terrace and alluvial material, located on both the left and right banks of the river within the reservoir area, up to 1,000 m distance. If this material does not meet the required specifications, an alternative is proposed, which involves using crushed stone (with specified particle size distribution) from the Čučuge quarry and sandy material from the "Kopovi Ub" company landfill. These alternative borrow pits are located approximately 5.5 km from the dam site.

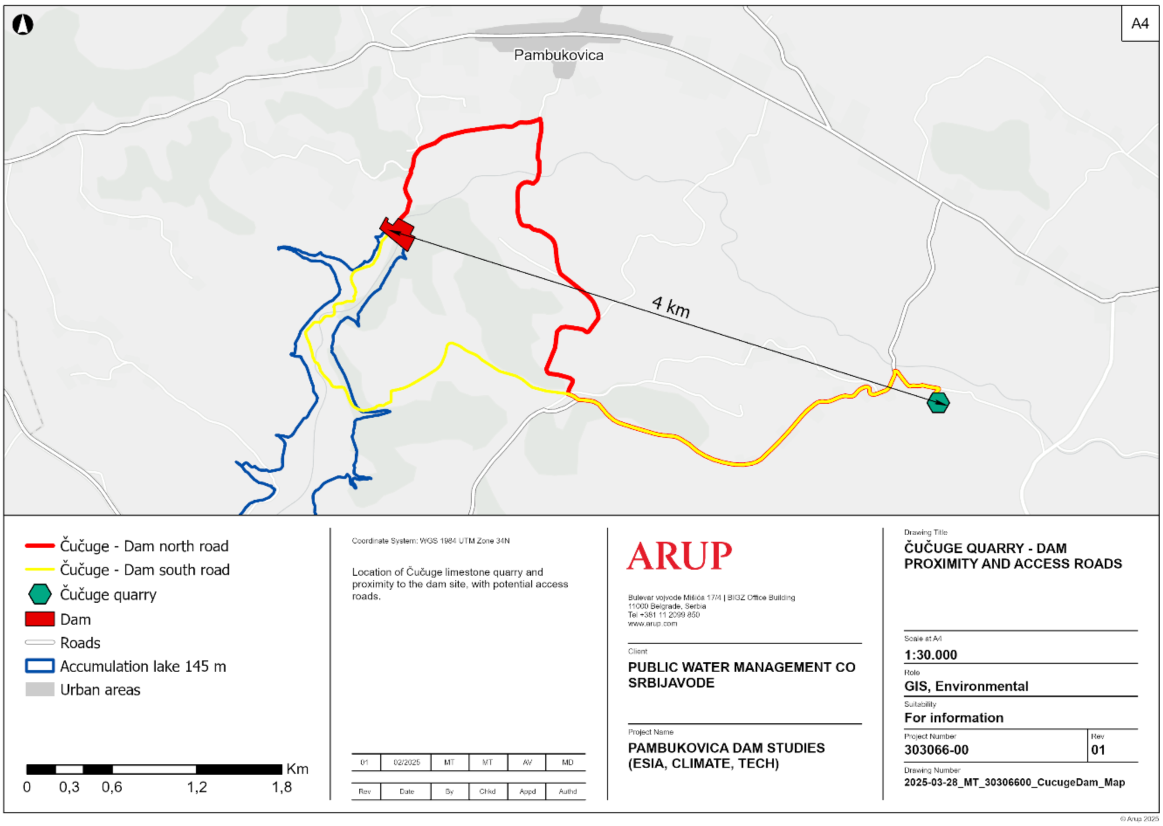

Figure 10 - Location of the Cucuge quarry, with potential transport routes

6.1.1.1 Description of the general concept, construction organization and dynamics and execution of works relevant for Phase 1

As presented in the Design for Construction Permit prepared by the “Energoprojekt-Hidroinženjering”, the construction of the Pambukovica Dam and its associated structures is planned to take three years. Key assumption made in planning documentation regarding construction works is that works will commence at the start of a year.

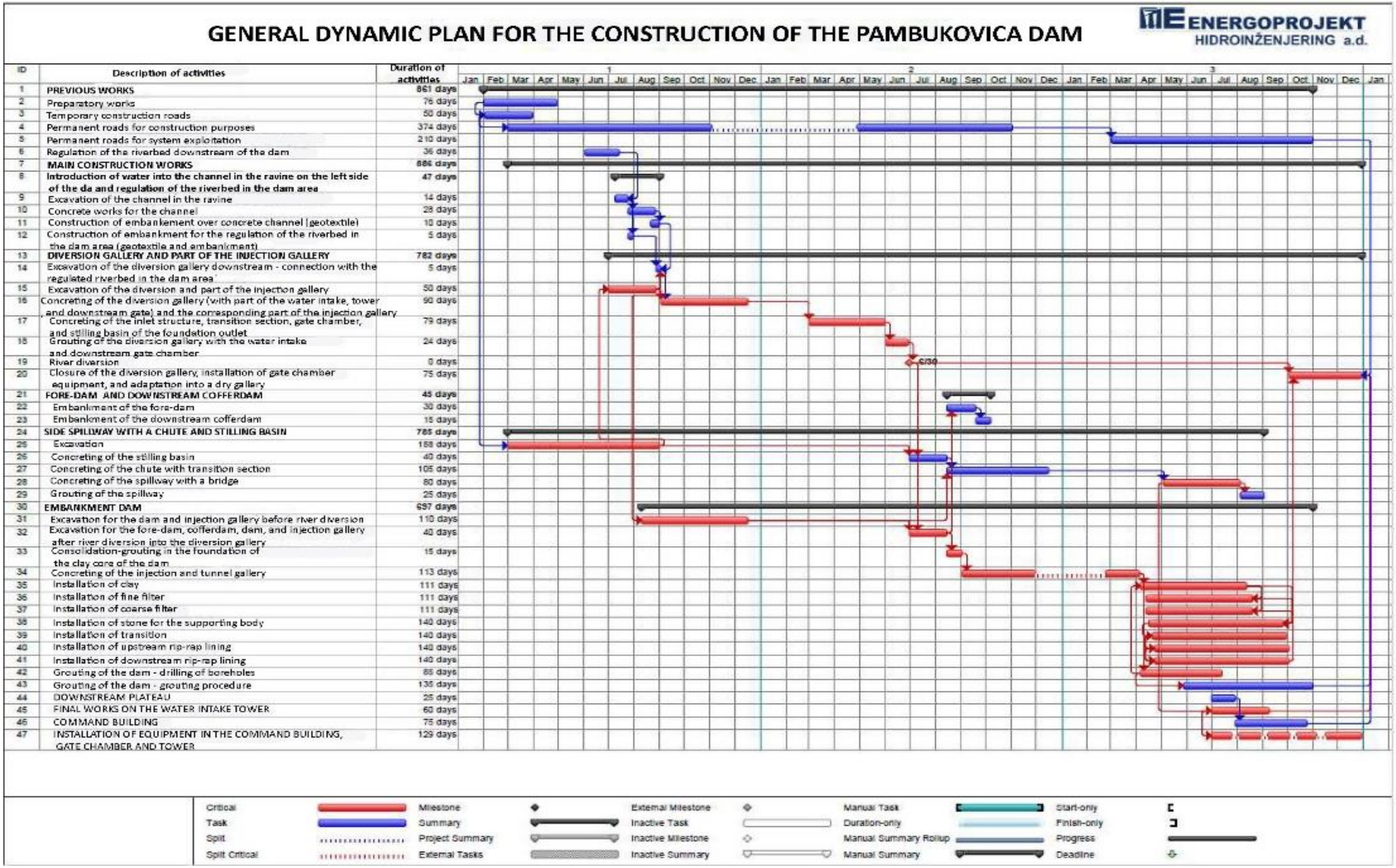
GENERAL DYNAMIC PLAN FOR THE CONSTRUCTION OF THE PAMBUKOVICA DAM
ENERGOPROJEKT
HIDROINŽENJERING a.d.
ID
Description of activities
Duration of activities
1
2
3
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
1 PREVIOUS WORKS 861 days
2 Preparatory works 76 days
3 Temporary construction roads 50 days
4 Permanent roads for construction purposes 374 days
5 Permanent roads for system exploitation 210 days
6 Regulation of the riverbed downstream of the dam 36 days
7 MAIN CONSTRUCTION WORKS 886 days
8 Introduction of water into the channel in the ravine on the left side of the da and regulation of the riverbed in the dam area 47 days
9 Excavation of the channel in the ravine 14 days
10 Concrete works for the channel 28 days
11 Construction of embankement over concrete channel (geotextile) 10 days
12 Construction of embankment for the regulation of the riverbed in the dam area (geotextile and embankment) 5 days
13 DIVERSION GALLERY AND PART OF THE INJECTION GALLERY 782 days
14 Excavation of the diversion gallery downstream - connection with the regulated riverbed in the dam area 5 days
15 Excavation of the diversion and part of the injection gallery 50 days
16 Concreting of the diversion gallery (with part of the water intake, tower, and downstream gate) and the corresponding part of the injection gallery 90 days
17 Concreting of the inlet structure, transition section, gate chamber, and stilling basin of the foundation outlet 79 days
18 Grouting of the diversion gallery with the water intake and downstream gate chamber 24 days
19 River diversion 0 days
20 Closure of the diversion gallery, installation of gate chamber equipment, and adaptation into a dry gallery 75 days
21 FORE-DAM AND DOWNSTREAM COFFERDAM 45 days
22 Embankment of the fore-dam 30 days
23 Embankment of the downstream cofferdam 15 days
24 SIDE SPILLWAY WITH A CHUTE AND STILLING BASIN 785 days
25 Excavation 158 days
26 Concreting of the stilling basin 40 days
27 Concreting of the chute with transition section 105 days
28 Concreting of the spillway with a bridge 80 days
29 Grouting of the spillway 25 days
30 EMBANKMENT DAM 697 days
31 Excavation for the dam and injection gallery before river diversion 110 days
32 Excavation for the fore-dam, cofferdam, dam, and injection gallery after river diversion into the diversion gallery 40 days
33 Consolidation-grouting in the foundation of the clay core of the dam 15 days
34 Concreting of the injection and tunnel gallery 113 days
35 Installation of clay 111 days
36 Installation of fine filter 111 days
37 Installation of coarse filter 111 days
38 Installation of stone for the supporting body 140 days
39 Installation of transition 140 days
40 Installation of upstream rip-rap lining 140 days
41 Installation of downstream rip-rap lining 140 days
42 Grouting of the dam - drilling of boreholes 85 days
43 Grouting of the dam - grouting procedure 135 days
44 DOWNSTREAM PLATEAU 25 days
45 FINAL WORKS ON THE WATER INTAKE TOWER 60 days
46 COMMAND BUILDING 75 days
47 INSTALLATION OF EQUIPMENT IN THE COMMAND BUILDING, GATE CHAMBER AND TOWER 129 days
6/30
Critical
Task
Split
Split Critical
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Progress
Deadline

Figure 11 - Construction schedule as presented in the Design for Construction Permit (Source: Design for Construction Permit)

The work will begin with the construction of temporary site roads to access the dam profile and the deposits of construction and excavated material, as well as the adaptation of existing dirt roads for the movement of construction and transport machinery. Simultaneously, the construction of the permanent road will start, which branches off from the existing asphalt road downstream and is traced to the dam crest along the left bank of the dam. This road is intended to be a permanent access road to the dam crest from the downstream side after the completion of the dam and structures.

Due to the large amount of excavation (~110,000m3) and the location of the spillway, which is not in the Ub riverbed, the spillway excavation will begin the earliest, at the beginning of March of the first construction year. Due to the inaccessibility of the terrain on the right bank for the formation of side construction roads to access the highest excavation levels, the excavation will be carried out from the location of the stilling basin, i.e., the terrain elevation 130.0m, with frontal excavation towards the highest spillway levels. This will form an access ramp along the rapid flow and transition section to the highest elevation 155.00m along the spillway axis, which will also serve as a construction road for transporting excavated material to temporary excavation deposits D1a and D1b. The spillway excavation is expected to last 6 months, until the end of August of the first construction year.

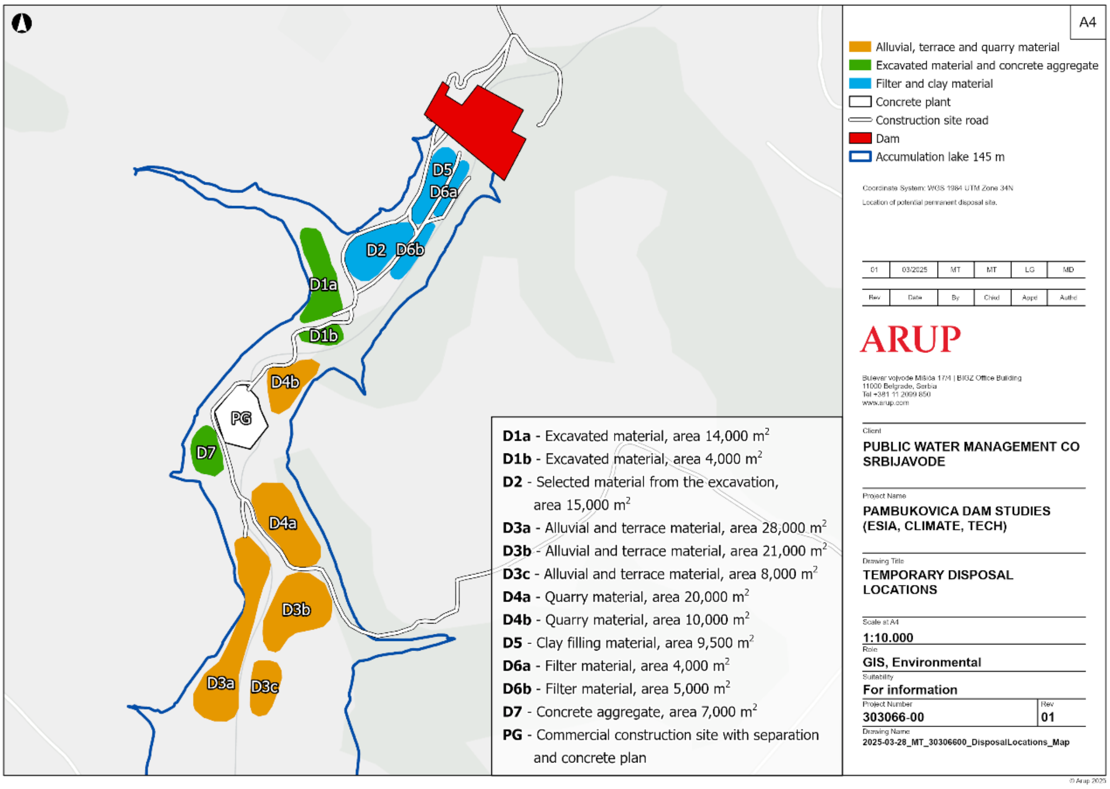

Figure 12 - Location of the temporary deposit areas

When the spillway excavation reaches elevation 150.50m (spillway plateau elevation), the excavation of the diversion gallery can begin. The diversion gallery excavation is scheduled to start in July and be completed by the end of August of the first construction year, coinciding with the completion of the spillway excavation.

During the summer of the first construction year, when the water level of the Ub river and existing watercourses is low, and before the river diversion and the start of major dam works (second construction year), the riverbed will be regulated downstream of the dam for about 800m. The purpose of this regulation is to allow the diverted river flow from the diversion gallery to be smoothly accepted during the construction period.

The protection of the dam construction works also requires the regulation of a torrential stream that appears in a deep ravine on the left bank of the terrain, downstream. In this regard, during the summer months of the first construction year, a concrete structure of a closed/open channel will be constructed to channel the waters from the ravine. Additionally, a channel will be constructed to regulate the Ub riverbed in the dam area, which continues into the channel section of the introduced waters from the ravine. All mentioned works on the regulation of the river and watercourses are planned to be carried out from June to August of the first construction year.

The concreting of the diversion gallery will begin after the excavation is completed, in September of the first construction year, and will be partially completed by the end of the year. The continuation of the concreting of the diversion gallery (entrance structures, transition sections, gate chamber, and stilling basin of the bottom outlet) will begin in March of the second construction year and will be completed, along with grouting, by the end of June, when the river diversion is planned.

The excavation for the left bank of the dam, being at higher elevations and outside the riverbed, can start in August of the first construction year. Along with this excavation, part of the excavation for the dam foundation, fore-dam, and downstream cutoff, the core trench of the fore-dam and dam, as well as part of the excavation for the grouting gallery, will be carried out. These works will be performed outside the riverbed. The completion of this part of the excavation is planned by the end of the first construction year.

In the second year of construction, at the beginning of July, the river is planned to be diverted into the diversion gallery, creating conditions for the continuation of the dam and other structures' construction in dry conditions. From July to the end of the second year of construction, the concreting of the stilling basin, rapid flow, and transition section of the side spillway will be carried out. Considering that, upon completion of the dam construction, one part of the diversion gallery will be adapted into the dam's bottom outlet/evacuator, and the other into a dry gallery, all construction works related to the diversion gallery and bottom outlet must be completed before the river diversion, i.e., by June 30th in the second year of construction.

In this regard, all works in the second year of construction related to the concreting of the entrance structure, transition section, and stilling basin of the bottom outlet as well as the grouting of the diversion gallery with the associated intake part and downstream gate chamber must be critical activities and must be completed before the river diversion. Additionally, the works after the river diversion (second half of the second year of construction) related to the excavation for the fore-dam, cutoff, part of the dam excavation, and grouting gallery, as well as the grouting in the clay core foundation of the dam, must be completed before the concreting of the grouting gallery and must be critical activities.

By the end of the second year of construction, simultaneously with the mentioned works on the spillway, the excavation for the dam, fore-dam, and part of the grouting gallery that could not be done in the first year due to the presence of the river flow will continue, followed by consolidation grouting in the dam foundation and concreting of part of the grouting gallery. Additionally, the filling of the fore-dam and downstream cutoff will be completed.

In the third year of construction, the concreting of the grouting gallery will continue, which is planned to be completed by April, when the dam filling will begin. Simultaneously with the dam filling, the concreting and grouting of the spillway and the bridge over the spillway will be completed. During the dam filling (from April to October), grouting of the dam will be carried out in the grouting gallery, and from the second half of the third year until the end of the year, works on the downstream plateau and control building, as well as equipment installation, will be carried out. The closure of the diversion gallery and the conversion of one part into the bottom outlet and the other part into a dry gallery for water supply will be carried out from the beginning of October until the end of the third year of construction.

The evacuation of large waters during the construction of the Pambukovica dam

The evacuation of large waters during the construction of the Pambukovica dam will involve diverting the Ub river into a reinforced concrete diversion gallery on the right bank of the dam profile, as well as constructing upstream and downstream cofferdams to protect the foundation pit from the influence of water from the riverbed upstream and downstream of the foundation pit.

The system is designed for the safe evacuation of large waters during the occurrence of a 20-year flood wave with a maximum flow rate of $Q5\%= 117\ m^3/s$. During this time, the diversion gallery will experience pressurized flow, while upstream of the foundation pit (upstream cofferdam) a water level estimated at 133.48 meters above sea level will be formed.

The diversion gallery with the intake will be converted into a bottom outlet after the construction of the main dam and adapted for the needs of water intake for the users of the reservoir. The upstream and downstream cofferdams will be constructed from embankment material and will, in the final phase of the construction of the Pambukovica dam, become integral parts of the main dam body.

6.1.2 Description of the expected construction works on the reconstruction of the State Road IB-21

The reconstruction and construction of State Road IB 21 involves several phases.

The first phase is road reconstruction, which includes raising the road level to ensure it remains above water during floods. This involves excavation, filling, and compaction of soil to achieve the desired elevation. Additionally, geometric corrections are made to adjust the road's geometry, ensuring traffic flow is maintained during construction. This includes realignment of curves, widening of lanes, and adjustments to road gradients. A new bridge is also constructed near the existing one, which is subsequently demolished. This involves foundation work, erection of bridge supports, installation of the bridge deck, and demolition of the old bridge.

The second phase focuses on infrastructure improvements. A controlled drainage system is installed to collect and treat stormwater before discharge. This involves the installation of drainage pipes, construction of catch basins, and implementation of water treatment facilities. A protective embankment up to 4 meters high is constructed to safeguard existing structures, involving earthworks, compaction, and installation of erosion control measures.

The third phase is traffic management, which includes implementing traffic signs, road markings, and safety barriers to ensure safe traffic flow. This involves the installation of traffic signals, painting of road markings, and placement of safety barriers. Intersections are modified to accommodate new road alignments and improve traffic safety, involving the redesign of intersection layouts, installation of traffic control devices, and construction of turning lanes.

The final phase addresses environmental considerations. Slope protection is achieved using stone lining to prevent erosion, involving the placement of stones along slopes, installation of retaining walls, and vegetation planting. Proper treatment of stormwater is ensured before it is released into the environment, involving the construction of water treatment facilities, monitoring of water quality, and maintenance of treatment systems.

6.1.3 Materials and borrow pits

The quantity of clay material embedded in the core of the dam, the fore-dam, and the downstream screen of the downstream embankment (drainage toes) is approximately 56,500 m^3. Considering that the excavated quantity of clay material from the borrow pit is in a loose state and needs to be compacted during installation, and taking into account the dispersion of material during transport, loading, and unloading, the required quantity of clay material from the borrow pit in a loose state is as follows:

56,500 m^3 x 1.25 x 1.1 ~ 80,000 m^3 – the required quantity of loose clay at the borrow pit.

For the supporting bodies of the embankment dam and upstream fore-dam, terrace, alluvial, and crushed rock material from the excavation for the dam and associated structures (side spillway with rapid flow and stilling basin, dam, fore-dam, diversion gallery, injection gallery) will be used.

Considering that the excavated quantity of soft and rock material is in a loose state and needs to be installed in the supporting bodies, and taking into account the dispersion of materials during excavation, blasting, crushing, transport, loading, and unloading, the following quantity of material from the excavation in a loose state needs to be provided:

80.000 m3 x 1,35 x 1,10 ~ 120.000 m3 – the required quantity of loose material from excavation for the structures for the purpose of embankment of the dam and fore-dam.

For the supporting bodies of the embankment dam and upstream fore-dam, terrace and alluvial materials from the borrow zones within the accumulation area will be used.

Considering that the excavated terrace and alluvial materials from the accumulation area are in a loose state and need to be installed in the supporting bodies, and taking into account the dispersion of materials during transport, loading, and unloading, the required quantity of terrace and alluvial materials from the accumulation area in a loose state is as follows:

80.000 m3 x 1,35 x 1,15 = 125.000 m3 – the required quantity of loose terrace and alluvial material from the accumulation area.

The stone material for the embankment of the supporting bodies of the dam, the fore-dam, and the downstream cofferdam (supporting body of the downstream drainage toe), as well as the stone material for the lining of the upstream and downstream slopes of the dam, the stone material as a lining on the dam crest, the transit and drainage layer will be provided from the local limestone quarry Čučuge, which is in operation and is located about 5.5 km from the dam site.

The quantity of loose stone material for installation in the dam, fore-dam, and downstream cofferdam, which needs to be provided at the quarry, taking into account the dispersion of material during transport, loading, and unloading, is estimated at:

75.000 m3 x 1,45 x 1,15 ~ 125.000 m3 – the required quantity of loose stone material from the quarry.

The estimated quantity of installed material for filter layers (sandy and gravelly-sandy filter material) is about 47,000 m³. The sandy material for the fine will be provided by crushing stone material from the Čučuge quarry. Both of these borrow pits are located about 5.5 km from the dam site. filter layer can be provided from the "Kopovi Ub" company's deposits, while the coarse filter material (gravelly-sandy filter) will be provided by crushing stone material from the Čučuge quarry. Both of these borrow pits are located about 5.5 km from the dam site.

The total quantity of concrete to be installed in all concrete structures is about 35,500 m³. The aggregate for the concrete will be provided from the nearest quarry with separation Čučuge, located 5.5 km from the dam profile. A concrete plant with a capacity of 60 m³/h will be installed at the dam profile, with a temporary aggregate depot by fractions. Alternatively, ready-mixed concrete can be transported from the concrete plant in Ub.

Works Buildings	Excavation (m3)		Concrete (m3)	Reinforcement (t)	Fill (m3)						Grouting (m)	
	In soft ground	In rock			Clay	Filter		Excavated material	Material from the accumulation area	Stone material from the quarry	drilling	grouting
						Fine	Coarse					
Upstream forebay	-	-	-	-	5,838	2,191	2,491	11,500	11,500	9,800	-	-
Downstream apron	-	-	-	-	5,592	-	-	-	10,200	10,200	-	-
Optical gallery with an intake structure, shut-off valve and spillway of the outlet/foundation discharge	19,700	19,200	8,200	1,090	-	-	-	-	-	-	-	-
Dam, forebay, downstream apron, and grouting gallery	90,000	34,900	-	-	-	-	-	-	-	-	-	-
Dam with a grouting gallery	-	-	3,500	477	47,947	21,952	19,992	68,613	68,613	55,050	-	-
Side spillway with rapid flow and waterfall	31,000	78,000	21,200	2,312	-	-	-	11,509	-	1,600	-	-
Riverbed regulation	2,600	-	30	1	-	-	390	1,200	-	1,110	-	-
Channel in the sluice on the left side of the dam	3,600	3,600	1,100	99	-	-	357	4,712	-	1,008	-	-
Downstream platform	-	-	-	-	-	-	-	4,415	4,415	4,140	-	-
Grouting curtain below the dam, spillway, and in the sides	-	-	-	-	-	-	-	-	-	-	8,214	7,565
Water intake tower and bridge			1200	100								
Control building			155	15								
Consolidation grouting below the dam, spillway of the diversion gallery, water intake, and downstream shut off structure	-	-	-	-	-	-	-	-	-	-	3.216	2.542

Table 12 – Material quantities of the main work positions as presented in the Design for Construction Permit

6.1.4 Temporary infrastructures required for construction pruposes

Based on the provisional construction methodology presented in the Design for Construction Permit, temporary infrastructure and facilities will be required for execution of construction works. These will have the potential (volume and footprint) to impact the local topography, land use, landscape, soil and vegetation.

Following are envisaged:

- Offices - These are temporary structures set up on the construction site to house the project management team, engineers, and administrative staff. They are equipped with necessary office furniture, communication systems, and IT infrastructure to facilitate project planning, coordination, and management.
- Storage Areas - These are designated spaces for storing construction materials, tools, and equipment. Proper storage is crucial to prevent damage, theft, and to ensure that materials are readily available when needed.
- Workshops - These are areas where construction workers can perform tasks such as cutting, welding, and assembling components. Workshops are equipped with necessary tools and machinery to support various construction activities.
- Construction Camps - Considering the scope of work and the number of workers on the construction site, accommodation for workers is planned in existing accommodation facilities in Ub and Pambukovica. On the construction site, container-type accommodation is planned only for on-duty staff and security personnel.
- Other Necessary Facilities - This includes restrooms, break rooms, and first aid stations. These facilities ensure the well-being and safety of the construction team.
- Construction roads – see next chapter.

6.1.5 Construction roads and traffic flows during the construction phase of the Pambukovica Dam

In the Design for Construction Permit the routes of access roads and temporary construction roads for the transport of construction machinery and materials during construction have been provisionally defined in accordance with the technical solution concept and the terrain topography.

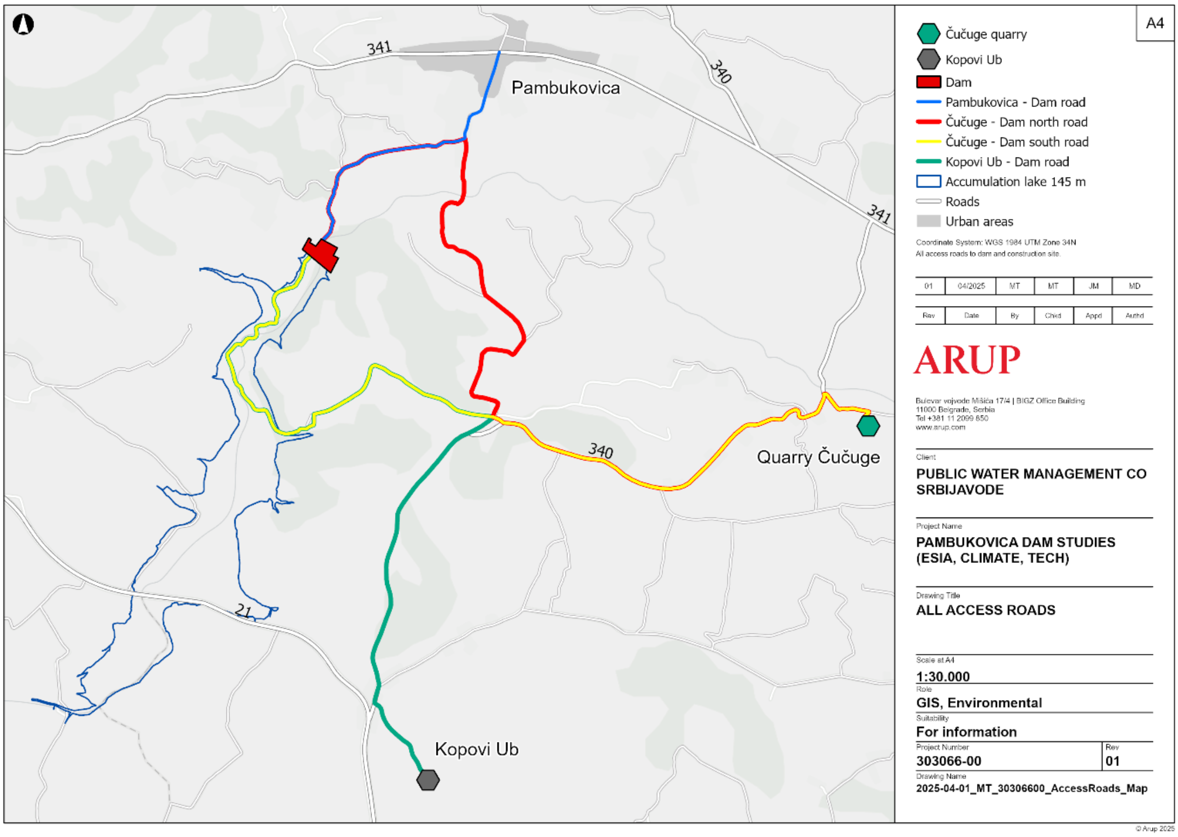

Figure 13 Provisional map of access roads

Generally, the right bank of the terrain at the dam site and upstream, up to about 800m from the dam site, is covered with dense forest that descends to the river. In the area of the spillway and diversion gallery, the bank is somewhat steeper and forested, making it difficult to construct construction roads upstream and downstream on the right bank to access the highest elevations during the works.

The left bank is more favourable in this regard, as the terrain upstream is flatter and without significant forest vegetation. Additionally, the borrow pits for construction materials (clay and terrace-alluvial material) from which material for the dam will be excavated are located upstream of the dam profile at 2-3 km.

Therefore, it is proposed that the construction material depots to be exploited from these borrow pits be formed upstream, up to 1.5-2 km, on expropriated agricultural parcels. Along this route, depots for stone material, concrete aggregate, and filter layers (sand and gravelly material) will also be formed, which will be procured from the Čučuge quarry and the Kopovi Ub company. The construction site with the concrete plant and other facilities will be located in the immediate vicinity of the concrete aggregate depot. Due to all the above, the greatest presence of construction roads will be upstream, on the left bank. They will be formed to connect the mentioned material depots and the construction site with the dam profile, i.e., they will be used for the transport of construction materials from the depots to the installation site. The width of the construction roads between the depots will be 7m, considering that larger tipper trucks and dumpers, as well as concrete mixers for transporting fresh concrete, will move along them.

In addition to temporary construction roads, the permanent newly designed road to the dam crest will be built before the start of excavation for the dam and will serve as a construction road connecting the downstream and upstream sides. Namely, when excavation for the dam foundation begins, communication between the upstream and downstream sides via existing roads passing through the dam profile will be interrupted. The transport of excavated material from the downstream side to the excavation depot D1a and D1b 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 construction site to the concreting locations (spillway, diversion gallery, injection gallery).

Table 13 List of temporary and permanent Project roads

Upstream Construction Roads (Left Bank):	
S1	Construction road from excavation dumps D1a and D1b to terrace-alluvial material dumps D3a, D3b, and D3c.
S2	Construction road from the dam site to the selected material dump from excavation D2.
S3	Construction road from the dam site to the filter material dumps D6a and D6b.
PP1	Temporary road from the dam crest location on the left bank to the downstream terrain.
S4	Adaptation of the existing road that connects the upstream and downstream sides of the terrain.
S5	Construction road to the entrance structure of the diversion gallery.
Downstream Construction Roads:	
S6	Construction road from the existing road to the spillway and bottom outlet stilling basin.
S7	Construction road in the form of an access ramp from the spillway stilling basin along the chute and transition section to the highest elevation of 155.00 meters above sea level along the spillway axis.
P1	Permanent road downstream to the dam crest.

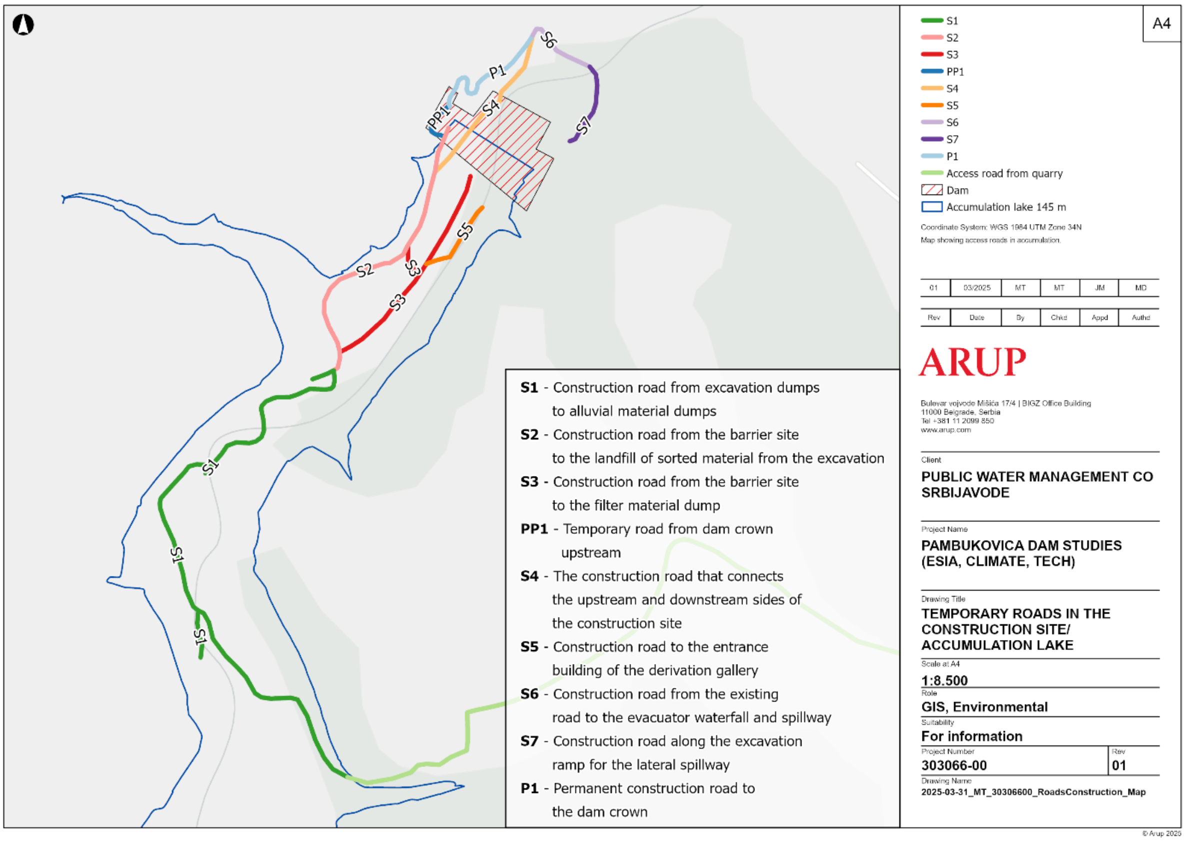

Figure 14 Map of proposed construction site roads

6.1.6 Spoil disposal areas

Spoil deposit areas have not been defined at this stage of the Project. Deposit of spoil material at location of existing borrow pits and quarry have been mentioned as options, no confirmation has been provided in project documentation or by the PWMC Srbijavode.

6.2 Operation

Detailed information about the Pambukovica Dam proposed operational rules are provided in the separate document Operational Rules, developed as a part of the Technical Assessment.

6.2.1 Daily operations

The daily operations of the Pambukovica Dam are designed to ensure a balance between water supply, water demand, and ecological requirements. The operational rules are flexible to account for changing water supply due to climate variability and longer-term climate change.

6.2.1.1 Water Level Management

The reservoir water level will be maintained between minimum operational level of 138.5 meters above sea level (masl) and spillway level of 145.5 masl. For Phase 1, the typical operation level will be 138.5 masl – which represent the water level to provide enough capacity to ensure ecological flow throughout the year. For Phase 2 the water level will fluctuate between 138.5 masl and 145.5 masl, with the introduction of the need for irrigation. This will ensure that there is sufficient storage capacity to manage floods, provide water supply for irrigation and ensure ecological flows. The water level will be regulated through the operation of the bottom outlet, which will be controlled to maintain the desired water level.

6.2.1.2 Flood Management

During high flow periods, the bottom outlet will be used to control the discharge of water to prevent downstream flooding and minimize the risk of dam overtopping. The gate percentage opening is limited to discharge no more than 50 cubic meters per second (m^3/s) during normal operations. In case of a reservoir safety emergency, the bottom outlet can be operated at full capacity to protect the integrity of the dam.

The flood management strategy for the Pambukovica Dam project is divided into two phases:

- Phase 1: Flood Control and Ecological Discharges
- Phase 2: Irrigation, Flood Control, and Ecological Discharges

Various scenarios have been modelled to check the available drawdown time ahead of flood hydrographs arriving at the reservoir. The scenarios include different flood events with and without sediments and with climate change for the 100-year flood and 50-year flood.

Implementation of flood forecasting, surveyance, and monitoring are essential for effective flood management. This includes inflow monitoring, pre-flood reservoir drawdown procedures, and downstream warning.

6.2.1.3 Irrigation Supply

During the irrigation demand period, the reservoir will be kept at full supply level (145.5 masl) to meet agricultural demands. The irrigation discharge outlet, with a capacity of up to 1,380 l/s, will be used to supply water for irrigation. The reservoir will be drawn down ahead of incoming storms to create storage capacity for flood management.

6.2.1.4 Sediment Management

Srbijavode would implement the watershed management that could comprise:

- Implementation of anti-erosion measures to related to grazing, forests, plowing etc
- Construction of upstream sediment traps.
- Proposed anti-erosion measures are listed below:
  - 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.).

Seven upstream sediment traps planned are:

- Sediment Trap Dam 1 - Babinac Stream: Located in the Babinac Stream area
- Sediment Trap Dam 2 - Babinac Stream: Located in the Babinac Stream area.
- Sediment Trap Dam 3 - Joševa River: Located in the area of the Joševa River.
- Sediment Trap Dam 4 - Joševa River: Located in the area of the Joševa River.
- Sediment Trap Dam 5 - Jasenovac Stream: Located in the Jasenovac Stream area.
- Sediment Trap Dam 6 - Medvednjak Stream: Located in the Medvednjak Stream area 1.
- Sediment Trap Dam 7 - Oglađenovačka River: Located in the area of the Oglađenovačka River

The sediment inflow into the reservoir shall be regularly monitored by doing regular bathymetric survey of the reservoir, especially accumulation of sediments in front of the intake and other outlets to risk of the intake gate blockage by sediments mitigated.

Proposed measures for the sediment's removal:

- flushing of sediment through the bottom outlet
- mechanical removal by dredging.

A balanced and integrated sediment management strategy that combines sediment traps, selective flushing in specific periods of the year and selective dredging when necessary has been recommended to optimize both environmental and social outcomes.

6.2.1.5 Monitoring and Maintenance

Continuous monitoring and maintenance activities are conducted to ensure the safe and efficient operation of the dam. This includes regular inspections, data collection, and analysis to detect any signs of deteriorating performance. The monitoring system includes visual inspections, instrumentation, and data interpretation to provide early detection of potential issues.

6.2.2 Power supply

Dam power supply during operation will be ensured through connection to the existing 10/0.4 kV substations "Pambukovica 1" and "Čučuge rudnik pumpa". The exact location of the transformer station and separate 10 kV line will be determined by the next stages of project documentation and the requirements of the relevant power distribution company.

The voltage of 3x400/231V, 50Hz is intended for the primary and backup power supply. The method and conditions of the primary power supply, along with all accompanying regulations of the future 10/0.4 kV substation located at the dam, are defined in the Conditions of Elektrodistribucija Srbije doo, Belgrade, Branch Elektrodistribucija Valjevo, System Number ROPMSGI-21420-LOCA-3-HPAP-4/2022 dated January 20, 2022, for the preparation of technical documentation for the Pambukovica dam with accumulation on the Ub river. The primary power supply is provided from the distribution network (10 kV), with transformation through a self-consumption transformer, transmission ratio 10/0.4 kV, supplied from two sides:

- The first supply will be achieved through a 10kV overhead line that needs to be built, on reinforced concrete poles (aerial), from the existing 10kV line on reinforced concrete poles that serves to supply the

10/0.4 kV substation "Pambukovica 1". The new 10kV transmission line is approximately 2.1 km long and it is expected to be through underground cable. This is not the subject of this Project, but is considered as associated facility.

- The second supply will be achieved through a 10kV overhead line on reinforced concrete poles, which also needs to be built from the existing pole substation 10/0.4 kV "Čučuge rudnik pumpa". This new 10kV transmission line is approximately 0.4 km long and it is expected to be through underground cable. This is not the subject of this Project, but is considered as associated facility.

6.3 Decommissioning

Assumed dam lifetime is 80 years. At this moment no information is available on any plans for decommissioning.

Any decommissioning needs to take into consideration Pambukovica Dam place and role in the Kolubara Basin Scheme.

The decommissioning of the Project might involve removal of the dam and returning the river to its original state, but this is considered unlikely. The reservoir may have established a new valuable ecosystem also beneficial to residents of the valley. Therefore, any removal of the civil works may have considerable impact.

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

Key expected differences compared to construction phase include:

a. Dismantling of the dam structure and sediment traps,

b. Demolition activities,

c. Debris removal and disposal,

d. Sediment management,

e. Restoration of site and natural ecosystem.

Planning and preparation for decommissioning would need to be initiated at least 5 years before targeted start of decommissioning. This would allow time for preparation decommissioning project, which would include separate impact assessment for the decommissioning based on the site conditions at the time of decommissioning.

7. Climate

7.1 Temperature

The average air temperature in GMS Valjevo from 1991 to 2020 was 12°C (Figure 15). On average, the hottest month is July at 22.6°C, and the coldest is January at 1.1°C. The highest recorded temperature is 42.4°C, and the lowest is -23.2°C. On average, there are 78.5 frost days (with minimum temperatures below zero) and 38.9 tropical days (with maximum temperatures above 30°C) throughout the year. The average annual air temperatures at the GMS Valjevo from 1949 to 2021 show an increasing temperature trend after 1990 (Figure 16).

The year is classed as:

- the ‘cold’ season from October to March
- the ‘warm’ season from April to September

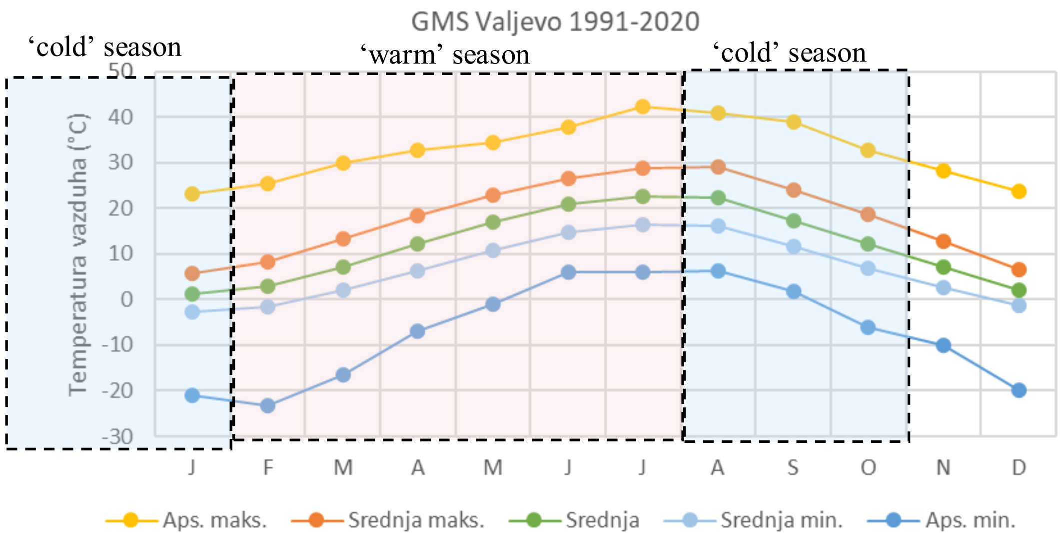

Figure 15 The monthly mean, minimum and maximum temperature variability in Valjevo (Source: 16018-PV-12)

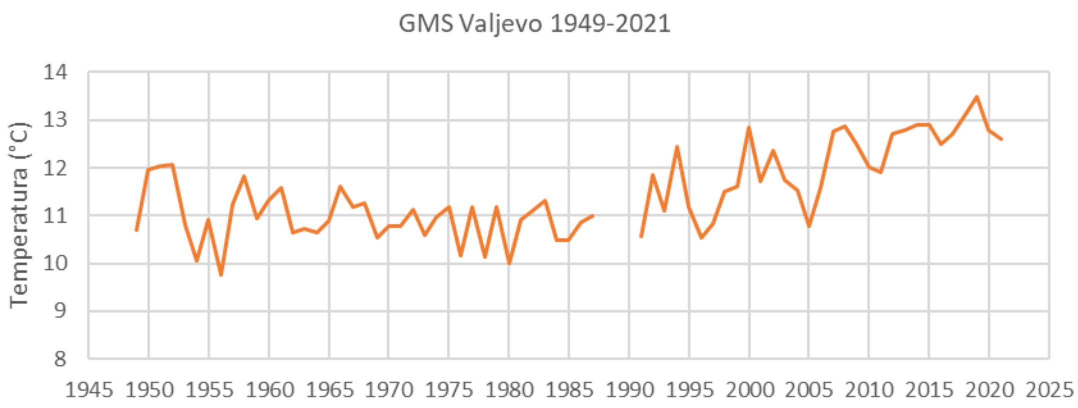

Figure 16 The average annual temperature trend in Veljevo from 1949 to 2021 (Source: 16018-PV-12)

7.2 Precipitation

The average annual precipitation at GMS Valjevo for the period 1991-2020 was 802 mm (Figure 17). The highest precipitation occurred in the warm part of the season in June, with an average of 103 mm of rain, while the lowest rainfall was in the cold part of the season in January, with an average of 49.3 mm. The average annual number of days with snow was 30.2. The highest daily precipitation during 1991-2020 was recorded in 2014 and amounts to 108.2 mm. The monthly total precipitation in May 2014 was 323.7 mm, which is 3.5 times higher than the May average. The 2014 event was synoptic in nature as a large-scale cyclone maintained presence over most of the Balkan's countries with slow trajectory movements.

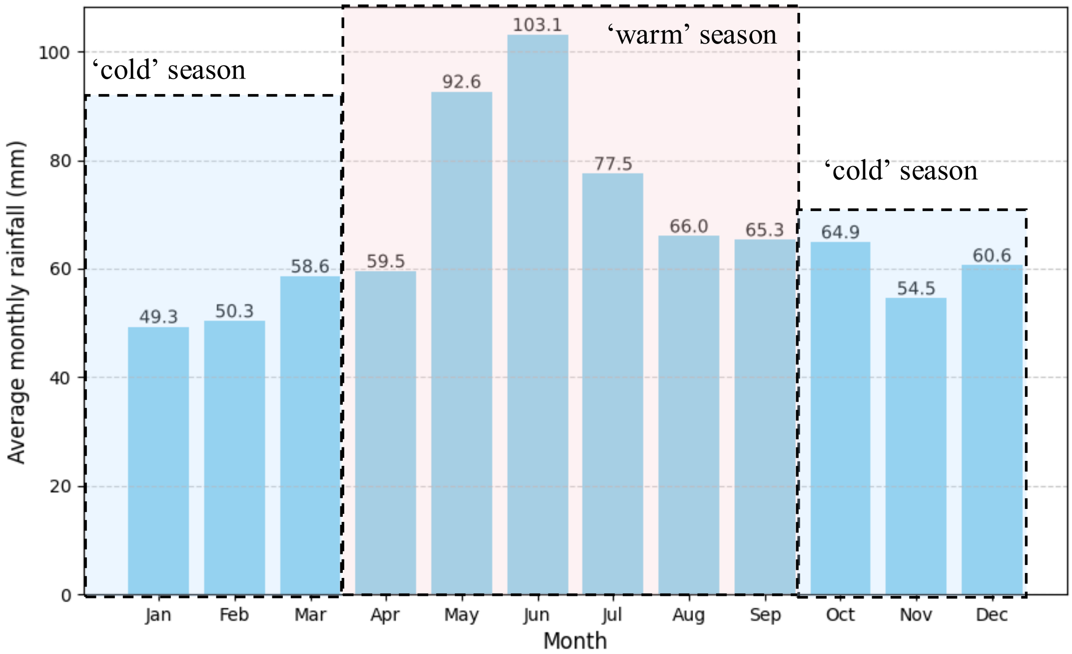

Figure 17 The average monthly precipitation at GMS Valjevo (1991-2020) (Source: Technical Assessment - Hydrology chapter)

7.3 Evaporation and transpiration

The average monthly evaporation from the water surface and potential reference evapotranspiration for 1991-2020 are highest in the warm part of the season in June, July and August (Table 14)

Table 14 Evaporation and potential reference evapotranspiration at GMS Valjevo (Source: 16018-PV-12)

The average evaporation from open water surfaces for GMS Valjevo. (mm/day)											
Jan	Feb	Mar	Apr	Maj	Jun	Jul	Avg	Sep	Okt	Nov	Dec
0.69	1.32	2.51	3.84	4.98	5.91	6.33	5.66	3.68	2.10	1.09	0.60
The average potential reference evapotranspiration for GMS Valjevo. (mm/day)											
Jan	Feb	Mar	Apr	Maj	Jun	Jul	Avg	Sep	Okt	Nov	Dec
0.41	0.87	1.73	2.70	3.56	4.28	4.60	4.09	2.58	1.39	0.68	0.35

8. Climate Change / Green Assessment

8.1 Overview

Climate change assessment has been prepared as a separate part of the Assignment, as a separate document, Green Assessment. Climate uplift has been taken into consideration as part of the hydrological analysis. Climate impacts have been taken into consideration and assess under individual topics, as required.

The Project is assessed as aligned with the goals of the Paris Agreement based on the outlined methodology. Specific assessments for climate adaptation and climate mitigation have been undertaken for Pambukovica Dam and reported on in this chapter.

8.2 Paris alignment assessment

8.2.1 Alignment with the mitigation goals of the Paris Agreement

A general screening against the mitigation goals of the Paris Agreement was undertaken which concluded that the Project is on the aligned list under the water supply and wastewater category, with no Project activities identified as 'non-aligned'.

A review against Serbia's Nationally Determined Contribution (NDC) and Low Emission Development Strategy determined that the Project does align with and contributes to some of the objectives outlined in these, including those related to improved irrigation and reduced flood risk. The country's energy policy also promotes energy efficiency in the water sector, in part through the installation of "water-efficient end-use equipment" and encourages support of schemes that promote energy efficiency in the agricultural sector, including irrigation systems.

A carbon lock-in test determined that there were no barriers identified to the use of renewable energy in the operation of the project and that the Project's overall lock-in risk can be considered low.

It has therefore been concluded that the Project is aligned with the mitigation goals of Paris Agreement (BB1 aligned).

8.2.2 Alignment with the adaptation goals of Paris Agreement

To define the current and future baseline, the assessment utilised historical climate data and climate projections from national, regional and site-specific sources where available. Sources included, but are not limited to, the World Bank Climate Change Knowledge Portal[2] and the Third National Communication of the Republic of Serbia to the United Nations Framework Convention on Climate Change[3].

A summary of the current and future climate conditions for Serbia and the Kolubara District is provided in Table below. Where reference is made to SSP2-4.5 and SSP5-8.5, the future projections represent the 50th percentile (or median) of the 6th phase of the Coupled Model Intercomparison Project CMIP6.

The key to the overall trend is as follows:

⬆ (red)	Increasing, negative impact	⬆ (green)	Increasing, positive impact
⬇ (red)	Decreasing, negative impact	⬇ (green)	Decreasing, positive impact
⟺ (orange)	No significant change		

[2] World Bank Climate Change Knowledge Portal: Serbia (2024). Available at: https://climateknowledgeportal.worldbank.org/country/serbia/climate-data-projections

[3] UNFCCC: The Third National Communication of the Republic of Serbia to the United Nations Framework Convention on Climate Change (2022). Available at: https://unfccc.int/sites/default/files/resource/3NC_Serbia.pdf

Table 15: Summary of baseline and future climate hazard conditions for Serbia and the Kolubura District

Climate hazard	Baseline	Projected change (time period)			Overall Trend
		2040-2059	2060-2079	2080-2099	
Wildfire	According to ThinkHazard, the Kolubara District is located in an area identified as having a high susceptibility to wildfires.	There is more than a 50% chance of weather events that could support a significant wildfire in the Kolumbara Province in any given year.			
Extreme wind	Data available on wind is limited. According to the Global Wind Atlas, winds from the northwest and west prevail during the warmer parts of the year. In the colder part of the year, the east and southeast Košava wind prevails, and winds from the southwest prevail in the mountainous areas of southwestern Serbia.	Changes in wind speed as a result of climate change are difficult to predict and are affected by high levels of uncertainty.			N/A
Precipitation patterns and changes	According to the World Bank Climate Change Knowledge Portal , the mean annual precipitation (1995 - 2014) in Serbia is 788.5mm, and in the Kolubara District it is 863.5mm.	Future projections for the period 2040-2059 under the SSP2-4.5 scenario in the Kolubara District indicate a projected average annual precipitation of 838.3mm. For the SSP5-8.5 scenario the projected average annual precipitation is 810.3mm.	Future projections for the period 2060-2079 under the SSP2-4.5 scenario in the Kolubara District indicate a projected average annual precipitation of 833.5mm. For the SSP5-8.5 scenario the projected average annual precipitation is 777.1mm.	Future projections for the period 2080-2099 under the SSP2-4.5 scenario in the Kolubara District indicate a projected average annual precipitation of 831.4mm. For the SSP5-8.5 scenario the projected average annual precipitation is 750.5mm.	
Heavy precipitation and flooding	According to the World Bank Climate Change Knowledge Portal , for the 1995-2014 period, the annual average largest 1-day precipitation was 24.9mm. The projected average largest 5-day cumulative precipitation was 57.7mm.	Future projections for the period 2040-2059 in the Kolubara District; the projected average largest 1-day precipitation under the SSP2-4.5 scenario is 26.0mm. For the SSP5-8.5 scenario the projected average largest 1-day precipitation is 26.8mm.	Future projections for the period 2060-2079 in the Kolubara District; the projected annual average largest 1-day precipitation under the SSP2-4.5 scenario is 26.8mm. For the SSP5-8.5 scenario the projected average largest 1-day precipitation is 27.4mm.	Future projections for the period 2080-2099 in the Kolubara District; the projected annual average largest 1-day precipitation under the SSP2-4.5 scenario is 26.5mm. For the SSP5-8.5 scenario the projected average largest 1-day precipitation is 28.7mm.	

Climate hazard	Baseline	Projected change (time period)			Overall Trend
		2040-2059	2060-2079	2080-2099	
	According to ThinkHazard, the river flood rating and urban flood hazard ratings for the Kolubara District are assigned as low to medium. This means that there is a chance of a potentially damaging and life-threatening river flood expected to occur at least once in the next 10 years, and more than 20% that potentially damaging and life-threatening urban floods occur in the coming 10 years.	For the future projections for the period 2040-2059 in the Kolubara District, the projected average largest 5-day cumulative precipitation under the SSP2-4.5 scenario is 58.5mm. For the SSP5-8.5 scenario the projected average largest 5-day cumulative precipitation is 60.5mm.	For the future projections for the period 2060-2079 in the Kolubara District, the projected average largest 5-day cumulative precipitation under the SSP2-4.5 scenario is 60.8mm. For the SSP5-8.5 scenario the projected average largest 5-day cumulative precipitation is 58.7mm.	For the future projections for the period 2080-2099 in the Kolubara District, the projected average largest 5-day cumulative precipitation under the SSP2-4.5 scenario is 59.1mm. For the SSP5-8.5 scenario the projected average largest 5-day cumulative precipitation is 61.7mm.	
Drought	According to ThinkHazard, the water scarcity hazard rating is assigned as medium to high, meaning there is up to 20% chance droughts will occur in the coming 10 years. According to ThinkHazard, the drought risk in the Kolubara District is assigned as medium to high, relative to global drought risk. No return period is available for this score, instead precipitation, land use, social, economic and infrastructural factor are taken into account.	For the future projections for the period 2040-2059 in the Kolubara District, the projected maximum number of consecutive dry days under the SSP2-4.5 scenario is 18.6 days. For the SSP5-8.5 scenario the projected maximum number of consecutive dry days is 19.7 days.	For the future projections for the period 2060-2079 in the Kolubara District, the projected maximum number of consecutive dry days under the SSP2-4.5 scenario is 19.1 days. For the SSP5-8.5 scenario the projected maximum number of consecutive dry days is 22.5 days.	For the future projections for the period 2080-2099 in the Kolubara District, the projected maximum number of consecutive dry days under the SSP2-4.5 scenario is 20.5 days. For the SSP5-8.5 scenario the projected maximum number of consecutive dry days is 22.5 days.	⬆
Erosion	It is understood erosion is an issue as a result of inappropriate land use management (e.g., unsustainable agriculture practices). A comprehensive assessment of landslide risks in the reservoir	Future projections of changes in temperature and rainfall as a result of climate change could increase the occurrence of erosion.			⟷

Climate hazard	Baseline	Projected change (time period)			Overall Trend
		2040-2059	2060-2079	2080-2099	
	area identified evidence of selective and planar erosion[4].				
Landslides	According to ThinkHazard, the landslide hazard rating for the Kolubara District is assigned as medium, meaning that there are conditions that contribute to making localised landslides an infrequent hazard phenomenon. A comprehensive assessment of landslide risks in the reservoir area concluded that the overall risk associated with landslides is low to moderate[4].	The Kolubara District has a medium risk for landslides to occur. Climate change has the potential to affect landslide risk through changes in temperature and precipitation but these are difficult to project.			N/A

[4]Arup (2025). 2024_H203_D3.6 Landslides Assessment

The exposure to the climate impacts and sensitivity of the Project and downstream where receptors were assessed, as shown in Table 16.

Table 16: Exposure and sensitivity rating for the Project and downstream receptors

Climate Hazard	Exposure Rating	Sensitivity Rating					
		Reservoir and Dam	Spillway	Guard house and Instrumentation	Downstream Communities	Agriculture and Industry	Ecological Receptors
Extreme high temperatures	Probable	Low	Low	Low	Low	Low	Low
Extreme low temperatures	Plausible	Low	Low	Low	Low	Low	Low
Forest fires	Plausible	Low	Low	Medium	Low	Low	Medium
Extreme wind	Plausible	Medium	Medium	Low	Low	Low	Low
Heavy precipitation and flooding	Plausible	High	High	Medium	High	High	High
Drought and increased water stress	Probable	Low	Low	Low	Low	Medium	Medium
Erosion	Plausible	Medium	Medium	Low	Low	Low	Low
Mass movement	Plausible	Medium	Medium	Medium	Medium	Medium	Medium

The assessment concluded that heavy precipitation and flooding are likely to have a major im-pact on the reservoir and dam, as well as the spillway and all three downstream receptors de-pending on their design parameters.

For the reservoir and dam, run-off from the uplands may compromise water quality and in-crease the eutrophication risk. In addition, storage requirements may become higher – and re-leases more frequent - as larger volumes of precipitation fall over shorter periods. For the spillway, higher rainfall events may lead to increased peak flows into the impounding reservoir which can lead to overtopping or spillway failure. In addition, higher or more frequent flows may increase the transport of debris, potentially damaging or blocking the spillway.

Overtopping would present a risk to individuals and buildings in the path of the flood waters. Similarly, a significant, heavy precipitation would have negative consequences for agricultural land and industry, in the event that flood waters cause damage to property or crops. The Biodiversity Chapter of the ESIA outlines in detail the results of the assessment conducted as part of this work. In summary, the primary environmental impacts associated with construction phase are associated with habitat loss, habitat and species disturbance through noise and vibration, pollution of land and water, the introduction and/or spread of invasive species, as well as sever-ance and limited movement of wildlife due to habitat fragmentation and construction activities. The operational phase of the dam presents long-term environmental changes, particularly due to altered river hydrology and flow regimes, habitat fragmentation, and changes in water quality. During both phases, mitigations are outlined to reduce the impact significance.

A comprehensive hydrological analysis, detailed in the Technical Assessment, has also provided detailed insights into the impact of climate change on flood risk, including in relation to peak flows and sediment transport and accumulation.

Briefly, a climate change design uplift value of 9% has been used, based on the climate change model ensemble median over the Ub catchment from scenario SSP2-4.5 (Technical Assessment). This is a similar value to SSP3-7 ensemble median over Kolubara catchment from the World Bank Climate Change Portal.

For residual risk and sensitivity testing, a climate change uplift value of 15% has been used, based on the ensemble median over the Kolubara catchment from scenario SSP5-8.5 from the World Bank Climate Change Portal.

Calculating risk as Exposure ×Sensitivity has resulted in the risk rating outlined in Table 17. The rating considers current and future climate conditions that may occur across the project lifecycle. For the purpose of this assessment, risks identified as 'High' are considered material and, accordingly, resilience measures were identified to reduce the materiality of these risks.

Table 17: Risk ratings for the Project and receptors located downstream of the Project

Climate hazard	Risk rating (Exposure x Sensitivity)					
	Reservoir and Dam	Spillway	Guard house and instrumentation	Downstream communities	Agriculture and industry	Ecological receptors
Extreme high temperatures	Medium	Medium	Medium	Medium	Medium	Medium
Extreme low temperatures	Low	Low	Low	Low	Low	Low
Forest fires	Medium	Medium	Medium	Low	Low	Medium
Extreme wind	Medium	Medium	Low	Low	Low	Low
Heavy precipitation and flooding	High	High	Medium	High	High	High
Drought and increased water stress	Medium	Medium	Medium	Medium	High	High
Erosion	Medium	Medium	Low	Low	Low	Low
Mass movement	Medium	Medium	Medium	Medium	Medium	Medium

8.2.3 Identification of recommended climate resilience measures

To mitigate against heavy precipitation and flooding events, the Technical Assessment, under-taken in parallel with this Green Assessment, drew the following conclusion in relation to miti-gating against heavy precipitation and flooding events, specifically a 1-in-10,000-year probable maximum flood (PMF) event. This list is not exhaustive, and more detail is provided in the Technical Assessment.

- Construction of seven sediment traps (2 – 3 m in height), 85 double living braids, a 10 m grass belt around the reservoir and afforestation in the upstream catchment to reduce the sediment inflow in the reservoir
- Construction of a 1.5m high wave wall on the dam crest to enhance the freeboard up to 2 meters above the PMF water level. The top elevation of the wave wall is proposed to be at 152 masl, 1.5 meters above the dam crest at 150.5 masl.
- Raising the side walls in the upstream section of the chute by 1m over a length of 41m on both sides to avoid overflow.

- Increasing the clear height of the culvert for inspection from 1.5 meters to at least 2.2 meters.
- Operating the bottom outlet at full capacity only in emergencies, and limiting normal opera-tion to 50 m^3/s to correspond with the flood protection standard in the town of Ub.

In addition to the recommendations above relating to heavy precipitation and flooding, a set of recommendations was compiled to address the risk of drought and increased water stress on downstream receptors. They include:

- Water use priorities and schedules during periods of drought, ecological releases to meet downstream requirements to ensure that flow patterns for maintaining riverine habitats and other hydro-ecological requirements are clear in the reservoir operation rules.
- A maximum 100 l/s should be discharged either via the bottom outlet or the irrigation pipe

As noted above, please refer to the Technical Assessment for additional information related to these findings.

8.2.4 Appraisal of the broader climate resilience context

In assessing the broader climate resilience context, the following conclusions can be drawn:

- The Project is likely to reduce flood risks significantly, thereby improving safety for approximately 50,000 residents in flood-prone areas and safeguarding approximately 10,000 hectares of productive farmland.
- Once operational, the spillway is designed to mitigate a 1:10,000yr flood event, while the stilling basin is designed to mitigate a 1:1,000yr flood event[5]. As a result, the damages avoided from a 1-in-50 year flooding event would amount to approximately €0.6 million in the Ub watershed[6], which has a history of severe flooding, including the catastrophic May 2014 flood.
- The Project is likely to increase irrigation efficiency and agricultural productivity by ensuring a consistent supply for 2,225 hectares of agricultural land, even during prolonged dry periods, stabilising yields and supporting high-value crop cultivation.
- Improved irrigation potential due to better water management can yield an additional €2 million annually in agricultural profit, bolstering local and regional economies and reducing the economic vulnerability of over 200,000 residents and businesses within the basin.
- Climate change may exacerbate water scarcity, making it crucial to implement adaptive management strategies to ensure sustainable water management and use.

8.3 Climate Change mitigation – CO2e impact analysis

The CO_2e impact analysis relied on the use of the GHG Reservoir Tool (G-res Tool) which is based on the principles agreed on by IPCC for net reservoir emissions. When assessing the CO_2e for a reservoir a whole catchment approach was followed to account for the terrestrial areas which act as net carbon sinks.

The calculation used in this assessment to define the net GHG footprint is:

$$\begin{aligned} &Net\ GHG\ Footprint \\ &= [Postimpoundment\ GHG\ balance\ from\ catchment\ after\ introduction\ of\ reservoir] \\ &- [Preimpoundment\ GHG\ balance\ of\ catchment\ before\ introduction\ of\ reservoir] \end{aligned}$$

The pre-impoundment GHG balance relied on an assessment of the landscape while post-impoundment GHG balance relies on an analysis of semi-empirical models based on existing datasets. The net GHG emissions from the reservoir results from summing all the sources of post-impoundment emissions (i.e. CO_2 emissions and CH_4 emissions). The post-impoundment emissions are expressed in the G-res as areal emissions

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[5] Arup (2025) Environmental and Social Impact Assessment, Climate Change Assessment and Technical Assessment for Pambukovica Dam in Serbia

[6] Energoprojekt–Hidroinženjering a.d. (2018) Construction of "Ub" Irrigation System Feasibility Study.

($gCO_2e/m^2/yr$) and as reservoir wide emissions (tCO_2e/yr) merged as GHG emissions but also separately as CO_2 and CH_4. A global warming potential for 100 years was used to obtain CH4 emissions as CO_2e.

The outputs indicate the post-impoundment areal emissions are limited. Pre-impoundment emissions are higher due to the pre-impoundment area land cover including forest. The reservoir emission over 50 years is 8,427 tCO_2e/yr (Table 18). The proportion of reservoir emissions due to CH4 post impoundment is approximately 96.5%, or 8,132 tCo2e/yr, due to the presence of forests and cropland in the pre-impoundment catchment. This is considered on average comparable to worldwide reservoirs.

Table 18: G-res outputs for Pambukovica Dam

Total net GHG footprint		
Total reservoir emissions at year 1	13,992	tCO_2e/yr
Total reservoir emissions at year 50	8,427	tCO_2e/yr
Reservoir net GHG footprint by pathway		
Emission rate of which CO_2	295	tCO_2e/yr
Emission rate of which CH_4	8,132	tCO_2e/yr

8.4 Green Economy Transition (GET) Assessment

Table 19 outlines the GET outcomes anticipated for the Project on the basis of the cost-benefit analysis undertaken as part of the 'Construction of Ub Irrigation System Feasibility Study'. We valorised the 'Increased agricultural potential' and 'Reduced damage from flooding' GET Climate Resilience Outcomes (CRO) as these have both been identified as benefits the project will deliver.

In relation to 'Reduced damage from flooding', it is noted that the calculated average annual avoided damage caused by the Ub River floods with the return period of 1 in 50 years amounts to approximately €0.6 million. For the increased agricultural potential, the cost-benefit analysis utilised a single representative cropping structure (substituting maize for fruit production) which only partly altered the cropping mix in the region.

We also identified that the Project would deliver benefits in relation to increased water availability, but we have not calculated this CRO as it would be considered as double counting if considered in addition to increased agricultural potential.

Table 19: GET Climate Resilience Outcomes (CRO) for the Project as outlined in the Feasibility Study cost-benefit analysis

GET Outcome	Valorisation of GET CRO
Increased agricultural potential (Net benefits from irrigation in € per year)	Year 1 - €132,610 Year 2 - €1,321,205 Year 3 - €3,534,635 Year 4 - €5,584,305 From Year 5 - €5,787,225
Reduced damage from flooding (Average annual avoided flood damage for return period 1 in 50 years)	€0.6 million

9. Hydrology / Environmental Flow

Hydrological analysis has been prepared as a separate document, as a part of the Technical Assessment Report Appendix 1. Hydrological impacts have been taken into consideration and assess under individual topics, in particular ESIA Volume I Book 3 Surface Water and Book 4 Biodiversity Impact Assessment.

The Ub river experiences seasonal flooding, particularly during periods of intense rainfall or rapid snowmelt in the spring. This natural phenomenon can affect nearby agricultural lands and settlements. The historic annual average mean discharge for the period 1960-2014 was determined as 0.72m3/s.

9.1 High flow

For high flows there is concern/risk that part of flow cannot be measured beyond the main channel as the capacity is overwhelmed, bypass flows form through town, and accurate gauging is not possible. Currently the only recorded event that has exhibited bypass flows is the 2014 flood event. The observed value at station Ub by RHMS was 146m3/s and the value used for the hydrological study is 214m3/s. This value is not observed but calculated as part of the hydrological model in an effort to calibrate the flow with flooding lines. The hydrology analysis report states that this difference is likely due to bypassing flows in town Ub around station Ub. As part of this work, a sensitivity analysis was conducted with a dataset including both values (observed and modelled) and results were reported as being within less of 10% standard measure of deviation. Mean minimum flows for 50% assurance is 38l/s

9.2 Average flow

Average flow for a 1970 wet year was 2.71 m3/s and for a 1990 dry year was 0.22 m^3/s. Average flow in the dam profile is 0.68 m^3/s

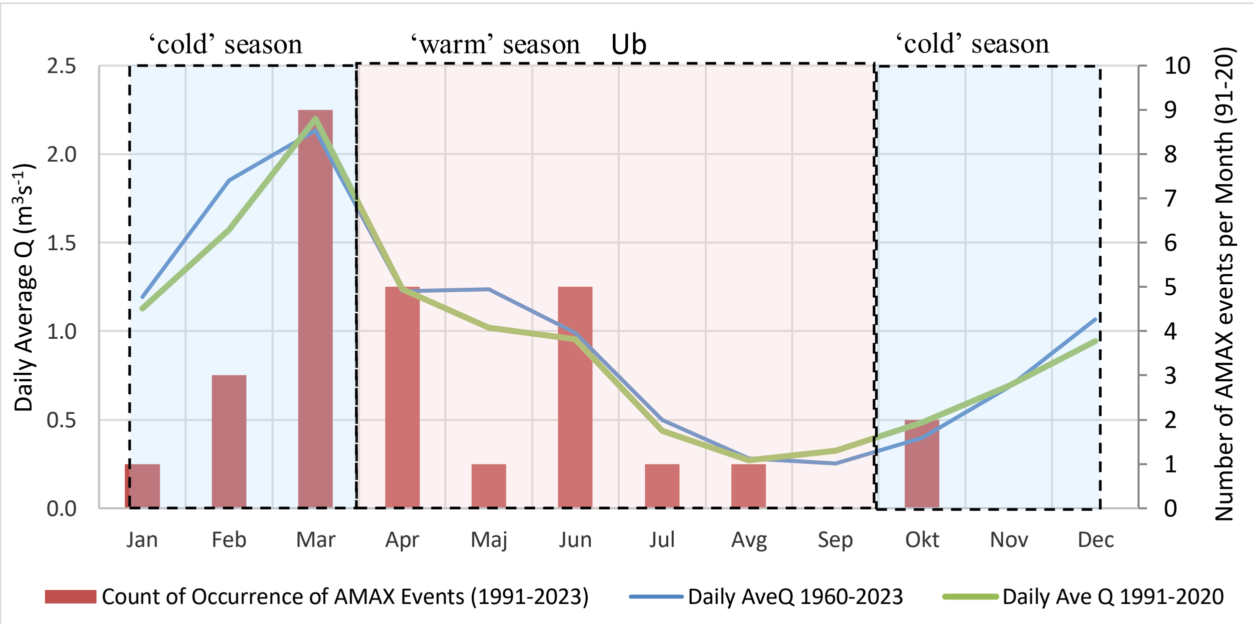

Figure 18 Monthly average daily average flows recorded at Ub gauging station for the periods 1960-2023 (blue) and 1991-2020 (green) and count of monthly occurrence of Annual Maximum flow for years between 1991-2020 (Source: Hydrology report)

9.3 Serbian minimum flow

The Guaranteed national ecological/minimum flow was determined using the GEP Serbian standard method. The method requires a higher flow in summer to support fish spawning. This flow is required to adhere with the Serbian legislation and calculated flow was as follows:

- For the cold season (i.e. October to March): Qe = 68 l/s
- For the warm season (i.e. April to September): Qe = 102 l/s

Hereafter, these Qe flows are termed the 'Serbian minimum flows' to distinguish it from actual operations flow that will present in the River Ub downstream. For the purposes of the ESIA, the 'operational flows' (as presented for Phase 1 and to be created for Phase 2) have been assessed as these constitute the environmental flow (E-flow) for the purposes of the assessment and Lender compliance. As per Work Bank guidance E Flows are defined as *the quantity, frequency, timing, and quality of water and sediment flows necessary* to sustain environmental and social receptors downstream. It is this definition of E Flow that is used and ESIA as define by the estimated Phase 1 and Phase 2 operational flow (see below).

9.4 Operation flow (E Flow)

Operation of Pambukovica dam the reservoir bottom outlet will be used as the primary source of environmental flow via a 200mm diameter pipe. Under Serbian legislation there is a requirement to deliver a seasonal minimum flow (Qe) which has been evaluated at 68 l/s for the cold season (Oct-Mar) and 102 l/s for the warm season (Apr-Sep). The maximum capacity of the environmental flow pipe is 200 l/s. However, operations phase flows (the E Flow) downstream of the reservoir typically far exceed the presented Serbian minimum, as additional water is required to be released to maintain both the Phase 1 (138.5 masl) and Phase 2 (145.5 masl) target reservoir levels. The release of additional water to maintain the target reservoir level will be delivered through the bottom outlet.

The E flow to be maintained in an average year (Figure 19), dry year (Figure 20) and wet year (Figure 21) is presented for Phase 1 below. From a hydrological perspective, these plots demonstrate the following for Phase 1 of operation:

- A minor reduction in monthly average flows during winter and spring, associated with storage in the reservoir.
- Monthly flows will mimic that of the baseline (albeit reduced) maintaining a nature-like hydrological regime, consisting of high flows and low flows in the required seasons. This is crucial to support and maintain the lifecycle of sensitive aquatic and riparian ecology downstream.
- In both the modelled 'average' and 'dry' year scenarios the operations phase flow will be higher than that under the baseline scenario, delivering drought resilience for the River Ub downstream.

In addition, the storage in the reservoir for the retention of flood water will also result in a reduction in the magnitude of downstream flood events in the River Ub. Stored water will be released at a slower rate following a storm event which change the flood hydrology of the river downstream of the proposed dam.

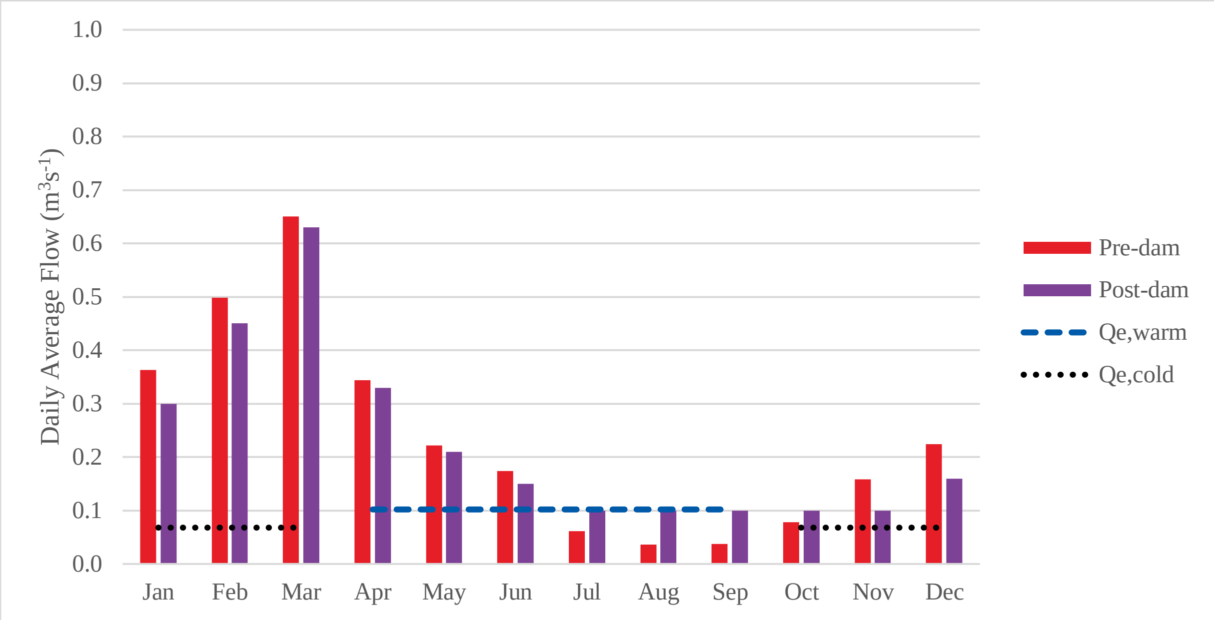

Figure 19 1991- 2023 Monthly median (q50) daily average flow at Pambukovica dam estimated from observed data (scaled from Ub station, red) and modelled with scheme (purple)

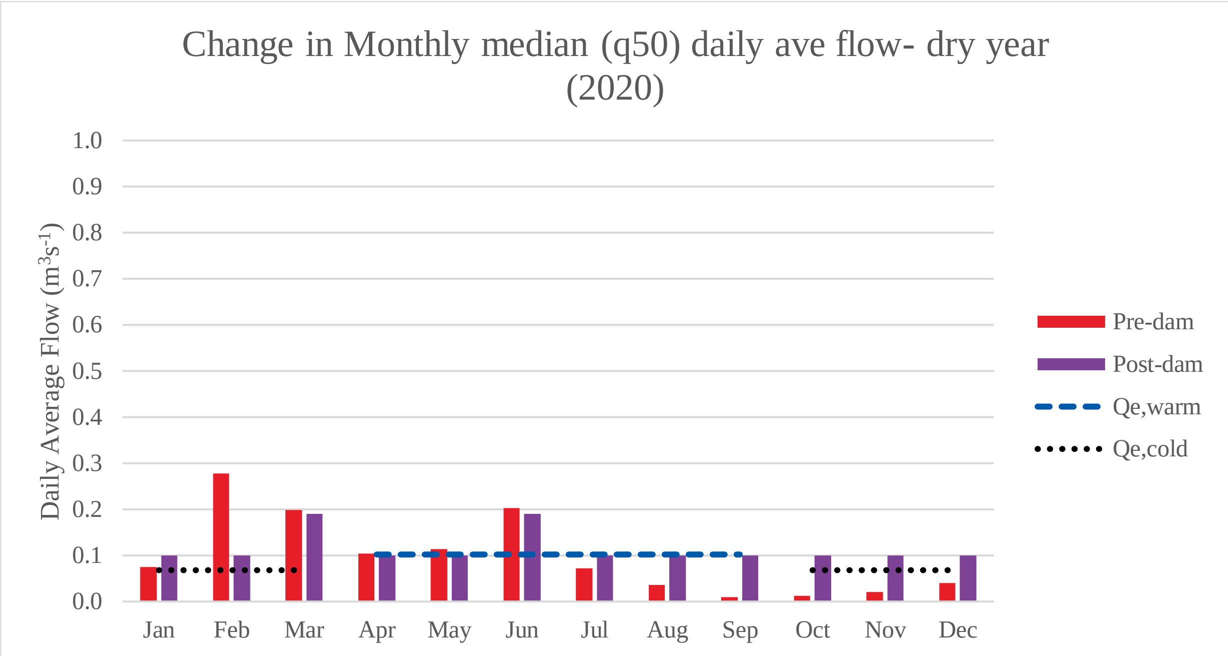

Figure 20 Example dry year (2020) monthly median (q50) daily average flow at Pambukovica dam estimated from observed data (scaled from Ub station, red) and modelled with scheme (purple)

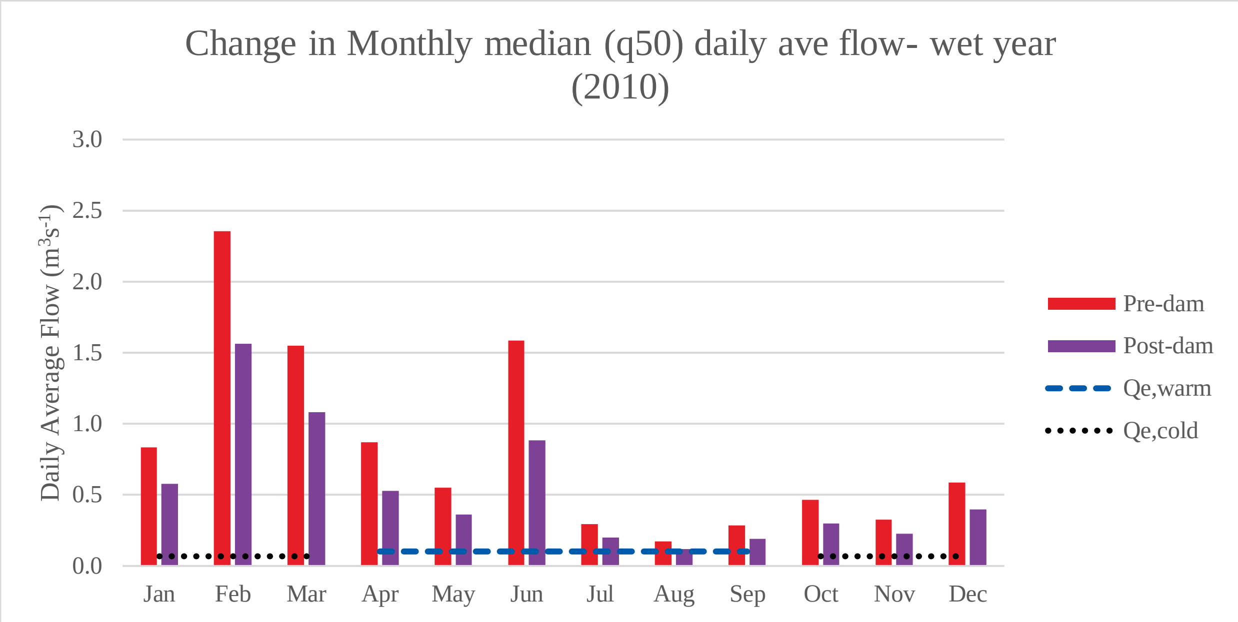

Figure 21 Example wet year (2010) monthly median (q50) daily average flow at Pambukovica dam estimated from observed data (scaled from Ub station, red) and modelled with scheme (purple)

Phase 2 Operation – The reservoir bottom outlet will be used as the primary source of Serbian minimum flow via a 200mm diameter pipe. During the year the Serbian minimum flow (Qe) will need to be maintained whilst accommodating for the use of the reservoir storage for flood mitigation and irrigation. However, Phase 2 operations (E Flow) downstream of the reservoir typically far exceed the presented Serbian minimal flow, as additional water is required to be released to maintain the Phase 2 target reservoir level of 145.5 masl. The release of additional water to maintain the target reservoir level will be delivered through the bottom outlet.

The Serbian minimal flow (Qe) for the warm season and cold season, and the E Flow in an average year (Figure 22), wet year (Figure 23) and wet year (Figure 24) is shown below for Phase 2. The reservoir storage volume (indicated by the blue line) considers an irrigation demand of 4.2 4.2Mm^3 per year, split over June-August, with higher demand assumed in July and August (see Technical Assessment Report Appendix 7 – Operational Rules). From a hydrological perspective, these plots demonstrate the following for Phase 2 of operation:

- For the representative **average year (2007)** both the irrigation demand and downstream Serbian minimum flow will be met through drawdown of the reservoir (indicated by the blue line). The E Flow to the River Ub downstream of the dam (indicated by the purple line) matches the natural baseline regime (indicated by the red line), other than for a short period in October / December where reservoir filling occurs. With the exception of this period of filling, daily flows will maintain a natural hydrological regime, consisting of high flows and low flows in the required seasons. This is crucial to support and maintain the lifecycle of sensitive aquatic and riparian ecology downstream.
- For the representative **wet year (2005)** both the irrigation demand and downstream Serbian minimum flow will be met through drawdown of the reservoir (indicated by the blue line). The E Flow to the River Ub downstream of the dam (indicated by the purple line) matches the natural baseline regime (indicated by the red line), other than for short periods in June to September where reservoir filling occurs. With the exception of this period of filling, daily flows will maintain a natural hydrological regime, consisting of high flows and low flows in the required seasons. This is crucial to support and maintain the lifecycle of sensitive aquatic and riparian ecology downstream
- For the representee **dry year (2020)** both the irrigation demand and downstream Serbian minimum flow will be met through drawdown of the reservoir. However, the reservoir storage would not fully recover to target level during Autume / winter and further recharge in January February of the following year would be required. However, water availability is high at this time of year (indicated by the peaks on the lefthand side of the graph) and recharge to target is expected to be quick. Once

the reservoir target level is achieved E flows would again mimic the natural regime. This is crucial to support and maintain the lifecycle of sensitive aquatic and riparian ecology downstream

- During all representative scenarios (average, wet and dry years) the E Flow will be higher than that under the baseline scenario, delivering drought resilience for ecosystems along the Ub, Tamnava and Kolubara Rivers downstream.

In addition, the storage in the reservoir for the retention of flood water will also result in a reduction in the magnitude of downstream flood events in the River Ub. Stored water will be released at a slower rate following a storm event which change the flood hydrology of the river downstream of the proposed dam.

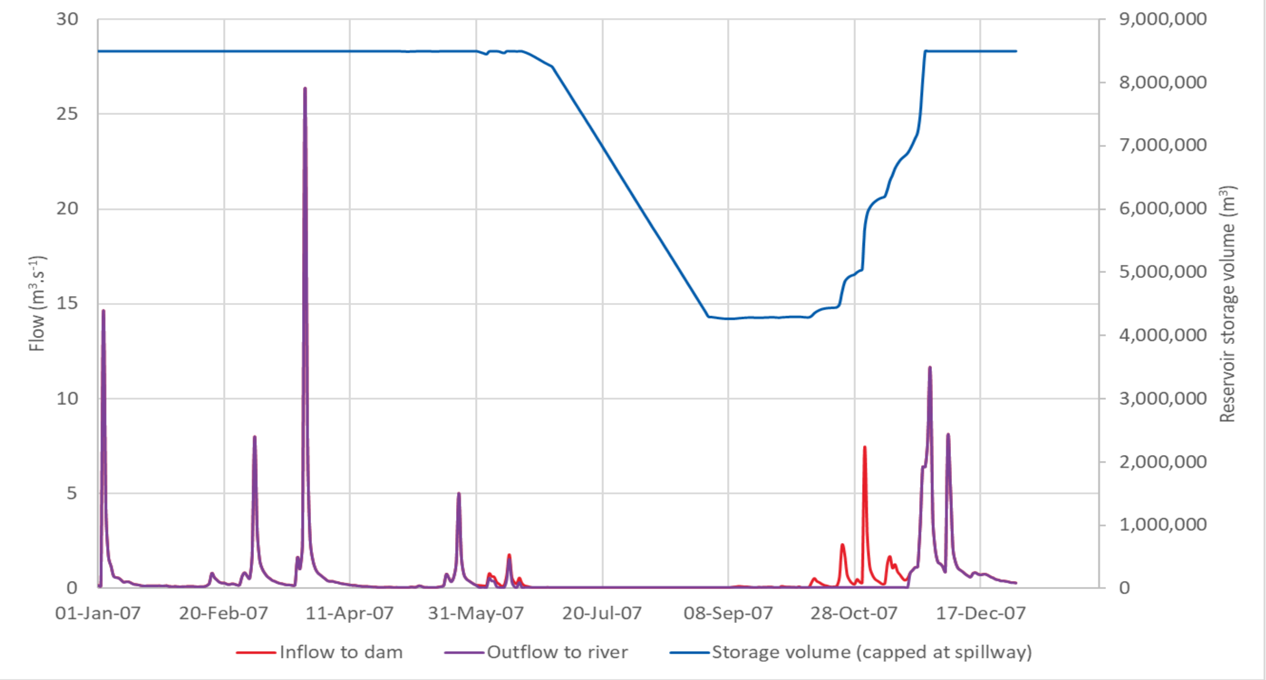

Figure 22 – Example average year (2007) daily flow into Pambukovica dam, out of the dam to Ub RIver and the change in stored water volume within the dam, when capped at the spillway

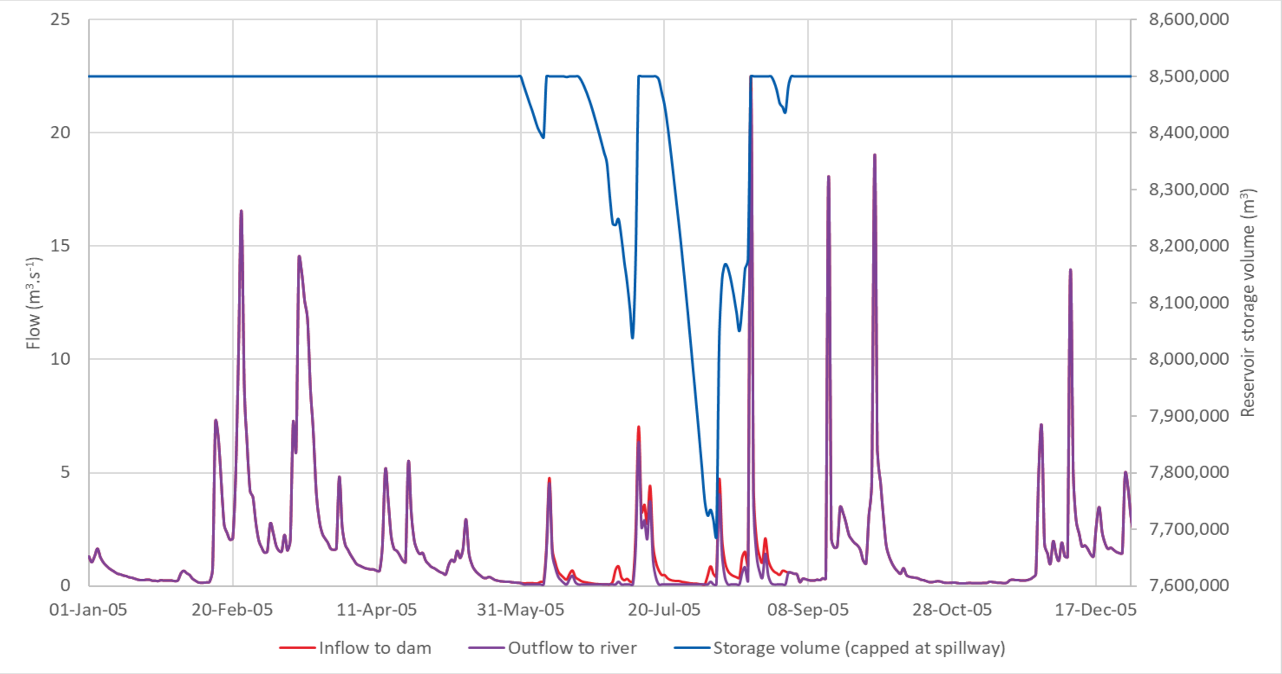

Figure 23 – Example wet year (2005) daily flow into Pambukovica dam, out of the dam to Ub River and the change in stored water volume within the dam, when capped at the spillway

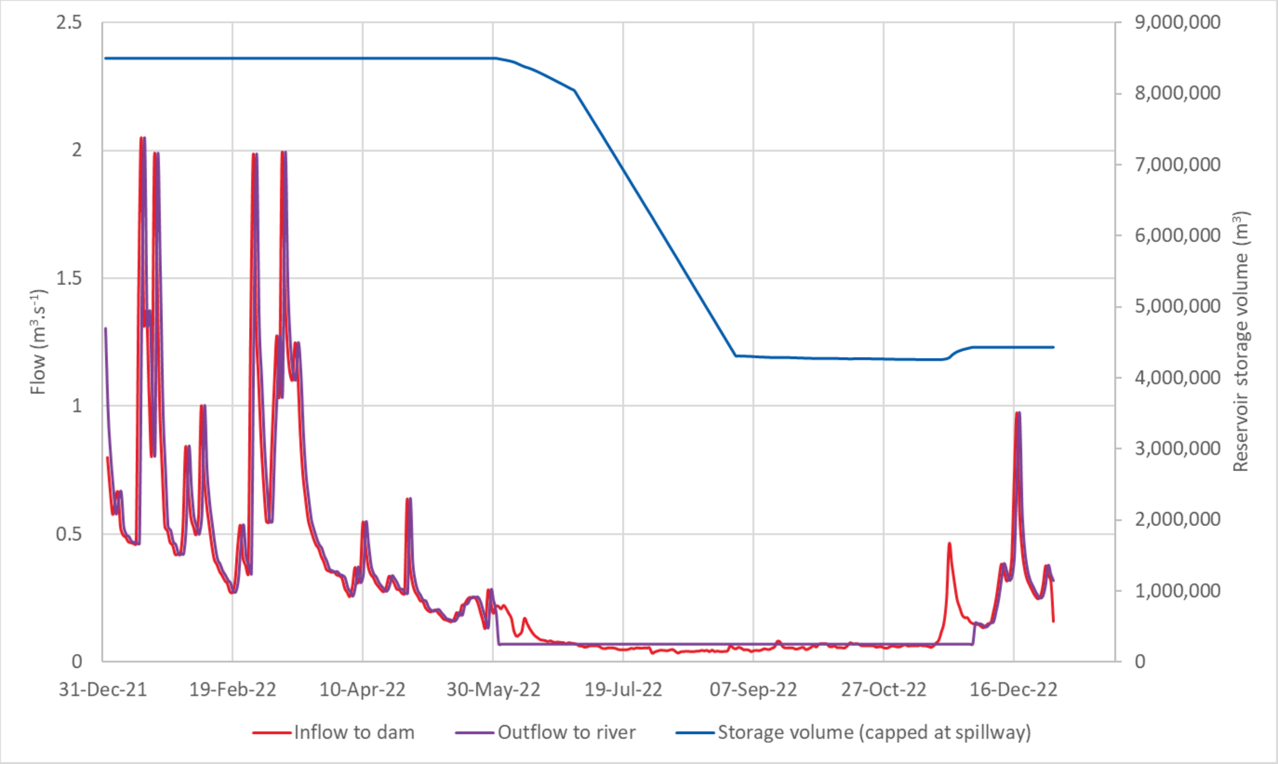

Figure 24 – Example dry year (2020) daily flow into Pambukovica dam, out of the dam to Ub River and the change in stored water volume within the dam, when capped at the spillway