EU4Environment in Eastern Partner Countries:
Water Resources and Environmental Data (ENI/2021/425-550)

TRANSBOUNDARY SURFACE WATER SURVEY ARMENIA – GEORGIA 2023

Contract-No: 20940-C1/GE-NEA-2023/7
20940-C1/AM-HMC-2023/6

Funded by the European Union

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ABOUT EU4ENVIRONMENT – WATER RESOURCES AND ENVIRONMENTAL DATA

This Programme aims at improving people's wellbeing in EU's Eastern Partner Countries and enabling their green transformation in line with the European Green Deal and the Sustainable Development Goals (SDGs). The programme's activities are clustered around two specific objectives: 1) support a more sustainable use of water resources and 2) improve the use of sound environmental data and their availability for policy-makers and citizens. It ensures continuity of the Shared Environmental Information System Phase II and the EU Water Initiative Plus for Eastern Partnership programmes.

The Programme is implemented by five Partner organisations: Environment Agency Austria (UBA), Austrian Development Agency (ADA), International Office for Water (OiEau) (France), Organisation for Economic Co-operation and Development (OECD), United Nations Economic Commission for Europe (UNECE). The action is co-funded by the European Union, the Austrian Development Cooperation and the French Artois-Picardie Water Agency based on a budget of EUR 12,75 million (EUR 12 million EU contribution). The implementation period is 2021-2024.

https://eu4waterdata.eu

CONTENTS

LIST OF ABBREVIATIONS **10**

EXECUTIVE SUMMARY **11**

1. INTRODUCTION AND SCOPE **12**

2. GENERAL DESCRIPTION OF THE SURVEY **13**

2.1. Selected river basin and sampling sites 13
2.2. Sampling period and conditions 15
2.3. Responsibilities Armenia 16
2.4. Responsibilities Georgia 17
2.5. Quality elements 18

3. METHODS **19**

3.1. Sampling methods 19
3.1.1. Chemical sampling *19*
3.1.2. Biological sampling *19*
3.2. Field protocols 19
3.3. Laboratory analyses 20
3.4. Quality assurance 21

4. RESULTS **23**

4.1. Field protocols and hydro-morphological site description 23
4.1.1. Hydrology (Short hydrographic characterization of Debeda River) *23*
4.1.2. Water quality assessment based on hydromorphological data *24*
4.2. Chemical results 25
4.2.1. Chemical Parameter Comparison *28*
4.3. Biological results 36

5. DISCUSSION OF RESULTS **41**

6. NEXT STEPS AND LESSONS LEARNED **42**

7. ANNEXES **43**

Annex A 43
Annex B 43
Literature used for determination by Armenia: 43
7.1. Armenian Annexes 44
AM-Annex 1 Field protocols 44
AM-Annex 2 Photos 44
AM-Annex 3 Hydromorphology 44
AM-Annex 4 Chemical data summary 44
AM-Annex 5 Protocol sample delivery and handover 44
AM-Annex 6 Hydrobiological data 44
AM-Annex 7 Water quality assessment norms 44
7.2. Georgian Annexes 44
GE-Annex 1 Field Protocols 44
GE-Annex 2-1 Photo 44
GE-Annex 2-2 Photo Documentation Hydrology 44
GE-Annex 3 template for hydro-morphological site description Field protocols 44

GE-ANNEX 4 CHEM+BIO DATA 44
GE-ANNEX 5 HANDOVER PROTOCOL 44
GE-ANNEX 6 BIOLOGICAL DATA 44

LIST OF TABLES

Table 1: Overview 12
Table 2: List of sampling sites in Armenia and Georgia 13
Table 3: Hydrological measurements by NEA 15
Table 4: Sampling conditions by HMC 15
Table 5: List of parameters, field and laboratory methods 20
Table 6: Hydrological assessment 24
Table 7: Overview table of the single morphology parameters per survey unit 25
Table 8: Hydromorphological assessment of the survey units 25
Table 9: Reported comparable physico-chemical parameters – Armenia and Georgia 27
Table 10: Comparison field measurements 28
Table 11: Comparison TSS 28
Table 12: Comparison COD 29
Table 13: Comparison BOD 30
Table 14: Comparison Ammonia 30
Table 15: Comparison Nitrate 31
Table 16: Comparison Phosphate 32
Table 17: Comparison Total Phosphorus 32
Table 18: Comparison Chloride 33
Table 19: Comparison Sulphate 33
Table 20: Comparison Sodium 34
Table 21: Comparison Magnesium 35
Table 22: Comparison Potassium 35
Table 23: Comparison Calcium 36
Table 24: Biological results – AG01 Bagratashen 37
Table 25: Biological results – AG02 Ayrum 38
Table 26: Biological results – AG03 Tumaniani 38
Table 27: Biological results – GA01 Tazakendi 39
Table 28: Biological results – GA02 Kirovka 39
Table 29: Biological results – GA03 Enikendi 40

LIST OF FIGURES

Figure 1: Map of the sampling sites as depicted by NEA. 14
Figure 2: Map of the sampling sites as depicted by HMC. 14

List of abbreviations

BQE ..... Biological Quality Elements

ESCS ..... Ecological Status Classification Systems

EU ..... European Union

EU4EnvWD..... EU4Environment in Eastern Partner Countries: Water Resources and Environmental Data

EUWI+..... European Union Water Initiative Plus

IOW/OIEau ..... International Office for Water, France

OECD..... Organisation for Economic Cooperation and Development

RBD ..... River Basin District

RBMP ..... River Basin Management Plan

UBA..... Umweltbundesamt GmbH, Environment Agency Austria

UNECE..... United Nations Economic Commission for Europe

WFD ..... Water Framework Directive

Country Specific Abbreviations Armenia

EMIC ..... Environmental Monitoring and Information Centre (until January 2020)

HMC..... Hydrogeological Monitoring Centre (since February 2020)

MNP..... Ministry of Nature Protection

SCWS..... State Committee on Water Systems

SWCIS..... State Water Cadastre Information System of Armenia

WRMA ..... Water Resources Management Agency

Country Specific Abbreviations Georgia

MENRP..... Ministry of Environment and Natural Resources Protection

NEA ..... National Environment Agency

NWP..... National Water Partnership

Executive Summary

This report presents and discusses the results of the transboundary surface water survey between Armenia and Georgia conducted on September 4-5, 2023 at six sites in the Debed[1] river basin (3 sites in Armenia, 3 in Georgia). The implementing institutions were the National Environment Agency of Georgia (NEA) and the Hydrometeorology and Monitoring Center of Armenia (HMC). The survey was supervised by international experts of the EU4Environment Water & Data programme. The investigation included chemical, biological, and hydro-morphological parameters with the aim to compare and harmonize the sampling, analyzing, and reporting routines of both participating institutions.

The results show that further coordination between the two laboratories is required. Chemical analyses reach comparable values for a part of the investigated parameters, while others differ significantly. The biological monitoring of benthic invertebrates showed similarities, but should be refined in the future. Possible reasons for the discrepancies in the results are discussed in this report. Recommendations are given on how both institutions should work closely together to identify sources of errors, harmonize methods, and improve the comparability of the results in the future.

[1] Debed (Armenian: Դեբեդ) or Debeda (Georgian: დებედა). This report will use the most common English spelling, which is 'Debed'.

1. Introduction and Scope

In the scope of implementing the EU4Environment Water & Data programme, both national and transboundary surface and groundwater surveys are being conducted with a focus on the Caucasus countries of the EU Eastern Partner region.

On 4th and 5th September 2023, the National Environment Agency of Georgia (NEA) and the Hydrometeorology and Monitoring Center of Armenia (HMC) conducted the 2nd Transboundary Surface Water Survey between their countries at 6 sites in the Debed[2] river basin (3 sites in Armenia, 3 in Georgia; see Table 2, Figure 1, and Figure 2). The first such survey was executed in September 2020.

The overall objective of the survey is to gain more experience and initiate a monitoring routine on transboundary rivers, as is committed by both agencies and the related ministries in Armenia and Georgia. Future surveys shall be conducted in the frame of joint water monitoring agreement that is a key result of this EU programme in 2024.

Table 1: Overview

Country	Armenia and Georgia
River basin	Debed
Campaign [1)]	Autumn, 2023
Objective	• Collecting environmental data in the border region between Armenia and Georgia • Comparing sampling methods, lab work, and results of HMC and NEA.
Quality elements	Biological quality components: • Macrozoobenthos • Phytobenthos (Was only collected, not assessed) Supporting elements: • Hydro-morphological site description • General physico-chemical quality elements
Preparation of field work	3 September 2023
Field work	4-5 September 2023

[2] Debed (Armenian: Դեբեդ) or Debeda (Georgian: დებედა). This report will use the most common English spelling, which is 'Debed'.

2. GENERAL DESCRIPTION OF THE SURVEY

2.1. Selected river basin and sampling sites

The list of sampling sites and their description are listed in Table 2. Exact locations of the sampling sites were discussed and agreed upon by the experts of EU4WD, NEA, and HMC.

Figure 1 shows a topographic map of the sampling sites as provided by NEA. Figure 2 depicts the location of the sites within the larger river network and was made by HMC.

Table 2: List of sampling sites in Armenia and Georgia.

Country	River	WB	River type[1)]	Site	Site No.	HMWB [2)]	Risk [3)]	Significant Pressure [4)]	Latitude [4)]	Longitude [4)]
Armenia	Debed	WB 1-054	III	(village) Bagratashen	AG01	no	R	H, E	41.241967N	44.812217E
	Debed	WB 1-052	III	(up to) Ayrum (town)	AG02	no	PR	H	41.187667N	44.89185E
	Martsiget (Marts)	WB 1-038	I	(river mouth) Tumanyan	AG03	no	R	H, E	40.985483N	44.653883E
Georgia	Debed	Deb201	XVI	(village) Tazakendi	GA01	no	R	H, E	41.2207N	44.854567E
	Debed	Deb202	XVI	(village) Kirovka	GA02	no	R	H, E	41.30225N	44.807567E
	Debed	Deb202	XVI	(village) Enikendi	GA03	no	R	H, E	41.344425N	44.878317E

[1)] Waterbody type as assigned per Armenia or Georgia respectively
[2)] Assignment as provisional HMWB: yes / no
[3)] Assignment of the risk status: R = at risk, PR = possibly at risk, NR = not at risk
[4)] Significant pressure: N = no significant pressure, P = organic pollution, E = eutrophication, T = toxic impact, H = hydro-morphological alterations, M = multistressor, O = other, U = unknown
[5)] Latitude, Longitude: Format = Degree with six decimals (e.g. as 44.630139, conversion from 44° 37’ 48.5’’ through calculation 44 + 37 / 60 + 48.5 / 3600)

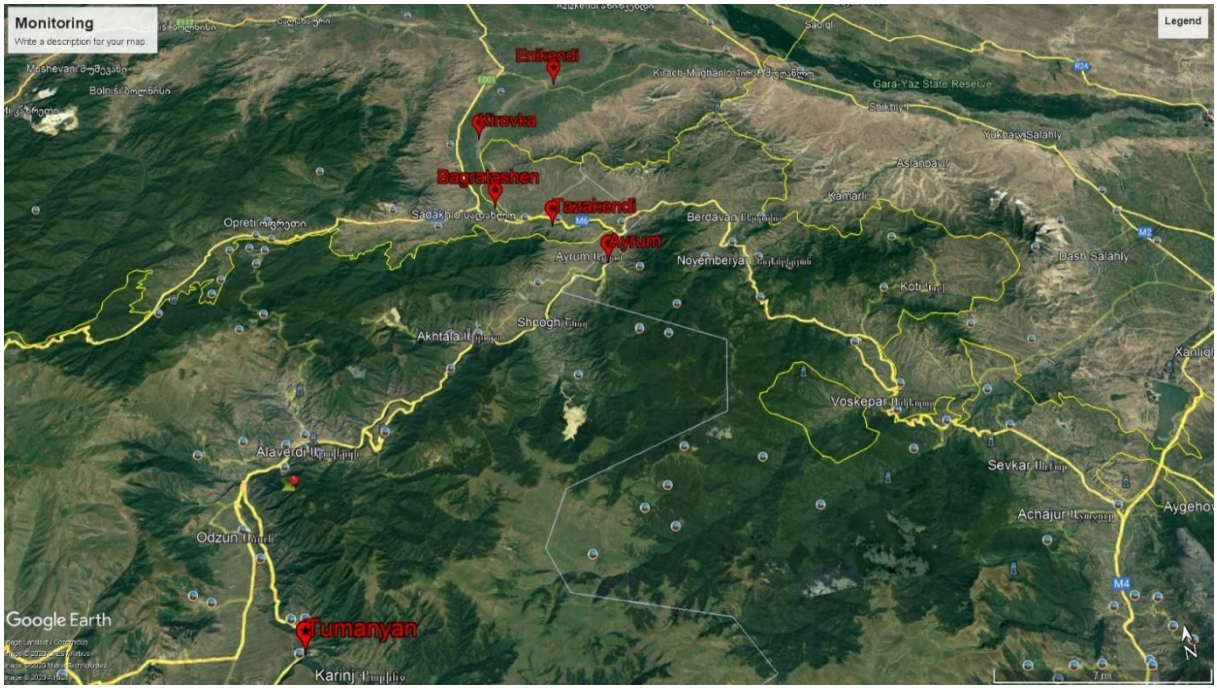

Figure 1: Map of the sampling sites as depicted by NEA.

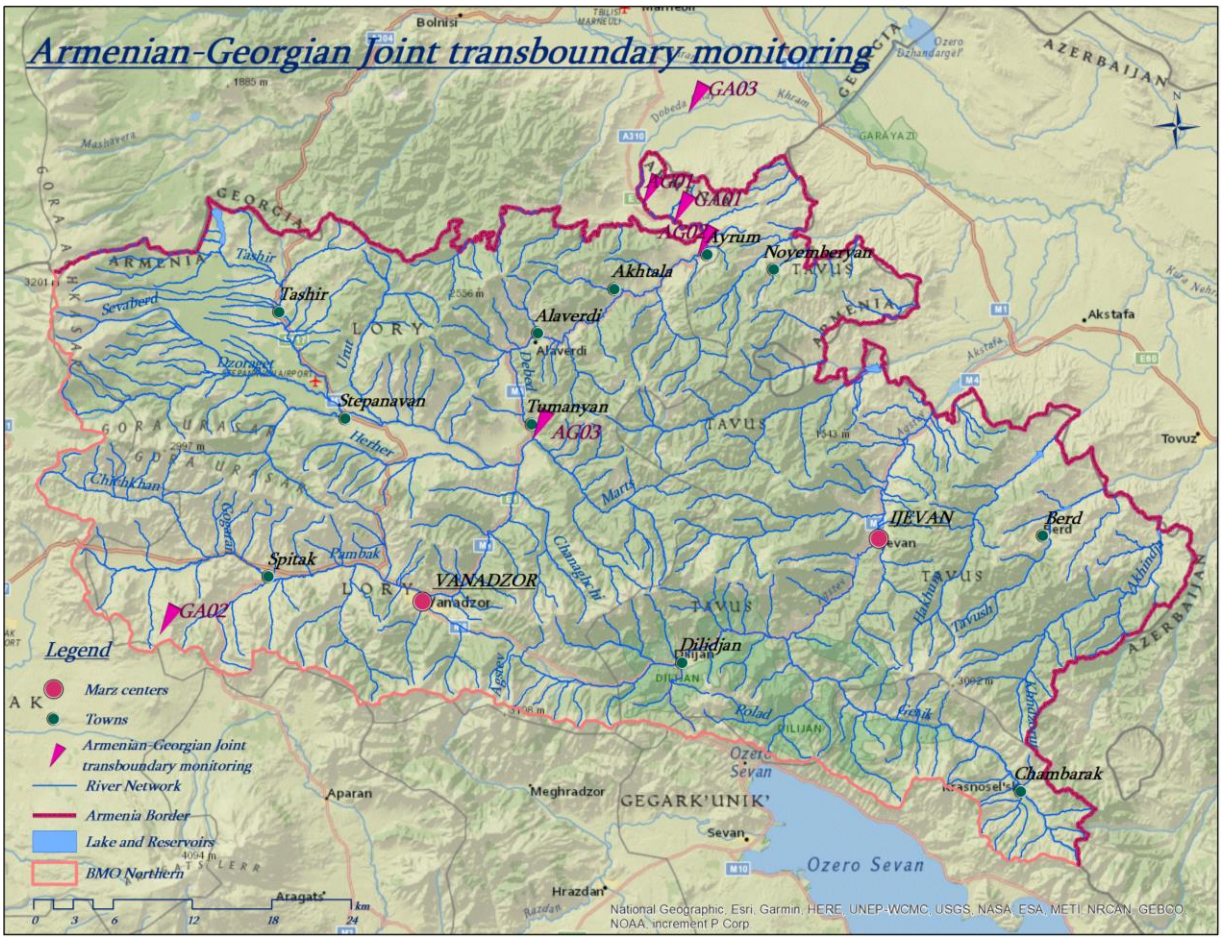

Figure 2: Map of the sampling sites as depicted by HMC.

2.2. Sampling period and conditions

The survey was carried out on September 4th and 5th, 2023. The dates and time of the field survey were coordinated with the Armenian and Georgian experts responsible for the sampling. The sampling was performed jointly by the teams of NEA, HMC, and experts of EU4WD from Austria. Table 3 lists the exact dates, time, hydrological conditions, etc. measured by NEA at the time of sampling. Table 4 lists the sampling conditions as noted by HMC.

Table 3: Hydrological measurements by NEA

Site Number	River	Site	Date	Time	Water Discharge [m^3/s]	Cross-sectional Area [m^2]	Average Velocity [m/s]	River Width [m]	Average depth [m]
AG01	Debed	Bagratashen	04.09.2023	11:45-12:05	5.84	7.42	0.79	19.5	0.38
AG02	Debed	Ayrum	04.09.2023	14:55-15:25	15.1	-	-	-	-
AG03	Martsiget	Tumanyan	04.09.2023	17:40-18:00	0.85	1.79	0.47	7.8	0.23
GA01	Debed	Tazakendi	05.09.2023	12:15-12:40	5.57	8.74	0.64	22.0	0.40
GA02	Debed	Kirovka	05.09.2023	13:36-14:00	3.88	3.96	0.98	11.5	0.34
GA03	Debed	Enikendi	05.09.2023	15:44-16:10	5.15	8.73	0.59	32.0	0.27

Table 4: Sampling conditions by HMC

Site Number	River	Site	Meteorology	Hydrology
AG01	Debed	Bagratashen	Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available	River type: first Stream order: large Turbidity of water: no turbidity
AG02	Debed	Ayrum	Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available	River type: first Stream order: large Turbidity of water: no turbidity
AG03	Martsiget	Tumanyan	Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available	River type: small Stream order: second Turbidity of water: no turbidity
GA01	Debed	Tazakendi	Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available	River type: first Stream order: large Turbidity of water: no turbidity
GA02	Debed	Kirovka	Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available	River type: first Stream order: large Turbidity of water: no turbidity
GA03	Debed	Enikendi	Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available	River type: first Stream order: large Turbidity of water: no turbidity

2.3. Responsibilities Armenia

Responsibilities	Institution, contact person, email-address
General	Hydrometeorology and Monitoring Center SNCO, Ministry of Environment
Responsible for the organisation of surface water body sampling	**Contact person**: Alina Zurnachyan (Head of surface water quality monitoring service) E-Mail: alina.zurnachyan@gmail.com Vardan Karyan (Head of Soil, Sediment and Hydrobiology Service) E-Mail: VHKaryan@gmail.com,

Fieldwork	Hydrometeorology and Monitoring Center SNCO, Ministry of Environment
Responsible for field work (biological and chemical sampling, hydro-morpho-logical site description)	**Contact person**: Alina Zurnachyan (Head of surface water quality monitoring service) Chemical: Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru Biological: Vardan Karyan, E-Mail: VHKaryan@gmail.com, Hydro-morphological: Hovakim Frunzikyan, h.frunzikyan@mail.ru
Responsible for functional check of sampling equipment	Chemical: Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru Biological: Vardan Karyan, E-Mail: VHKaryan@gmail.com,
Responsible for calibration of on-site measuring equipment	Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru

Chemical analysis	Hydrometeorology and Monitoring Center SNCO, Ministry of Environment
Overall responsible for the chemical analyses in the laboratory, including reporting and data delivery	**Contact person**: Gayane Shahnazaryan (Deputy Director), E-Mail: shahnazaryangayane@gmail.com Alina Zurnachyan (Head of surface water quality monitoring service) E-Mail: alina.zurnachyan@gmail.com Anna Zatikyan (Head of Information Analytical Service) E-Mail: anna_zatikyan@hotmail.com Tigran Araqelyan, (Head of surface water quality field survey and sampling department) E-Mail: tigranarakelyan91@mail.ru Vardan Karyan, (Head of Soil, Sediment and Hydrobiology Service) E-Mail: VHKaryan@gmail.com
Responsible for sample transport from the field to the laboratory	**Contact person**: Tigran Araqelyan (Head of surface water quality field survey and sampling department) E-Mail: tigranarakelyan91@mail.ru
Analysing laboratory and contact person	**Contact person**: Alina Zurnachyan (Head of surface water quality monitoring service) E-Mail: alina.zurnachyan@gmail.com

Biological analysis	Hydrometeorology and Monitoring Center SNCO, Ministry of Environment
Overall responsible for the biological analysis in the lab, including reporting and data delivery	**Contact person**: Vardan Karyan (Head of soil, sediment and hydrobiological monitoring service) E-Mail: VHKaryan@gmail.com

2.4. Responsibilities Georgia

Responsibilities	Institution, contact person, email-address
General	National Environmental Agency
Responsible for the organisation of surface water body sampling	**Contact person**: Gela Sandodze E-Mail: gela.sandodze@nea.gov.ge

Fieldwork	National Environmental Agency
Responsible for field work (biological and chemical sampling, hydro-morpho-logical site description)	**Contact person:** Gela Sandodze, George Guliashvili, Irakli Kordzaia E-Mail: gela.sandodze@nea.gov.ge giorgi.guliashvili@nea.gov.ge
Responsible for functional check of sampling equipment	**Contact person:** Gela Sandodze, George Guliashvili, Irakli Kordzaia E-Mail: gela.sandodze@nea.gov.ge giorgi.guliashvili@nea.gov.ge
Responsible for calibration of on-site measuring equipment	**Contact person:** Gela Sandodze, George Guliashvili, Irakli Kordzaia E-Mail: gela.sandodze@nea.gov.ge giorgi.guliashvili@nea.gov.ge

Chemical analysis	National Environmental Agency
Overall responsible for the chemical analyses in the laboratory, including reporting and data delivery	**Contact person:** Lia Aptsiauri E-Mail: lia.aptsiauri@nea.gov.ge
Responsible for sample transport from the field to the laboratory	**Contact person**: Gela Sandodze, George Guliashvili, Irakli Kordzaia E-Mail: gela.sandodze@nea.gov.ge giorgi.guliashvili@nea.gov.ge
Analysing laboratory and contact person	**Contact person:** Lia Aptsiauri E-Mail: lia.aptsiauri@nea.gov.ge

Biological analysis	National Environmental Agency
Overall responsible for the biological analysis in the lab, including reporting and data delivery	**Contact person:** Lia Aptsiauri E-Mail: lia.aptsiauri@nea.gov.ge
Reporting	
Overall responsible for completing the technical report including data annexes and metadata templates	**Contact person**: Lia Aptsiauri E-Mail: lia.aptsiauri@nea.gov.ge

2.5. Quality elements

Both teams sampled at all 6 locations and took the samples back to their respective laboratories for analyses. The survey included the following physico-chemical parameters and biological quality elements. The list of analyzed parameters slightly differs between the laboratories. Quality elements and parameters covered by both labs are given in the following list. They can be compared after this survey:

Biological Quality Elements:

- Benthic Invertebrates

Chemical and physico-chemical elements

- Field measurements
    - Water Temperature (T), Dissolved Oxygen concentration (DO, mg/L), Dissolved Oxygen Saturation (DO, %), pH, Electric Conductivity (EC, µS/cm)
- Laboratory analyses
    - Suspended Solids (TSS, mg/L)
    - Chemical Oxygen Demand (COD, mg/L)
    - Biological Oxygen Demand (BOD_5, mg/L)
    - Ammonia (NH_4-N, mg/L)
    - Nitrate (NO_3-N, mg/L)
    - Phosphate (PO_4-P, mg/L)
    - Total phosphorus (TP, mg/L)
    - Chloride (Cl, mg/L)
    - Sulphate (SO_4, mg/L)
    - Sodium (Na, mg/L)
    - Magnesium (Mg, mg/L)
    - Potassium (K, mg/L)
    - Calcium (Ca, mg/L)

Phytobenthos was sampled in order to practice the sampling procedure itself. However, both labs are in the beginning stage of implementing this quality element and the samples were not yet analyzed. Therefore, no comparison was carried out.

3. Methods

3.1. Sampling methods

3.1.1. Chemical sampling

The water **sampling for physico-chemical** analysis was conducted following the requirements of ISO 5667-3:2018 and General Manual for Surveys in Running Waters (EUWI+, ENI/2016/372-403). Water samples for chemical analysis were taken using bottles made of HDPE. The sampling containers and preservation solutions were provided by the laboratory. The bottles of water samples were labelled clearly attributable to the sampling site, river name, and date of sampling.

To minimize bias effects from stirred-up sediment, water samples for chemical analyses were taken before collecting biological samples. Before filling the sampling bottle, it was rinsed with sample water twice. Samples were generally taken directly by hand, with the most representative samples collected at mid-height between the surface and bottom.

All bottles were put into cooling boxes immediately after the sampling. The preservation, handling, transport and storage of all water samples were followed the procedure outlined in ISO 5667-3:2018 laboratory standard operating procedure.

The water samples were transported to HMC laboratory and NEA after each day for the further processing and analysis with the handover documented using the "Protocol for the delivery and handover of samples" (see attached Annex 5).

3.1.2. Biological sampling

Benthic invertebrates were sampled using the multi-habitat sampling (MHS) method developed during EU AQEM and STAR projects.

The entire sample, ranging from 10 to 20 sub-samples (depending on sampling site characteristics) from each sampling site, was taken to the laboratory for further analysis. Rare and endangered animals such as large mussels or crayfish were carefully picked out, documented in the field, and released again.

Samples were fixed with a formaldehyde solution, stored in a cooling box, and delivered to the laboratory for sorting and identification.

Diatoms (Bacillariophyceae) are the most important class of phytobenthos with several thousand species, were sampled in wadable rivers following the standard EN 13946 “Water Quality - Guidance for the routine sampling and preparation of benthic diatoms from rivers and lakes”. The samples were preserved with buffered formaldehyde solution and transported to the laboratory in a cooling box.

The transportation of the samples was done in accordance with the standard operating procedures.

3.2. Field protocols

The field protocols (AM-Annex 1, GE-Annex 1) for each sampling sites (from 6 sample sites) were filled. The protocols include detailed information about river basin, name and type, site number and coordinates, sampling date and time, weather and water quality conditions, name of surveyor with signature and other comments.

3.3. Laboratory analyses

Table 5 lists the physico-chemical parameters and heavy metals were analyzed in each of the 6 water samples. Five parameters (Water temperature, Oxygen concentration, Oxygen Saturation, Electric conductivity and pH) were measured in the field by the sampling team. The physico-chemical parameters were measured by the appropriate ISO standard methods and are listed in the table below as well.

Not all parameters were measured by each laboratory. The comparison will therefore only apply to parameters available from both institutions.

Table 5: List of parameters, field and laboratory methods

		ARMENIA				GEORGIA
Parameter	Unit	LOD_3	LOQ_4	Methods/ Standards	MPC_5	Methods/ Standards
Field measurements						Mobile apparatus -WTW 3630 Multi
Water temperature (WT)	°C					Mobile apparatus -WTW 3630 Multi
Oxygen concentration (DO)	mg/L			ISO 5814		Mobile apparatus -WTW 3630 Multi
Oxygen saturation (O_2-Sat)	%			ISO 10523		Mobile apparatus -WTW 3630 Multi
pH	-			ISO 10523	6,5-8,5	HI 98108 pH Tester-HANNA
Turbidity						HI 98703 Turbidimeter-HANNA
Electric conductivity (EC)	µS/cm			ISO 7888		Mobile apparatus -WTW 3630 Multi
Laboratory analyses						
Water temperature (WT, lab control)	°C					
Oxygen concentration (DO, lab control)	mg/L			ISO 5814		ISO 5815-1:2010
Oxygen saturation (O_2-Sat, lab control)	%			ISO 5814		
pH (lab control)	-			ISO 10523		ISO 10523:2010

[3] Limit of Detection

[4] Limit of Quantification

[5] Maximum permissible concentrations On Approval of Technical Regulations for Protection of Surface Water Pollution in Georgia (Government of Georgia Resolution # 425 December 31, 2013 Tbilisi

Electric conductivity (EC, lab control)	µS/cm			ISO 7888		ISO 7888:2007
Total suspended solids (TSS)	mg/L			ISO 11923		ISO 11923:2007
Biological oxygen demand (BOD_5)	mg/L			ISO 5815	6,0	ISO 5815-1:2010
Chemical oxygen demand ($K_2Cr_2O_7$) (COD)	mg/L			ISO 6060	30,0	ISO 6060:2010
Ammonia-N (NH_4-N)	mg/L	0.003	0.005	ISO 7150-1	0,39	ISO 7150-1:2010
Nitrate-N (NO_3-N)	mg/L	0.001	0.01	ISO 10304-1	45,0	ISO 10304-1:2007
Nitrite-N (NO_2-N)	mg/L	0.001	0.002	ISO 6777	3,3	ISO 10304-1:2007
Orthophosphate, as P (PO_4-P)	mg/L	0.001	0.002	ISO 6878	3,5	ISO 10304-1:2007
Total phosphorus (TP)	mg/L	0.005	0.01	ISO 17294		Ю.Ю. Лурье ”Унифици¬ро¬ва¬¬¬н¬¬ные методы анализа вод”
Chloride (Cl)	mg/L	0.025	0.05	ISO 10304-1	350	ISO 10304-1:2007
Sulphate, total ion (SO_4)	mg/L	0.125	0.25	ISO 10304-1	500	ISO 10304-1:2007
Calcium (Ca)	mg/L	0.005	0.01	ISO 17294		ISO 6058:2008
Magnesium (Mg)	mg/L	0.005	0.01	ISO 17294		ISO 6058:2008
Sodium (Na)	mg/L	0.005	0.01	ISO 17294		ISO 11885:2007
Potassium (K)	mg/L	0.005	0.01	ISO 17294		ISO 11885:2007

Concerning benthic invertebrates, all specimens picked out of the sediment sample were kept for later validation and stored in vials with formalin. The invertebrates were separated into the major taxonomic groups and identified to the appropriate taxonomic level.

The sorting of macroinvertebrate samples was adapted to meet the requirements of the STAR project (www.eu-star.at).

The ecological status was calculated following the Ecological Status Classification System (ESCS) developed by EUWI+ for each respective country. The ESCS considers the composition and abundance of taxa, the ratio of disturbance-sensitive taxa to insensitive taxa, the level of diversity and the occurrence of major taxonomic groups (EUWI+ RefCond reports).

3.4. Quality assurance

The transport storage, preservation and the chemical analyses were undertaken according to the laboratory accredited procedures together with the application of internal analytical quality controls.

During the pre-treatment period of the samples and before tests were performed, each sample for physico-chemical parameters were kept according to the instructions, specific methodology and specific standard operating procedures (SOP). In order to maintain integrity of the samples, keeping samples for a long period was avoided. At the same time, samples were kept in the proper condition of temperature and humidity. Before the analyses were done, the measurement and test equipment were calibrated internally by the laboratory staff.

4. Results

4.1. Field protocols and hydro-morphological site description

4.1.1. Hydrology (Short hydrographic characterization of Debed River)

The river Debed originates in the territory of Armenia. Its source is on the northern slope of the Jandur range at an altitude of 1850 meters and mouths into the river Khrami at a height of 295 meters in the territory of Georgia. The total length of the river is 176 km, the total drop is 1455 meters, the average slope 8.27‰, and the catchment area is 4080 km^2. In the territory of Georgia, the lower section of the river is 25 km long. In this section of the river, the catchment area covers 290 km^2. The main tributaries are the Debed river are located on the territory of Armenia, and one comes from within Georgia. The left tributary of the Debed is called Banushchai and it is 20 km long.

The river basin is divided into mountainous and lowland zones. The mountainous area is completely located in the territory of Armenia, and the lowland zone on Georgian territory. The geological structure of the mountainous area are volcanic rocks, while the geology of the lowland is made up of old alluvial sedimentation. Mountain-forest and mountain-meadow are common in the basin. In the mountainous zone of the basin there is a “mechkheri” mixed forest. The lowland zone is devoid of forest cover. A large area of the lowland zone is used for agriculture. The slopes of the valley in the territory are heavily eroded (dry ravines with incised valleys). The river bed in the territory of Armenia is mostly a single channel, but it is branched in the territory of Georgia and strongly meanders.

The river is fed by snow, rain and groundwater. The water regime is characterized by spring-summer floods and with water scarcity in other periods of the year. The lowest discharges are being observed during the winter months.

Brief characteristics of the 6 points assessed in the field survey are described below.

AG01 – Debed(a), Bagrtashen. The place is located near the Georgian-Armenian border, the hydromorphological conditions have been altered significantly. On the upper side of the point, water is taken by abstraction systems and there is a reduced flow in this section. The influence of wastewater is present. Following structural elements are found: Gravel bars, small island, riffle. Bed Substrates is made up of boulders, cobbles, gravel/pebble, sand. Flow types are broken standing waves, unbroken standing waves, rippled.

AG02 – Debed(a), Ayrum. There is a slight hydromorphological change at this point. The water flow of the river maintains its natural state, water is taken from the abstraction systems in the lower part of the section. Following structural elements are found: Gravel bars, small island, riffle. Bed Substrates is made up of boulders, cobbles, gravel/pebble, sand. Flow types are broken standing waves, unbroken standing waves, rippled, upwelling, smooth, and no perceptible flow.

AG03 – Martsiget (Marts), Tumanyan. It is a tributary of Debed River. There was a shortage of water in the river, the parameters of the flow and the hydromorphological condition were significantly changed. Sewage effluents have a great influence on water flow. Following structural elements are found: bars, small island, riffle, rock. Bed substrate is made up of bedrock boulder, cobbles, Gravel/pebble, Sand. Flow types are broken standing waves, unbroken standing waves, Rippled, and no perceptible flow.

GA01 - Debed(a), Tazakendi - The place is located near the Georgian-Armenian border. The hydromorphological conditions have been altered significantly. The scarcity of water is addressed by

melioration and water abstraction. Wastewater is present. Following structural elements are found: Bars, small Island, Riffle. Bed Substrates is Boulder, Cobble, Gravel/pebble, Sand. Flow Types are Broken standing waves, unbroken standing waves, Rippled, and no perceptible flow.

GA02 - Debed(a), Kirovka - The water flow characteristics and hydromorphological condition have been altered. The scarcity of water is being addressed by melioration and water abstraction. Wastewater is important. The Debed causes intense lateral erosion in this section, due to which the right bank is damaged. A bank protection gabion has been installed to protect against erosion. After reaching the plain, the river Debed is characterized by an underground flow. Following structural elements are found: Bars, small island, riffle. Bed Substrates are made up of boulders, cobble, gravel/pebble, sand. Flow types are broken standing waves, unbroken standing waves, rippled, chute, and no perceptible flow.

GA03 - Debed(a), Eninkendi - The water flow characteristics and hydromorphological condition have changed at the point. The scarcity of water is replaced by melioration with water abstraction. Wastewater is important. Debeda produces intense lateral erosion in this section. As a result, both banks of the river are damaged. After reaching the plain, the river Debeda is characterized by an underground flow. A small tributary joins Mdianre Debeda from the right side at the given coordinate. There are also swampy areas in the same section. Following structural elements are found: Bars, Riffle. Bed Substrates is Boulder, Cobble, Gravel/pebble, Sand. Flow Types are Broken standing waves, unbroken standing waves, Rippled, and no perceptible flow.

4.1.2. Water quality assessment based on hydromorphological data

The field protocols of hydromorphological investigation with photos (JPG format) are provided as separate attachments in AM-Annexes 2, 3 and GE-Annexes 2-1, 2-2, 3. The hydro-morphological assessment is provided in AM-Annex 3.

HYDROLOGICAL ASSESSMENT

Characterizations of the hydrological regime in respect of mean and low flow, flow range and flow fluctuation. This chapter should provide an overview of the single hydrological parameters and the overall hydrological score status including the identification of the drivers for an observed hydrological change. The quantitative parameters of each hydrology assessment category are shown in AM Annex 3.

Table 6: Hydrological assessment

River basin/River name	Date	Survey unit No	Mean flow	Low flow	Water level range	Flow fluctuation	Hydro Score
Debed	04.09.2023	AG01	3	3	5	3	3.5
Debed	04.09.2023	AG02	3	3	3	3	3
Martsiget	04.09.2023	AG03	1	3	3	1	2
Debed	05.09.2023	GA01	3	3	3	3	3
Debed	05.09.2023	GA02	5	5	3	3	4
Debed	05.09.2023	GA03	3	3	1	1	2

MORPHOLOGICAL ASSESSMENT

The morphological parameters cover four categories: channel form, instream features, bank/riparian zone and floodplain parameters. This chapter should provide an overview of the single morphological parameters and the overall morphological status. The single parameters within each morph assessment category are shown in AM-Annex 3.

Table 7: Overview table of the single morphology parameters per survey unit

River basin/River name	Date	Survey unit No	Channel form	Instream features	Riparian zone	Floodplain	Morph Score
Debed	04.09.2023	AG01	1	2.5	2.7	1.5	1.9
Debed	04.09.2023	AG02	1	2.2	3	1.95	2.04
Martsiget	04.09.2023	AG03	1	2.8	2.9	2.5	2.3
Debed	05.09.2023	GA01	1	2.7	2.7	4	2.6
Debed	05.09.2023	GA02	1	1	3.7	2.5	2.1
Debed	05.09.2023	GA03	1	2.6	3.8	5	3.1

COMBINING HYDROLOGICAL AND HYDROMORPHOLOGICAL ASSESSMENT

The separate assessments of hydrology and hydromorphology can be combined to provide an overall hymo assessment (Table 8).

Table 8: Hydromorphological assessment of the survey units

River name	Date	Survey unit No	Site name	Hydrological status	Morphological status	Hy-Mo Status
Debed	04.09.2023	AG01	village Bagratashen	3.5	1.9	2.7
Debed	04.09.2023	AG02	up to Ayrum town	3	2.04	2.5
Martsiget	04.09.2023	AG03	River Mouth, Tumanyan	2	2.3	2.2
Debed	05.09.2023	GA01	village Tazakendi	3	2.6	2.8
Debed	05.09.2023	GA02	village Kirovka	4	2.1	3.1
Debed	05.09.2023	GA03	Village Enikendi	2	3.1	2.6

4.2. Chemical results

The comparison of the laboratories reveals that the analysis data only match for some of the parameters. Where differences occur, both parties are encouraged to review their approach and methods. **In the scope of this report, it is not possible to determine the exact reason for the discrepancies**. Therefore, only preliminary conclusions are drawn and, in some cases, possible causes for deviations are discussed.

Table 9 lists the results as they were reported to Umweltbundesamt and can herewith be compared. For additional parameters analysed by only one of the laboratories, no comparison can be provided.

Table 10 to Table 21 compare the single parameters. Here, UBA experts provide a first assessment. Values marked in red show significant differences at the same sampling site, values marked in green are estimated to have an acceptable deviation from each other.

Table 9: Reported comparable physico-chemical parameters – Armenia and Georgia

ARMENIA

River	Sampling site	Site num.	Date	WT field	DO field	O_2-Sat field	pH field	EC	TSS	COD	BOD_5	NH_4-N	NO_3-N	PO_4-P	TP	Cl	SO_4	Na	Mg	K	Ca
				°C	mg/L	%		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Debed	Bagratashen	AG01	04.09. 2023	19.9	9.20	101.0	8.35	405	18.4	20	2.38	0.131	2.245	0.0665	0.0951	9.988	61.547	19.475	8.825	2.661	50.788
Debed	Ayrum	AG02		19.8	9.21	101.0	8.51	383	14.6	10	2.94	0.154	2.285	0.0731	0.1021	8.248	49.906	16.672	8.960	2.546	50.479
Martsiget	Tumanyan	AG03		19.0	8.60	92.8	8.59	323	18.2	30	2.30	0.202	0.684	0.0330	0.0535	2.778	15.442	10.853	8.451	2.350	52.932
Debed	Tazakendi	GA01	05.09. 2023	21.3	10.35	117.0	8.58	396	8.7	20	2.62	0.178	2.228	0.0635	0.0990	10.224	58.049	20.842	9.414	2.607	51.171
Debed	Kirovka	GA02		24.0	9.80	116.4	8.39	523	7.2	20	2.81	0.152	2.218	0.0451	0.0779	17.463	104.411	43.667	11.553	2.844	60.461
Debed	Enikendi	GA03		23.0	8.40	98.1	7.62	656	16.7	25	2.06	0.308	1.491	0.0128	0.0354	22.834	157.065	62.471	12.902	2.984	71.779

GEORGIA

River	Sampling site	Site num.	Date	T	DO	DO	pH	Cond.	Suspended Solids	COD	BOD_5	Ammonia	Nitrate	Phosphate	Total phosphorus	Chloride	Sulphate	Sodium	Magnesium	Potassium	Calcium
				°C	mg/L	%		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Debed	Bagratasheni	AG01	04.09. 2023	19.9	9.2	101.0	8.4	405.0	28.0	2.6	1.3	0.2	10.5	0.5	0.2	7.6	51.8	17.1	16.5	2.3	58.3
Debed	Ayrum	AG02		19.8	9.2	101.0	8.5	382.6	6.0	2.5	1.2	0.2	13.6	0.6	0.2	6.7	45.8	14.2	17.5	1.9	57.1
Martsiget	Tumaniani	AG03		19.0	8.1	92.8	8.6	322.5	32.0	2.6	1.3	0.2	5.1	0.5	0.2	2.1	14.2	8.7	16.1	1.8	54.3
Debed	Tazakendi	GA01	05.09. 2023	21.3	10.4	117.0	8.6	396.2	14.0	2.4	1.2	0.2	12.4	0.8	0.2	8.0	54.0	16.8	16.9	2.1	59.6
Debed	Kirovka	GA02		24.0	9.8	116.4	8.4	523.0	6.0	2.8	1.4	0.2	10.9	0.7	0.2	13.1	96.8	27.4	21.5	2.1	67.6
Debed	Enikendi	GA03		23.0	8.4	98.1	7.6	656.0	14.0	2.4	1.2	0.2	10.0	0.2	0.2	16.9	148.3	37.8	27.2	2.5	84.4

4.2.1. Chemical Parameter Comparison

FIELD MEASUREMENTS

Field measurements in Table 10 are almost identical, with only the conductivity deviating slightly presumably due the rounding of the values. If the same instrument was used by both teams during the survey, it is not meaningful to compare these values, but rather take them as information for the given situation at the sites. In order to be able to compare results, it is recommended that each team uses their own instruments for field measurements. In that way, the measurements act as a quality control.

Table 10: Comparison field measurements

Lab	River	Sampling site	Site num.	WT field	DO field	O_2-Sat field	pH field	EC
				°C	mg/L	%		µS/cm
HMC	Debed	Village Bagratashen	AG01	19.9	9.20	101.0	8.35	405
NEA	Debeda	Bagratasheni	AG01	19.9	9.2	101	8.35	405
HMC	Debed	Up to Ayrum town	AG02	19.8	9.21	101.0	8.51	383
NEA	Debeda	Ayrum	AG02	19.8	9.21	101	8.51	382.6
HMC	Martsiget	River Mouth, Tumanyan	AG03	19.0	8.60	92.8	8.59	323
NEA	Marts	Tumaniani	AG03	19	8.1	92.8	8.59	322.5
HMC	Debed	Village Tazakendi	GA01	21.3	10.35	117.0	8.58	396
NEA	Debeda	Tazakendi	GA01	21.3	10.35	117	8.58	396.2
HMC	Debed	Village Kirovka	GA02	24.0	9.80	116.4	8.39	523
NEA	Debeda	Kirovka	GA02	24	9.8	116.4	8.39	523
HMC	Debed	Village Enikendi	GA03	23.0	8.40	98.1	7.62	656
NEA	Debeda	Enikendi	GA03	23	8.4	98.1	7.62	656

TOTAL SUSPENDED SOLIDS

The values of Total Suspended Solids show significant differences at the first 4 sites. Only at GA2 and GA2 are the deviation of the results reasonably low. The laboratories should compare their methods and sample containers should be checked for contaminations.

Table 11: Comparison TSS

Lab	River	Sampling site	Site num.	TSS
				mg/L
HMC	Debed	Village Bagratashen	AG01	18.4
NEA	Debeda	Bagratasheni	AG01	28

HMC	Debed	Up to Ayrum town	AG02	14.6
NEA	Debeda	Ayrum	AG02	6
HMC	Martsiget	River Mouth, Tumanyan	AG03	18.2
NEA	Marts	Tumaniani	AG03	32
HMC	Debed	Village Tazakendi	GA01	8.7
NEA	Debeda	Tazakendi	GA01	14
HMC	Debed	Village Kirovka	GA02	7.2
NEA	Debeda	Kirovka	GA02	6
HMC	Debed	Village Enikendi	GA03	16.7
NEA	Debeda	Enikendi	GA03	14

COD

COD results are significantly different at each site. Both laboratories use the ISO 6060 method for determining COD. Why there are such differences in the values would have to be reviewed with each lab team. HMC provides results in steps of 5 units. This is a very low resolution of the method and should be discussed.

Table 12: Comparison COD

Lab	River	Sampling site	Site num.	COD
				mg/L
HMC	Debed	Village Bagratashen	AG01	20
NEA	Debeda	Bagratasheni	AG01	2.62
HMC	Debed	Up to Ayrum town	AG02	10
NEA	Debeda	Ayrum	AG02	2.45
HMC	Martsiget	River Mouth, Tumanyan	AG03	30
NEA	Marts	Tumaniani	AG03	2.55
HMC	Debed	Village Tazakendi	GA01	20
NEA	Debeda	Tazakendi	GA01	2.4
HMC	Debed	Village Kirovka	GA02	20
NEA	Debeda	Kirovka	GA02	2.75
HMC	Debed	Village Enikendi	GA03	25
NEA	Debeda	Enikendi	GA03	2.42

BOD_5

BOD_5 results are different as well. Again, both laboratories use the same method (ISO 5815) for this parameter. The differences cannot be explained by simply looking at the numbers.

Table 13: Comparison BOD

Lab	River	Sampling site	Site num.	BOD_5
				mg/L
HMC	Debed	Village Bagratashen	AG01	2.38
NEA	Debeda	Bagratasheni	AG01	1.32
HMC	Debed	Up to Ayrum town	AG02	2.94
NEA	Debeda	Ayrum	AG02	1.22
HMC	Martsiget	River Mouth, Tumanyan	AG03	2.30
NEA	Marts	Tumaniani	AG03	1.31
HMC	Debed	Village Tazakendi	GA01	2.62
NEA	Debeda	Tazakendi	GA01	1.21
HMC	Debed	Village Kirovka	GA02	2.81
NEA	Debeda	Kirovka	GA02	1.42
HMC	Debed	Village Enikendi	GA03	2.06
NEA	Debeda	Enikendi	GA03	1.22

NH_4-N / Ammonia

In the case of Ammonia the difference in the reported results is due to the fact that HMC values are the N of NH_4, while NEA values concern the whole molecule. When the NEA values are converted (see Table 14, "NEA adjusted"), the results reach comparable levels. We would ask both laboratories to confirm if these assumptions are correct. For further comparisons like future transboundary surveys and proficiency tests, it is important to report in the correct unit for the corresponding parameter, in order to avoid bad results.

There is one outlier, which is GA03.

Table 14: Comparison Ammonia

Lab	River	Sampling site	Site num.	NH_4-N
				mg/L
HMC	Debed	Village Bagratashen	AG01	0.13
NEA	Debeda	Bagratasheni	AG01	0.21
NEA adjusted				0.16
HMC	Debed	Up to Ayrum town	AG02	0.15
NEA	Debeda	Ayrum	AG02	0.20
NEA adjusted				0.16
HMC	Martsiget	River Mouth. Tumanyan	AG03	0.20
NEA	Marts	Tumaniani	AG03	0.24
NEA adjusted				0.19
HMC	Debed	Village Tazakendi	GA01	0.18

NEA	Debeda	Tazakendi	GA01	0.22
NEA adjusted				0.17
HMC	Debed	Village Kirovka	GA02	0.15
NEA	Debeda	Kirovka	GA02	0.19
NEA adjusted				0.15
HMC	Debed	Village Enikendi	GA03	0.31
NEA	Debeda	Enikendi	GA03	0.17
NEA adjusted				0.13

NO_3-N / Nitrate

Nitrate results have partly comparable values. Like for Ammonia, it was assumed that the NEA values of Nitrate are the concentrations for the whole molecule.

Table 15: Comparison Nitrate

Lab	River	Sampling site	Site num.	NO_3-N
				mg/L
HMC	Debed	Village Bagratashen	AG01	2.24
NEA	Debeda	Bagratasheni	AG01	10.54
NEA adjusted				2.38
HMC	Debed	Up to Ayrum town	AG02	2.29
NEA	Debeda	Ayrum	AG02	13.64
NEA adjusted				3.08
HMC	Martsiget	River Mouth. Tumanyan	AG03	0.68
NEA	Marts	Tumaniani	AG03	5.13
NEA adjusted				1.16
HMC	Debed	Village Tazakendi	GA01	2.23
NEA	Debeda	Tazakendi	GA01	12.36
NEA adjusted				2.79
HMC	Debed	Village Kirovka	GA02	2.22
NEA	Debeda	Kirovka	GA02	10.90
NEA adjusted				2.46
HMC	Debed	Village Enikendi	GA03	1.49
NEA	Debeda	Enikendi	GA03	9.96
NEA adjusted				2.25

PO_4-P / Phosphate

Again, it is suspected that the reported units are different. One Laboratory seems to provide the results in PO_4 and the other in P-PO_4. HMC values seem very low, but also when the NEA values are converted, they are still higher.

Table 16: Comparison Phosphate

Lab	River	Sampling site	Site num.	PO_4-P
				mg/L
HMC	Debed	Village Bagratashen	AG01	0.07
NEA	Debeda	Bagratasheni	AG01	0.46
NEA adjusted				0,15
HMC	Debed	Up to Ayrum town	AG02	0.07
NEA	Debeda	Ayrum	AG02	0.56
NEA adjusted				0,18
HMC	Martsiget	River Mouth, Tumanyan	AG03	0.03
NEA	Marts	Tumaniani	AG03	0.52
NEA adjusted				0,17
HMC	Debed	Village Tazakendi	GA01	0.06
NEA	Debeda	Tazakendi	GA01	0.76
NEA adjusted				0,25
HMC	Debed	Village Kirovka	GA02	0.05
NEA	Debeda	Kirovka	GA02	0.70
NEA adjusted				0,23
HMC	Debed	Village Enikendi	GA03	0.01
NEA	Debeda	Enikendi	GA03	0.17
NEA adjusted				0,06

Total Phosphorus

Differences are too big and it is unclear which ones are correct. Results from NEA are in a very narrow range when compared with the results from other parameters. There should be a higher variation in the Total Phosphorus values.

Table 17: Comparison Total Phosphorus

Lab	River	Sampling site	Site num.	TP
				mg/L
HMC	Debed	Village Bagratashen	AG01	0.0951
NEA	Debeda	Bagratasheni	AG01	0.186
HMC	Debed	Up to Ayrum town	AG02	0.1021
NEA	Debeda	Ayrum	AG02	0.152

HMC	Martsiget	River Mouth, Tumanyan	AG03	0.0535
NEA	Marts	Tumaniani	AG03	0.168
HMC	Debed	Village Tazakendi	GA01	0.0990
NEA	Debeda	Tazakendi	GA01	0.166
HMC	Debed	Village Kirovka	GA02	0.0779
NEA	Debeda	Kirovka	GA02	0.17
HMC	Debed	Village Enikendi	GA03	0.0354
NEA	Debeda	Enikendi	GA03	0.159

Cl / Chloride

Chloride seems to be comparable for the first 4 sites, while the results at the last 2 sites are significantly different. Reason for the differences is unknown.

Table 18: Comparison Chloride

Lab	River	Sampling site	Site num.	Cl
				mg/L
HMC	Debed	Village Bagratashen	AG01	9.988
NEA	Debeda	Bagratasheni	AG01	7.55
HMC	Debed	Up to Ayrum town	AG02	8.248
NEA	Debeda	Ayrum	AG02	6.71
HMC	Martsiget	River Mouth, Tumanyan	AG03	2.778
NEA	Marts	Tumaniani	AG03	2.08
HMC	Debed	Village Tazakendi	GA01	10.224
NEA	Debeda	Tazakendi	GA01	8.04
HMC	Debed	Village Kirovka	GA02	17.463
NEA	Debeda	Kirovka	GA02	13.05
HMC	Debed	Village Enikendi	GA03	22.834
NEA	Debeda	Enikendi	GA03	16.85

SO_4 / Sulphate

All of the Sulphate results at each site are comparable values.

Table 19: Comparison Sulphate

Lab	River	Sampling site	Site num.	SO_4
				mg/L
HMC	Debed	Village Bagratashen	AG01	61.547
NEA	Debeda	Bagratasheni	AG01	51.75
HMC	Debed	Up to Ayrum town	AG02	49.906

NEA	Debeda	Ayrum	AG02	45.79
HMC	Martsiget	River Mouth, Tumanyan	AG03	15.442
NEA	Marts	Tumaniani	AG03	14.19
HMC	Debed	Village Tazakendi	GA01	58.049
NEA	Debeda	Tazakendi	GA01	54.01
HMC	Debed	Village Kirovka	GA02	104.411
NEA	Debeda	Kirovka	GA02	96.8
HMC	Debed	Village Enikendi	GA03	157.065
NEA	Debeda	Enikendi	GA03	148.29

NA / SODIUM

The deviations of the results at AG01, AG02, AG03, GA01 are reasonable, while they are too high at GA02 and GA03. Notably there are two different methods used for this parameter at each lab (Armenia: ISO 17294; Georgia: ISO 11885).

Table 20: Comparison Sodium

Lab	River	Sampling site	Site num.	Na
				mg/L
HMC	Debed	Village Bagratashen	AG01	19.475
NEA	Debeda	Bagratasheni	AG01	17.07
HMC	Debed	Up to Ayrum town	AG02	16.672
NEA	Debeda	Ayrum	AG02	14.24
HMC	Martsiget	River Mouth, Tumanyan	AG03	10.853
NEA	Marts	Tumaniani	AG03	8.71
HMC	Debed	Village Tazakendi	GA01	20.842
NEA	Debeda	Tazakendi	GA01	16.83
HMC	Debed	Village Kirovka	GA02	43.667
NEA	Debeda	Kirovka	GA02	27.38
HMC	Debed	Village Enikendi	GA03	62.471
NEA	Debeda	Enikendi	GA03	37.79

MG / MAGNESIUM

Presumably there might have happened a calculation error at some point. By either dividing the NEA values by 2, or by doubling the HMC results, one would reach very comparable levels. It is unclear if the HMC or the NEA value needs to be adjusted. It is advised to review the calculation.

Table 21: Comparison Magnesium

Lab	River	Sampling site	Site num.	Mg
				mg/L
HMC	Debed	Village Bagratashen	AG01	8.825
NEA	Debeda	Bagratasheni	AG01	16.51
NEA adjusted				8,255
HMC	Debed	Up to Ayrum town	AG02	8.960
NEA	Debeda	Ayrum	AG02	17.54
NEA adjusted				8,77
HMC	Martsiget	River Mouth, Tumanyan	AG03	8.451
NEA	Marts	Tumaniani	AG03	16.05
NEA adjusted				8,025
HMC	Debed	Village Tazakendi	GA01	9.414
NEA	Debeda	Tazakendi	GA01	16.91
NEA adjusted				8,455
HMC	Debed	Village Kirovka	GA02	11.553
NEA	Debeda	Kirovka	GA02	21.48
NEA adjusted				10,74
HMC	Debed	Village Enikendi	GA03	12.902
NEA	Debeda	Enikendi	GA03	27.17
NEA adjusted				13,585

K / Potassium

All levels could be more similar, but the differences are still somewhat acceptable.

Table 22: Comparison Potassium

Lab	River	Sampling site	Site num.	K
				mg/L
HMC	Debed	Village Bagratashen	AG01	2.661
NEA	Debeda	Bagratasheni	AG01	2.29
HMC	Debed	Up to Ayrum town	AG02	2.546
NEA	Debeda	Ayrum	AG02	1.9
HMC	Martsiget	River Mouth, Tumanyan	AG03	2.350
NEA	Marts	Tumaniani	AG03	1.82
HMC	Debed	Village Tazakendi	GA01	2.607
NEA	Debeda	Tazakendi	GA01	2.07

HMC	Debed	Village Kirovka	GA02	2.844
NEA	Debeda	Kirovka	GA02	2.14
HMC	Debed	Village Enikendi	GA03	2.984
NEA	Debeda	Enikendi	GA03	2.46

Ca / Calcium

Levels are comparable at the first 5 sites, while they differ too much at the last one.

Table 23: Comparison Calcium

Lab	River	Sampling site	Site num.	Ca
				mg/L
HMC	Debed	Village Bagratashen	AG01	50.788
NEA	Debeda	Bagratasheni	AG01	58.31
HMC	Debed	Up to Ayrum town	AG02	50.479
NEA	Debeda	Ayrum	AG02	57.12
HMC	Martsiget	River Mouth, Tumanyan	AG03	52.932
NEA	Marts	Tumaniani	AG03	54.31
HMC	Debed	Village Tazakendi	GA01	51.171
NEA	Debeda	Tazakendi	GA01	59.6
HMC	Debed	Village Kirovka	GA02	60.461
NEA	Debeda	Kirovka	GA02	67.62
HMC	Debed	Village Enikendi	GA03	71.779
NEA	Debeda	Enikendi	GA03	84.39

4.3. Biological results

Both the Georgian and the Armenian Ecological Status Classification System (ESCS) for benthic invertebrates developed during the EUWI+ project were applied for the each respective sample. The single metrics can give interesting indications. However, the comparison of the status classification has to be regarded with caution as the ESCS and their reference values and class borders are derived from specific national data for certain river types. What follows are the comparison of the ESCS, while the taxa lists are given in AM-Annex 6 and GE-Annex 6-**Fehler! Verweisquelle konnte nicht gefunden werden.**

The Debed is classified as a Type XVI in the Georgian delineation. This type was also assumed for Armenian sites AG01 and AG02 when applying the Georgian data to the Georgian ESCS. The site AG03 at Martsiget is a small tributary with <100km² catchment area and lies just above >800m elevation. Therefore, the most fitting Georgian river type is a Type VII. As for the Georgian sites GA01, GA02, and GA03, the most fitting type according to the Armenian delineation is Type III.

In the case of Georgia, the ESCS was developed based on data from the Alazani-Iori and Khrami-Debed catchments. It should therefore fit the area quite well. The Armenian ESCS is based on data from the

Hrazdan and Sevan catchments. The reason why the Armenian ESCS boundaries can nevertheless also fit for the Debed is that the method is relatively coarse. The metrics partly assume family level (BMWP, ASPT) and only partly a higher taxonomic resolution (EPT, Diversity Index). For this reason, the type differences in this respect are expected to be acceptable.

However, where the method reacts very sensitively is with different taxa numbers, different sample sizes, and level of determination. The addition of one or two sensitive taxa can shift the result significantly. The sample size and the number of individuals (i.e. the number of sub-samples of an MHS sample) are also important, as the Margalef Diversity Index takes abundance into account. (At the time, this diversity index was a concession to the older methods from EPIRB, where the Margalef was included. Other diversity indices such as Shannon-Wiener are less sensitive in this respect. A revision of the ESCS could be possible in the future.)

BIOLOGY – AG01 BAGRATASHEN

Assessment results are similar, including the nEQR. Georgia reaches Good Status and Armenia High Status. It is noteworthy, that the number of sampled individuals per team is very different. AM number is about three times higher, but this is due to the high numbers in Chironomidae and Hydropsychidae.

Table 24: Biological results – AG01 Bagratashen

NEA Data with GE ESCS		
Sampling date	04.09.2023	
River name	Debed	
Site name	Bagrateshen	
River type	XVI	
Site No.	AG01	
Sampling No.		
	original	*stand.*
nr of individuals	214	
Abundance [ind./m²]	171	
taxa richness	11	
BMWP	53	0.40
ASPT	5.89	0.69
EPT	5	0.32
%EPT	66.4%	0.69
Margalef	1.94	0.47
MMI		0.56
ref. MMI		0.72
EQR		0.78
	nEQR	**0.74**
	Ecol. status	**GOOD**

HMC Data with AM ESCS		
Sampling date	04.09.2023	
River name	Debed	
Site name	Bagratashen	
River type	III	
Site No.	AG01	
Sampling No.		
	original	*stand.*
nr of individuals	643	
Abundance [ind./m²]	514	
taxa richness	13	
BMWP	61	0.38
ASPT	6.10	0.93
EPT	5	0.39
%EPT	60.2%	0.78
Margalef	1.92	0.36
MMI		0.69
ref. MMI		0.75
EQR		0.92
	nEQR	**0.89**
	Ecol. status	**HIGH**

BIOLOGY – AG01 AYRUM

nEQR values show differences. The Georgian method reaches Good Status, while the Armenian method reaches Moderate Status. But this because of the presence of *Ecdyonurus* sp. and *Ephemerella* sp. in the Georgian sample. These taxa have a high BMWP score and because of 3 individuals the results deviate from each other. This circumstance underlines the earlier statement, that the method reacts sensitively to different taxa numbers, sample sizes, and level of determination.

Table 25: Biological results – AG02 Ayrum

NEA Data with GE ESCS		
Sampling date	04.09.2023	
River name	Debed	
Site name	Ayrum	
River type	XVI	
Site No.	AG02	
Sampling No.		
	original	*stand.*
nr of individuals	267	
Abundance [ind./m²]	214	
taxa richness	8	
BMWP	49	0.37
ASPT	6.13	0.74
EPT	4	0.25
%EPT	66.7%	0.70
Margalef	1.30	0.30
MMI		0.55
ref. MMI		0.72
EQR		0.77
	nEQR	**0.73**
	Ecol. status	**GOOD**

HMC Data with AM ESCS		
Sampling date	04.09.2023	
River name	Debed	
Site name	Ayrum	
River type	III	
Site No.	AG02	
Sampling No.		
	original	*stand.*
nr of individuals	516	
Abundance [ind./m²]	413	
taxa richness	9	
BMWP	47	0.20
ASPT	5.22	0.57
EPT	3	0.18
%EPT	85.9%	1.13
Margalef	1.33	0.09
MMI		0.45
ref. MMI		0.75
EQR		0.60
	nEQR	**0.59**
	Ecol. status	**MODERATE**

BIOLOGY – AG03 TUMANIANI

Status results are identical. Both samples and methods show High Status. Differences in number of taxa and individuals can be observed.

Table 26: Biological results – AG03 Tumaniani

NEA Data with GE ESCS		
Sampling date	04.09.2023	
River name	Martsiget	
Site name	Tumaniani	
River type	VII	
Site No.	AG03	
Sampling No.		
	original	*stand.*
nr of individuals	168	
Abundance [ind./m²]	134	
taxa richness	14	
BMWP	71	0.55
ASPT	6.45	0.80
EPT	6	0.38
%EPT	76.8%	0.80
Margalef	2.65	0.66
MMI		0.68
ref. MMI		0.71
EQR		0.96
	nEQR	**0.93**
	Ecol. status	**HIGH**

HMC Data with AM ESCS		
Sampling date	04.09.2023	
River name	Martsiget	
Site name	Tumaniani	
River type	I	
Site No.	AG03	
Sampling No.		
	original	*stand.*
nr of individuals	638	
Abundance [ind./m²]	510	
taxa richness	21	
BMWP	105	0.91
ASPT	6.56	1.12
EPT	11	1.00
%EPT	85.0%	1.12
Margalef	3.21	0.94
MMI		1.05
ref. MMI		0.85
EQR		1.24
	nEQR	**1.00**
	Ecol. status	**HIGH**

BIOLOGY – GA01 TAZAKENDI

Both the Georgian ESCS and the Armenian ESCS reach Good Status at Tazakendi. Differences in number of taxa and individuals can be observed.

Table 27: Biological results – GA01 Tazakendi

NEA Data with GE ESCS		
Sampling date	05.09.2023	
River name	Debeda	
Site name	Tazakendi	
River type	XVI	
Site No.	GA01	
Sampling No.		
	original	*stand.*
nr of individuals	113	
Abundance [ind./m²]	90	
taxa richness	6	
BMWP	31	0.22
ASPT	5.17	0.54
EPT	4	0.25
%EPT	46.9%	0.49
Margalef	1.11	0.25
MMI		0.41
ref. MMI		0.72
EQR		0.57
	nEQR	**0.60**
	Ecol. status	**GOOD**

HMC Data with AM ESCS		
Sampling date	05.09.2023	
River name	Debed	
Site name	Tazakendi	
River type	III	
Site No.	GA01	
Sampling No.		
	original	*stand.*
nr of individuals	129	
Abundance [ind./m²]	103	
taxa richness	10	
BMWP	41	0.13
ASPT	5.13	0.53
EPT	5	0.39
%EPT	73.6%	0.96
Margalef	1.94	0.37
MMI		0.46
ref. MMI		0.75
EQR		0.62
	nEQR	**0.60**
	Ecol. status	**GOOD**

BIOLOGY – GA02 KIROVKA

Status results are identical. Both reach High Status. Differences in number of individuals. Higher numbers of Hydropsyche and Chironomids in the Armenian sample.

Table 28: Biological results – GA02 Kirovka

NEA Data with GE ESCS		
Sampling date	05.09.2023	
River name	Debeda	
Site name	Kirovka	
River type	XVI	
Site No.	GA02	
Sampling No.		
	original	*stand.*
nr of individuals	196	
Abundance [ind./m²]	157	
taxa richness	13	
BMWP	64	0.49
ASPT	6.40	0.79
EPT	7	0.44
%EPT	81.1%	0.85
Margalef	2.37	0.58
MMI		0,67
ref. MMI		0,72
EQR		0,93
	nEQR	**0,89**
	Ecol. status	**HIGH**

HMC Data with AM ESCS		
Sampling date	05.09.2023	
River name	Debeda	
Site name	Kirovka	
River type	III	
Site No.	GA02	
Sampling No.		
	original	*stand.*
nr of individuals	629	
Abundance [ind./m²]	503	
taxa richness	17	
BMWP	74	0.53
ASPT	6.17	0.96
EPT	7	0.59
%EPT	69.3%	0.90
Margalef	2.57	0.65
MMI		0,80
ref. MMI		0,75
EQR		1,06
	nEQR	**1,00**
	Ecol. status	**HIGH**

BIOLOGY – GA03 ENIKENDI

Both the Georgian ESCS and the latest Armenian ESCS reach Good Status at Enikendi. Differences in number of individuals. Higher numbers of Caenidae, Baetidae, and Chironomids in the Armenian sample.

Table 29: Biological results – GA03 Enikendi

NEA Data with GE ESCS		
Sampling date	05.09.2023	
River name	Debeda	
Site name	Enikendi	
River type	XVI	
Site No.	GA03	
Sampling No.		
	original	*stand.*
nr of individuals	182	
Abundance [ind./m²]	146	
taxa richness	8	
BMWP	36	0.26
ASPT	5.14	0.53
EPT	3	0.19
%EPT	75.8%	0.79
Margalef	1.41	0.33
MMI		0.43
ref. MMI		0.72
EQR		0.60
	nEQR	**0.63**
	Ecol. status	**GOOD**

HMC Data with AM ESCS		
Sampling date	05.09.2023	
River name	Debed	
Site name	Enykendi	
River type	III	
Site No.	GA03	
Sampling No.		
	original	*stand.*
nr of individuals	413	
Abundance [ind./m²]	330	
taxa richness	11	
BMWP	43	0.16
ASPT	5.38	0.64
EPT	4	0.29
%EPT	61.0%	0.79
Margalef	1.72	0.27
MMI		0.48
ref. MMI		0.75
EQR		0.64
	nEQR	**0.62**
	Ecol. status	**GOOD**

5. Discussion of results

The results show that further coordination between the two countries, especially between the laboratories, is required. The delivery of results in different units is mentioned here as an example. The values for 4 parameters (COD, BOD_5, PO_4, total P) are too far apart for all samples and the reasons for this must be found. Furthermore, reference is made to standardized sampling, sample stabilization and sample transport in accordance with the ISO 5667 series. Compliance with this will lead to an improvement in the comparability of the results. The efforts of the laboratories in the area of quality assurance, such as regular participation in proficiency tests and comparative measurements should also contribute to comparability.

Nevertheless, it should also be noted that there can always be differences in the measurement results, the causes of which should be investigated.

It is further recommended to participate in proficiency-tests whenever possible and to continue the transboundary activities and surveys to increase the credibility and comparability of future results.

Regarding the results of the chemical analysis, a significant increase of electric conductivity as well as concentrations of the main ions (especially sulphate and sodium) from upstream to downstream was observed. The reason for this striking longitudinal gradient (with highest vales at Kirovka and Enikendi) is not clear and should be investigated in the future.

Regarding the biological assessment, the respective ESCS indicates a good or high biological status at the investigated sites, with the exception of the Armenian ESCS at Ayrum (medium status). However, looking at the data behind the assessment, differences become visible. It is recommended to more strictly follow the guidelines of the AQEM method, which requires a) 20 replicates per MHS sampling, b) sorting and identifying at least 700 individuals per sample. In the HMC lab, the number of individuals identified was between 413 sn 643 with one outlier with 129 individuals. In the NEA lab, the number of individuals identified ranged between 113 and 267, so clearly below the required 700 individuals. Both the varying number of replicates and the low number of individuals identified in the NEA samples may be one of the reasons for a tendency to a higher taxa richness in the samples analyzed by HMC as compared to NEA, although the difference was not statistically significant (Mann Whitney test, p=0.22).

One of the reasons for different assessment results between the countries at the same site might be the differences in reference values (e.g. EPT at site GA02 Kirovka is 7 as analyzed by both samples, but nEQR is 0.44 in the GE ESCS, whereas it is 0.59 in the AM ESCS. This highlights the necessity to refining type-specific reference values.

The upstream – downstream gradient of conductivity and salt concentrations was not reflected in the biological samples, either because it is too small to have a visible impact on the benthic communities or because other environmental factors have a higher impact on the macrozoobenthos than the chemical properties mentioned (at least within the observed range). It would be helpful to have a higher frequency of physico-chemical data (more sampling per year) to cope with possibly high seasonal fluctuations.

6. Next steps and lessons learned

- Investigation of possible errors in the analytical procedures to improve the confidence in the chemical analysis
- Internal training of biological experts to harmonize the sampling (no. of replicates) and lab method (no. of individuals identified)
- Enlarge the database of biological data to provide data for refining the type-specific reference values
- Increase the frequency of physico-chemical sampling to investigate possible seasonal fluctuations

7. Annexes

Annex A

Annex_A_AM-GE_CHEM-Data.xlsx

Annex B

Annex_B_AM-GE_MZB-Data.xlsx

Literature used for determination by Armenia:

- Taxonomie für die Praxis, Bestimmungshilfen - Makrozoobenthos (1), LANUV-Arbeitsblatt 14, Recklinghausen 2010
- Taxonomie für die Praxis, Bestimmungshilfen - Makrozoobenthos (2), LANUV-Arbeitsblatt 20, Recklinghausen 2015
- Atlas of Central European Trichoptera Larvae, Johann Waringer, Wolfram Graf, 2011
- Identification Guide to Aquatic and Semiaquatic Diptera Larvae, German Limnological Society, 2015
- Chironomidae of the Holarctic Region, Keys and diagnoses – Larvae, Lund, Sweden, 2013
- Полевой определитель пресноводных беспозвоночных, Калининград 2002 (Field guide for freshwater invertebrates, Kaliningrad 2002)
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- Hydrobiologicky Determinacny Atlas (Hydrobiological Determination Atlas), Emilia Elexova, Bratislava 2000
- Plecoptera Slovenska (Plecoptera of Slovakia), I. Krno, Bratislava 2011
- Podenky (Ephemeroptera), I. Krno, T. Derka, Bratislava 2011

7.1. Armenian Annexes

AM-Annex 1 Field protocols

AM-Annex 2 Photos

AM-Annex 3 Hydromorphology

AM-Annex 4 Chemical data summary

AM-Annex 5 Protocol sample delivery and handover

AM-Annex 6 Hydrobiological data

AM-Annex 7 Water quality assessment norms

7.2. Georgian Annexes

GE-Annex 1 Field Protocols

GE-Annex 2-1 Photo

GE-Annex 2-2 Photo Documentation Hydrology

GE-Annex 3 template for hydro-morphological site description Field protocols

GE-Annex 4 Chem+Bio Data

GE-Annex 5 Handover Protocol

GE-Annex 6 Biological Data

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