Shuakhevi Hydropower Project

Low flow mitigation strategy including Ecological Baseline Review

26 September 2017

AGL

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1 Introduction

The purpose of this report is to set out a strategy to mitigate the potential impacts caused by reduced flows downstream of the dams and weirs that form part of the Shuakhevi Hydropower Project (the Project). This is achieved by outlining the expected impacts that the scheme will create and the potential mitigation measures available. The report then focusses on each river, detailing its characteristics, hydrology and ecology. This understanding is used to assess specific impacts for each river which in turn informs recommendations for the specific, robust mitigation measures which will be required to achieve no residual adverse impact to biodiversity. The approach is informed by the precautionary principle at all times; i.e. in the absence of a complete understanding of potential impacts a reasonable worst case is assumed with effects subject to a monitoring programme.

The report is framed around the minimum standards which the project must achieve, namely no residual adverse impact to biodiversity and no irreversible damage to the local ecosystem. With all mitigation measures successfully implemented, the project is not expected to cause significant irreversible damage to the local ecosystem over the long term. Eventually its structures will be decommissioned (estimated design life 100 years) and the river will be able to return to its unmodified state. As such, the report focusses on how the minimum standard of no residual adverse impact to biodiversity can be achieved for each river system.

The development of the mitigation strategy presented in the main body of the report has been informed through comprehensive appraisal of the pre-construction and construction aquatic ecology surveys undertaken for the Project through to the end of the summer 2016. A full review of this aquatic ecology baseline information is presented in the Ecological Baseline Review (EBR) in the Appendix.

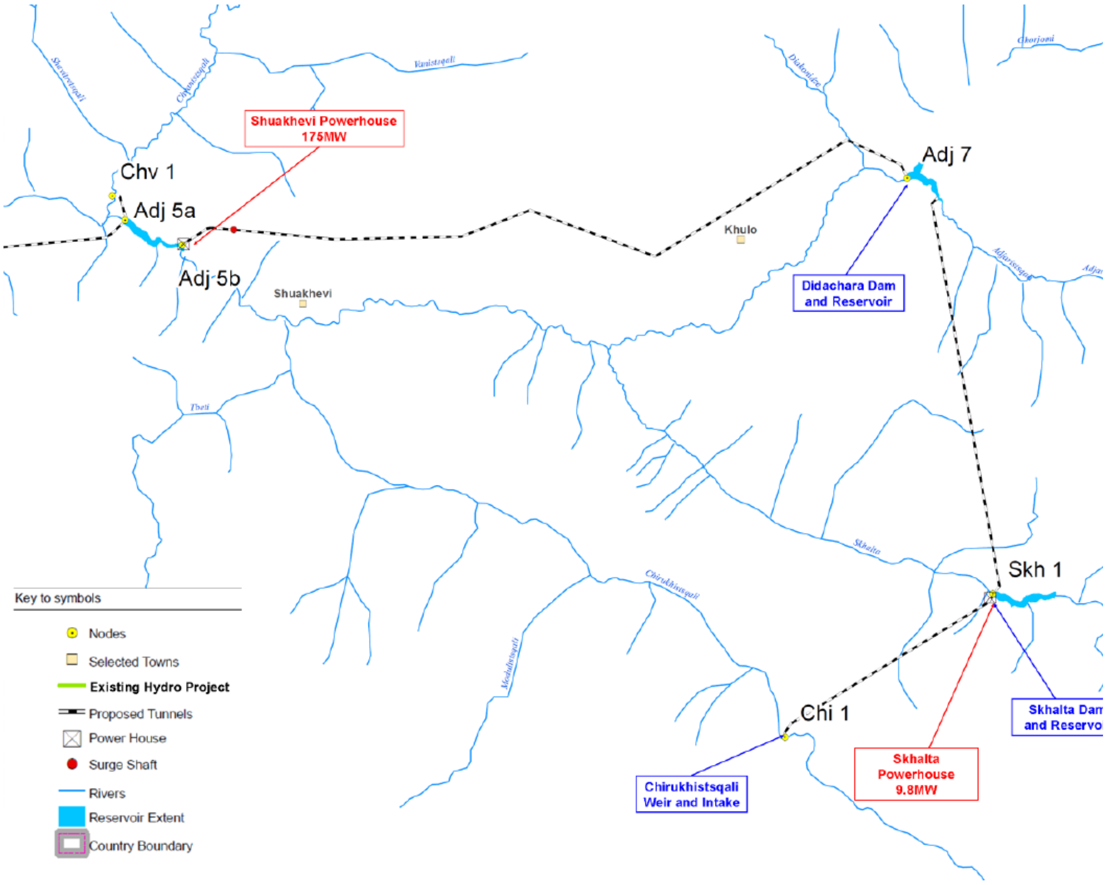
2 Project overview

The Project once complete will divert water from the Chirukhistsqali and Skhalta Rivers into a reservoir on the Adjaristsqali River at Didachara. The reservoir (behind Didachara dam) will provide diurnal storage and will facilitate the transfer of water via a head race tunnel on the right bank, to a powerhouse downstream from Shuakhevi village. Additional small reservoir storage will be provided on the Skhalta River at the Chirukhistsqali outfall and storage at Skhalta will be supplemented by waters diverted from a weir pond on the Chirukhistsqali River. A small powerhouse will be built at the Chirukhistsqali outfall to generate from the head differential of over 100m. The key components of the scheme are detailed in Figure 1 and the proposed operating regime for the Project is provided in Table 1.

Table 1 Proposed operating regime

	Chirukhistsqali	Skhalta	Didachara
Environmental flow (m^3/s)	0.477	0.578	0.715
Maximum intake (m^3/s)	10.6	25	48.88
Flushing flow (m^3/s)	5 to 10	17	25
Frequency of flushing (/yr.)	2	2	2

Figure 1: Scheme layout



3 Methodology

3.1 Preceding studies and limitations

In order to assess the potential impact of the changes to the downstream flow regime a range of surveys including mesohabitat mapping, flow measurements, fish surveys and macroinvertebrate surveys were carried out between 2012 and 2016[1]. These studies supplement and build on the ESIA for the Project.

Mesohabitat survey techniques enable mapping and description of river habitat characteristics and availability in large river sections. Mesohabitat methods rely on the classification of hydro-morphological units based on hydraulic attributes such as water depth, velocity and physical characteristics. The mesohabitat method selected for this project was based on the Norwegian Mesohabitat Classification Method. The Norwegian Method builds on and provides more detail than commonly used riffle-run-pool-methods, classifying river sections into a maximum of ten physical meso-scale morphological (mesohabitat) classes by visual observation.

The Norwegian Method relies on surveys at higher and lower flow conditions to extrapolate impacts during lower operational flow conditions. The efficacy of the technique is improved with data obtained as close as possible to operational low flow levels. Operational flow levels are however very rare in the Project catchment and due to the flashy nature of the river systems it was not possible to obtain monitoring data at operational flow levels. Low flow data at approximately 20% annual average flow was obtained for the Adjaristsqali River but interpretation of the data found that it enabled only a relatively coarse understanding of potential impacts and mitigations. It was not possible to obtain low flow data for the Chirukhistsqali River or Skhalta River.

In summary, it was originally intended that the surveys would allow the function and habitat availability of the rivers at the intended environmental flow to be extrapolated. However, extrapolation of these results did not provide a satisfactory basis for developing potential mitigation measures. In particular it could not inform the requirements for the potential reconfiguration of river channels. As such a revised methodology was developed and is described below.

3.2 Revised approach to designing mitigation measures

In December 2016, a team from MML and AGL surveyed each of the rivers below the impoundment sites to assess the likely hydro-geomorphological changes to each river following commissioning. Photographs and observations of each section were made, with particular attention to the stretches between the impoundment and the first significant tributaries. The survey team comprised senior engineering, environmental and ecology personnel.

The team estimated flow rates on the day and then visualised this in comparison to the proposed downstream flow regime, i.e. environmental flow, spilling/flood flows, ground water flow and flushing flows. The survey assessed how the river will behave under the new regime and what habitat will be provided, observing:

- channel shape and depth
- river morphologies

[1] Macroinvertebrate surveys up to 2015.

- sources of sediment
- likely obstacles
- additional flow from tributaries and ground water

The survey focused on the stretch of river within approximately 5km of the dams and weirs as these will be the reaches most affected by the new flow regime. The information gained through these surveys has been combined with existing knowledge from the ESIA and subsequent fish surveys to define robust mitigation measures for the project.

4 Overview of anticipated impacts and available mitigation measures

4.1 Anticipated impacts

The ESIA predicted the main aquatic environmental impacts during the operational phase to be:

- reduced flows downstream of each dam and weir
- physical barriers to aquatic species caused by the dams, weirs and discharges from the powerhouse
- changes to sediment regime (particularly sediment flushing from the dams)
- creation of small reservoirs

The fish communities are dominated by cyprinids and most fish species present are widely distributed in the catchment (Transcaucasian spirlin, Anatolian kramulya, colchic barbel, chub). A few species are endemic to the Kolkheti region, but their distribution is not restricted to Georgia or the Project area. None of the species recorded between 2012 and 2016 (spring) in the Shuakhevi Project area are described as being Vulnerable or Endangered globally (the IUCN Red List), but Black Sea trout is classified as Vulnerable on the Georgian Red List.

Spawning habitats are present in river reaches influenced by the scheme and will be lost or degraded through direct impacts and inundation. In the Adjaristsqali River for example, spawning habitat has been recorded for the Transcaucasian spirlin, common roach, chub, colchic kramulya, and colchic nase within the reach most influenced by Project (downstream of the Didachara dam). However, equivalent spawning habitats are also present in reaches upstream the dams and weir and in tributaries not influenced by the Project. Consequently, it is unlikely that the Project will result in a significant reduction or loss of spawning habitat.

The reduction of flows downstream of the dams and weirs will result in a reduction of wetted perimeter as well as important changes in hydraulic characteristics (flow velocity and water level). As water level reduces the velocity will also reduce. These changes will not only result in loss of habitats but could also lead to a barrier effect and habitat fragmentation if water level and velocity are not sufficient for individuals to move upstream. This in turn could prevent access to some tributaries. These are the key impacts which mitigation measures aim to address.

In the Adjaristsqali and Skhalta Rivers the presence of a dam will result in a physical barrier to upstream habitats. Although spawning habitats exist in other tributaries, a local reduction in fish numbers for some species (for example the Black Sea trout and colchic barbel) could result. The fish assemblage in the reservoir is likely to change significantly due to the change into a lentic habitat. However, roach is likely to colonise the new reservoir as it is able to thrive in lakes or reservoirs.

4.2 Available mitigation measures

The Project was taken forward by AGL following agreement that the environmental flow would be set at 10% of the annual average. The Project ESIA captured this scenario within the assessment of hydrological and ecological impacts, however detailed mitigation was not set out. With the constraint that the environmental flow cannot be increased beyond 10% of the annual average, there are a limited number of mitigation measures available to the project that can be utilised to achieve the minimum standards for each river. These are:

- channel modification to concentrate the environmental flow and maintain access to tributaries
- native fish stocking and/or trap and transport programme to ensure a stable population of fish upstream of the dams
- bank stabilization to reduce erosion into the river which could block the environmental flows

Merits and challenges of these approaches are discussed below.

4.2.1 Channel modification

4.2.1.1 Background and challenges

The survey team considered the use of channel modification measures on each river to concentrate flow to maintain hydraulic connectivity. *The Handbook for environmental design in regulated salmon rivers by* Torbjørn Forseth and Atle Harby describes the concept as:

> *'confining the stream course and introducing alternate reaches of riffles and pools. Such measures are named "a river in the river". Current deflectors, rocks and other structures are used to narrow river width permitting current velocities to increase and the river to meander more. If necessary and feasible, deep pools can be excavated and small weirs constructed to produce alternate slow- and faster flowing reaches, respectively'*

It is important to note that this concept is relatively innovative, not widely practiced, and poses a number of specific challenges in the rivers affected by the Shuakhevi project:

- The project rivers are highly geo-morphologically active and will be challenging to permanently reconfigure
- If soft engineering is used, it will require reconfiguration after every flood or flush
- If hard engineering is used, it would disrupt the natural river processes and would not provide a natural habitat
- There is low certainty that any modification would function in the long term
- Implementation and maintenance would require experienced contractors that may not be available in Georgia
- River access in many places is challenging and could pose a health and safety risk

In addition, healthy rivers are dynamic and need to move to redistribute sediment. Fixed structures within a river have not evolved as a result of natural processes and will change a river's dynamic. Prioritising natural processes will ensure that the river evolves and finds a sustainable path which will support enduring habitat for existing flora and fauna.

4.2.1.2 Proposed approach to channel modification

In consideration of the challenges and constraints outlined above it was determined that a permanent engineering solution would not be an effective long-term solution within the context of the Project and would also be contrary to good practice in maintaining natural river function. As such we recommend some minor channel configuration during commissioning and the initial years of the project to ensure hydraulic connectivity and to allow the river to find its new equilibrium – 'kick starting' natural processes.

Despite the range of surveys undertaken on the river, it remains difficult to predict how it will behave under the new flow conditions. As such, it is not recommended to design channel modification before commissioning. However, to ensure no residual adverse impact to biodiversity the rivers will require careful, expert monitoring during the commissioning phase and first years of operation to rapidly address any issues that manifest.

4.2.1.3 Expertise required

The Project will commit to employing an appropriately qualified geomorphologist/hydrologist and a fisheries specialist to assist through commissioning and operation. These individuals will be responsible for the delivery of the ecological and geomorphological aspects of the LFMS objectives. They will ensure adequate monitoring is undertaken to inform any channel modification that may be needed to enable compliance with the Lenders requirements (i.e. EBRD PS6, IFC PS6 etc.) and avoid net loss of biodiversity.

The geomorphologist/hydrologist should be qualified to PhD level and have at least 5 years of experience of working with a range of stakeholders, particularly on hydropower projects[2]. The fluvial geomorphologist will survey the rivers during commissioning and immediately instruct (through AGL) a competent contractor to make minor channel modifications if required. This could be, for example, to concentrate flows in wide shallow reaches, remove boulders in event of a blockage, or to act to avoid the river splitting into multiple braids.

Specific responsibilities will include:

- Establishing a programme of site inspections in the reach below each of the new dams/weirs. Site inspections at regular intervals and after major events eg spill from dam, sediment flushing release.
- Agree with fishery expert on criteria for assessing when action might need to be triggered because the channel has changed in a way viewed as detrimental to the aquatic ecosystem.
- Trigger river works as needed, specify what is to be done and supervise works to ensure channel modification is as required
- Annual report to client detailing status of the key critical reaches; details of any remedial measures taken in the year, and assessment from monitoring of effectiveness of previous remedial measures

Specific aspects monitored will include:

- site inspections at critical reaches early in operations, at regular intervals thereafter and after major events e.g. spill from dam, sediment flushing release. If concerns are raised then frequency should increase accordingly.
- Site inspections to include a set of photographs taken at each target site replicated at each inspection visit to allow comparison over time.
- Sediment samples continuing preconstruction monitoring programme (sites and frequency) to allow comparison over time against baseline.
- Bed samples (size) continuation of preconstruction monitoring
- Water quality continuation of preconstruction monitoring
- Analyse release flow figures from operations team but also take ad hoc velocity measurements in the critical reaches to check conditions in low flow conditions

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[2] These requirements are in line with recommendations of the Department for Environment, Food and Rural Affairs (DEFRA) in the UK for similar works.

The fisheries specialist should be qualified to PhD level and have at least 5 years of experience of working with a range of stakeholders, particularly on hydropower projects. They will assist the geomorphologist/hydrologist by collecting and analysing ecological monitoring data to understand and predict the effect of reduced flows and potential channel modifications on the aquatic ecology. Specific responsibilities will include routine inspection of the river habitat and fish populations downstream and upstream of dams and weir. Specific aspects monitored will include;

- Monitoring of in-channel habitats
- Identification of the presence of sensitive habitats and distribution and assess changes
- Monitoring fish pass efficiency
- Liaison with experts' teams responsible for undertaking fish and macroinvertebrate surveys

Routine inspections will be carried out during the early period of operation, at regular intervals thereafter and after major evens (e.g. flooding and flushing).

4.2.1.4 Ongoing channel monitoring and modification after flushing and flooding

Monitoring the river during the initial years of project operation will be particularly important to build an understanding the reaction and behaviour of the river morphology and fish habitat to the new flow regime. The specialists will be required to undertake monitoring similar to that undertaken through commissioning, after each flushing action and after each significant flooding event.

MML recommend flushing at Didachara and Skhalta with the reservoir drawn down at least once a year. The flushing will be undertaken when flow in the river is in excess of the required flushing flow. It may also be necessary to sluice the intake area at more frequent intervals. Some mechanical excavation may be required for the upstream end of the reservoir where flushing will not remove sediment. The need to flush will depend on the incoming sediment load which in turn depends on the flows in the river so AGL intend to monitor sediment build up monthly and flush in the spring and autumn floods as and when required. They intend to monitor downstream impact of flushing and will finalise the sediment management plan after two years of operation and monitoring.

If monitoring shows that flushing has predictable results and does not cause significant issues for fish habitat then physical river mitigation activities may not be required over the long term. If, however, monitoring shows that flushing negatively impacts fish habitat or connectivity, and mitigation is needed, then ongoing monitoring and management of the river channel may be required over a longer duration guided by the specialists described above. If monitoring during the initial years of operation shows that ongoing or routine channel modification is required, the Project will need to continue channel monitoring and management as required to maintain a functional river and longitudinal ecological connectivity. The sustainability of the mitigation interventions will be a key metric of their success. The input of both specialists will be necessary to ensure that consideration of the local geomorphology ensures a long-term solution to minimising disruption to the aquatic ecology.

Specific actions for each river, are described in Section 5.

4.2.2 Fish monitoring and management

4.2.2.1 Outline of monitoring program

A fish monitoring and management programme will be undertaken to provide a long-term study of the biological environment in the Adjaristsqali River and its tributaries. The purpose of the programme is to test the suitability of the mitigation and management measures and subsequently to identify the need for additional mitigation or offsetting measures as necessary. The programme will include surveys to inform identification of fish species present, specification of their reproduction, nursing and feeding areas and conditions as well as confirmation of sensitive reaches, spawning habitats, and juvenile and adult habitat requirements.

Surveys will be undertaken four times a year for ten years during the operation phase. Survey methodologies will follow previous fish capture methodologies including cast nets (weight 7 kilograms, 20mm spacing) and fishing rods. Fish surveys will cover the same area at each site each time. The number of throws carried out during each survey will be the same and will be noted in fish monitoring forms. Fish specimens will be measured and returned to the river. Data will be analysed to determine the need for adaptive management measures. The monitoring results will be analysed at the end of the year to decide if the proposed triggers are met.

Electrofishing is not possible in Georgia which makes the standardization of methodologies and results difficult. Data collected previously was recorded as fish numbers per catch (abundance). As it is not possible to net the survey area, density results have not been provided.

Monitoring of fish will be undertaken at locations previously surveyed, these are listed in Table 2 and shown in Figure 2. The proposed number of sites and locations were chosen by local consultants who have good knowledge of the river. The sites were chosen based on habitat criteria (good surrogates of river habitats) and where safe access to the river exists. Safe access for surveyors is a major constraint in these rivers particularly in the tributaries that could be used as control sites. Control sites proposed are also listed in Table 2 and shown in Figure 2. Control sites include points located some distance downstream of the dams to provide understanding of less affected stretches. Sites in the main rivers include reaches where less impact is expected.

Key species abundance will be used to trigger adaptive management measures. Key species are:

- Trout *Salmo labrax fario*
- Colchic khramulya *Capoeta sieboldii*
- Colchic nase *Chondrostoma colchicum*

The presence of both the Colchic kramulya and Colchic nase is low and sporadic, regularly not recorded at sites during the baseline surveys. For this reason, the most appropriate triggers are listed below and detailed in detailed in Table 2.

- Abundance of trout;
- Species diversity; and
- Total abundance (all species considered)

Table 2 shows the abundance range for Trout, all species abundance and species diversity. Species presence and abundance is varied throughout the catchment and particularly at the sites listed.

Table 2: Monitoring sites, indicator range and triggers, species recorded

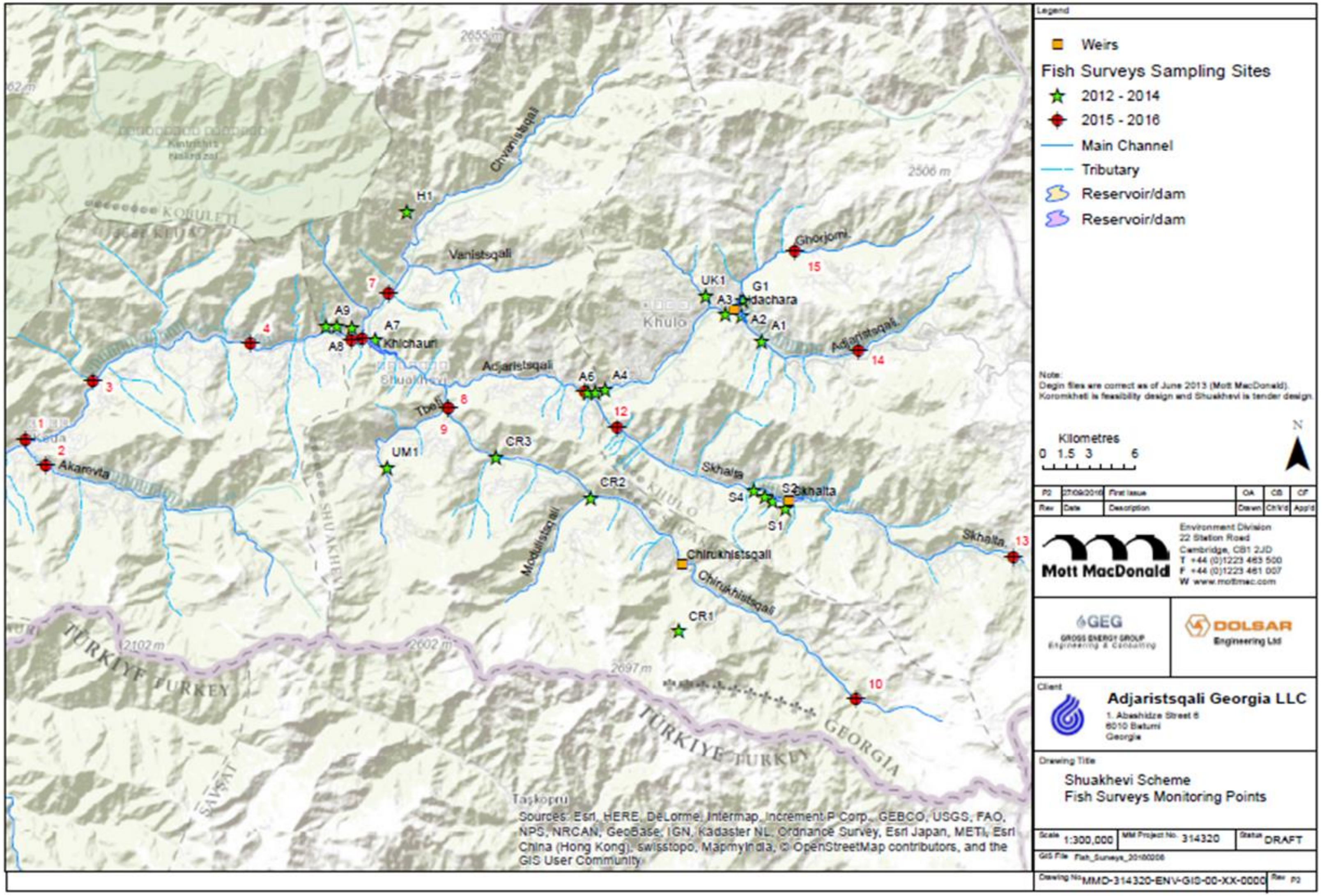
Site	Location	Purpose	Trout Salmo labrax fario Range	Trout Salmo labrax fario Trigger	Total abundance Range	Total abundance Trigger	Species diversity Range	Species diversity Trigger	Species recorded at each site
14	US of the Didachara Dam	Survey	0-2	1	0-6	3	0-2	1	*Salmo labrax fario, Luciobarbus escherichii*
A3	DS of the Didachara Dam	Survey	0	1	1-6	3	1-3	1	*Barbus escherichii, Alburnoides bipunctatus, Alburnoides alburnoides, Chondrostoma colchicum, Capoeta sieboldi, Squalius cephalus, Capoeta tinca, Alburnoides faciatus, Ponticola constructor*
11	DS of the Didachara Dam	Survey	0-1	1	1-7	3	1-5	2	*Alburnoides faciatus, Capoeta tinca,Luciobarbus escherichii, Squalius cephalus, Ponticola constructor, Ponticola constructor, Salmo labrax fario*
10	US of Chirukhistsqali Dam	Survey	0-6	3	0-6	3	0-1	1	*Salmo labrax fario*
CR 2	DS of Chirukhistsqali Dam	Survey	0-4	2	0-4	2	0-2	1	*Barbus escherichii, Salmo labrax fario, Alburnoides bipunctatus faciatuss, Luciobarbus escherichii*
CR 3	DS of Chirukhistsqali Dam	Survey	0-2	1	0-6	3	0-2	1	*Barbus escherichii, Salmo labrax fario*
9	DS of Chirukhistsqali Dam	Survey	-	-	2-19	6	0-4	2	*Barbus escherichii, Salmo labrax fario*
13	US of Skhalta Dam	Survey	0-2	1	0-2	1	0-1	1	*Salmo labrax fario*
S4	DS of Skhalta Dam	Survey	-	1	5-3803	8	0-2	1	*Barbus escherichii, Cobitis satunini, Chondrostoma calchicum, Nemacheilus angorae, Rutilus rutilus*
15	Ghorjomi	Control							
UK 1	Adjaristquali tributary	Control							

[3] High value, thought to be outlier

			Trout Salmo labrax fario	Trout Salmo labrax fario	Total abundance	Total abundance	Species diversity	Species diversity	Species recorded at each site
CR 1	Chirukhistsqali tributary (US of weir)	Control							
UM 1	Chirukhistsqali tributary (DS of weir)	Control							
H1	Chvanistsqai	Control							
7	Chvanistsqai	Control							

Source: Mott MacDonald

Figure 2: Fish survey site locations



4.2.2.2 Fish pass monitoring

The function of the fish pass at Chirukhistsqali weir will be closely monitored, using an automatic scanner within the pass. The data gathered will be regularly analysed by the fisheries specialist. When compared to manual monitoring a remote counter will prove cheaper and provide a more comprehensive record of the fish using the pass.

One possible counter is provided by VAKI[4] Aquaculture Systems Ltd, Iceland. The company supplies a scanner unit which can be installed in in the fish pass. It consists of two scanner plates (20 x 60 cm) inside a frame approximately 40 cm apart. Inside the scanner, light diodes send infra-red beams to receivers on the other side. When a fish swims through the net of light beams, the resulting silhouette image is used to count and estimate the size of each fish. Each individual image is recorded in the control unit so that the counting can be verified afterwards. A Control Unit receives the information from the scanner and stores it. It can be connected to a computer for processing the data as often as required. The temperature of the water is measured at programmable intervals and the date and time of day that each fish passes the counter is also recorded. In this way, fish movements can be correlated with environmental factors. Power is supplied by solar panels and a deep cycle battery.

The fish counter will be complemented with automated monitoring of depth and flow velocity within the fish pass to validate its design. This is a necessary aspect of the engineering control and will be undertaken permanently and transmitted to the power house in real time. The flow monitoring will confirm that flow and depth are as expected and suitable for key species.

In addition, AGL staff will need to check that the fish pass entrance, exits, baffles and resting pools are clear of obstructions and that the gates are working smoothly, every other day during the migratory periods[5]. If the fish pass proves to be ineffective the connectivity between the fish pass and the river will be reviewed to ensure the fish pass hydraulics are consistent with the design. This will be AGL's responsibility. However, the fish pass design is well-established and has proved to effective in similar situations elsewhere, so is expected to function well.

Automated monitoring will be in addition to the traditional up and downstream monitoring of fish populations in the river described above. Fish monitoring, native stocking and trap and transport will be undertaken as described in Section 4.2.2.3 if required. However, given the presence of the fish pass, it is not anticipated that this will be necessary, and will only be drawn upon as a secondary measure.

4.2.2.3 Native fish stocking and/or trap and transport program

If monitoring shows a successive and significant decrease in fish species diversity for more than two years, stocking with native fish and/or a trap and transport programme will commence[6]. If monitoring shows a successive and significant decrease in a species of fish previously present within a reach, for more than two years, stocking with native fish and/or a trap and transport programme will commence. The program will focus on the species that are identified to be decreasing (i.e. salmonid and other local fish species) and will be unlimited until monitoring shows a stable population. We propose marking the stocking fish to allow analysis of the effectiveness of the program. It is likely that when the population stabilises, the programme will no longer be necessary. The numbers and species of fish to be transported will be determined by an ecologist following the initial monitoring results. The location where the fish will be added

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[4] http://www.riverwatcher.is/

[5] The freshwater trout spawns in October to January and is likely to migrate from September to November

[6] It should be noted that this is separate to the stocking required under the Environmental Permit, although the latter may influence the results of the former.

will also be determined at this stage. Monitoring will show if the location where fish are introduced is successful or requires reconsideration. It is likely that efforts will focus on the Adjaristsqali and Skhalta rivers, and will only be used on the Chirukhistsqali River if the monitoring indicates that the fish pass is ineffective.

Fish stocking is required by the project's environmental licence issued by the Government of Georgia[7]. However, we recommend that a trap and transport program would be preferential to stocking, and that if stocking does happen it is with native wild fish rather than farmed fish. A trap and transport program involves moving wild fish from an unimpacted or healthy river system up or down stream of the dams to support the impacted stocks. This approach is preferred to the use of farmed fish, which would dilute the wild gene pool with genetic traits tailored to the fish farm environment[8]. AGL should prepare a Fish Stocking Plan which will explore the relative merit of stocking and trap and transport options. The plan should be used to engage the GoG in discussions around the long-term biodiversity benefits of the proposed Environment Permit stocking obligation/requirement. Stocking and/or trap and transport will only be considered if monitoring shows that it would be of value, it is not considered a mandatory measure.

4.2.3 Bank stabilisation

Given the naturally high sediment load in the catchment and naturally unstable geomorphology, bank stabilisation is not at this stage considered practical or to be necessary for the achievement of the minimum environmental standards. The river ecosystem has adapted to function in a high sediment environment and the species and habitats present reflect that environment[9]. The project's ongoing monitoring activities will however identify risks posed to connectivity by landslide or bank collapse and unique isolated bank stabilisation measures will be implemented on an ad-hoc basis as required.

[7] Under the Environmental Permit 10,000 fish fry (trout) are required to be added to the reservoirs / rivers. The locations, timing and frequency however require further definition in consultation with the Government of Georgia.

[8] It is now illegal in the UK to stock with fertile trout fish as research has shown it is detrimental to the long-term health of a population. Only adult infertile "triploid" fish are stocked for recreational fishing.

[9] It is noted that the River Basin Management Plan for the Adjaristsqali catchment does identify bank stabilisation as a means of improving water quality. Based on our understanding of the sources of sediment in the catchment we would consider such an approach as enhancement.

5 Analysis for each river

5.1 Introduction

The following section summarises baseline conditions, predicts impacts and specifies mitigation measures for each river. For each river, this section:

- describes the river and its tributaries
- outlines the typical existing hydrology and the new regime
- describes potential impact to ecology and hydro geomorphology
- outlines the mitigation measures which will need to be undertaken in order to achieve no residual adverse impact to aquatic biodiversity

5.2 Chirukhistsqali

5.2.1 Minimum standards to achieve no residual adverse impact to biodiversity

The Chirukhistsqali weir contains a fish pass to allow fish residing at higher elevations (above 800m) migratory movement for spawning. This includes not only trout but also other species recorded in this catchment such as the Colchic barbel *Luciobarbus escherichii* and chub *Squalius cephalus*, both recorded in this river. As such it is important that the channel downstream of the weir maintains full hydraulic connectivity to allow this migration. Particular care will be required to ensure connectivity during commissioning and after flushing and flood events. Monitoring will be required to show that species abundance and diversity is not reduced.

5.2.2 Description of river

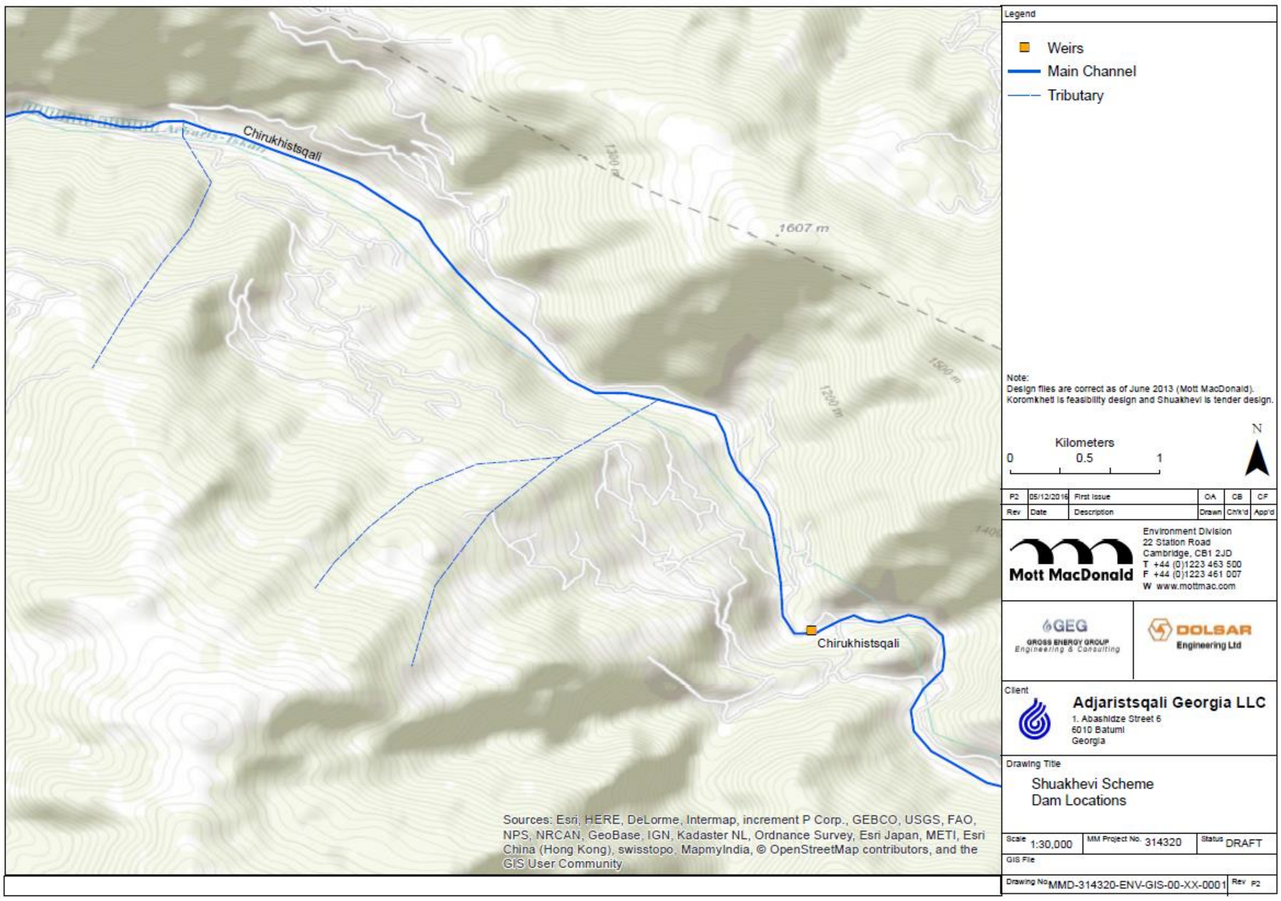
The Chirukhistsqali is a single thread river with bed rock control and multiple large boulders, as shown in Figure 3. It is the smallest of the three rivers with a narrow, constrained channel. In-channel habitats in the unmodified river in low flow conditions are dominated by fast flowing F and B2 types (broken and unbroken standing waves, steep surface gradient, fast surface velocity and shallow water depth, interspersed with smooth or rippled surface, moderate surface gradient, fast surface velocity and shallow water depth).

The flow rate shown in Figure 3 is approximately 3 m^3/s. This is approximately six times the specified environmental flow.

Figure 3: The Chirukhistsqali River, 130 metres downstream of the weir on the day of survey

Figure 4 shows two small tributaries, not influenced by the Project, which join the Chirukhistsqali River within a few kilometres of the weir. The tributaries will continue to provide additional flows to the river and support suitable fish habitat and bankside vegetation. On the day of the survey it was noted that the Chirukhistsqali River's discharge increased quickly below the weir due to inflows from these minor tributaries and from ground water. The discharge had approximately doubled on the day of the survey at the confluence of the first tributary, approximately 1km below the weir.

Figure 4: Location of weir and closest tributaries



5.2.3 Aquatic ecology survey results[10]

Only six fish species were recorded at the monitoring locations on the Chirukhistsqali River between 2012 and 2016, and the ones found were present in low numbers. Species found include the colchic barbel and the colchic kramulya, and the transcaucasian spirlin. Trout was also recorded in 2013, 2014 and 2016. The colchic barbel is widespread in the catchment and found frequently with trout which may suggest that they share the same type of habitat or may have overlapping habitat requirements for some stages of their life cycle. The colchic kramulya was recorded in one of the tributaries in 2013.

The survey results show a macroinvertebrate community dominated by the EPT group suggesting the water quality at this river is good. A decrease in numbers in the 2015 surveys (autumn) could be related to construction activities; however, values are still within the natural range and comparable with samples collected before construction.

[10] Detailed survey results are in the EBR in Appendix 0. These results refer only to the most affected stretch downstream of the dam.

5.2.4 Anticipated changes to hydrology

5.2.4.1 Estimated regime at the weir location

Figure 5: Chirukhistsqali - Daily Average flows at the weir location (historical data)

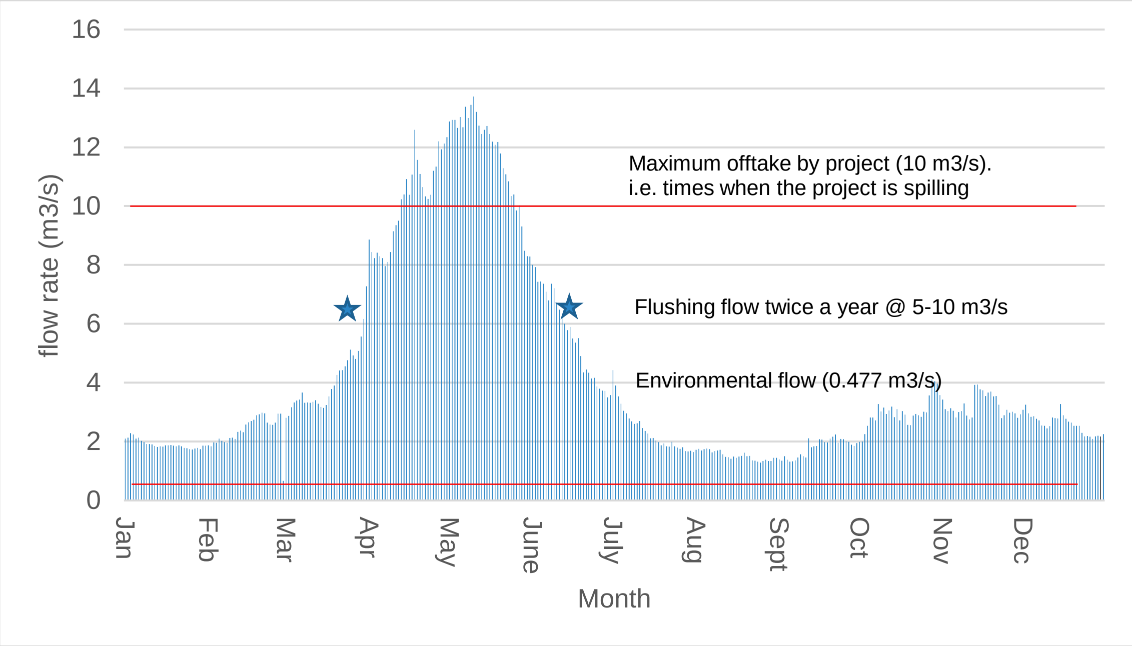


Figure 5 shows that in addition to the constant environmental flows the Chirukhistsqali will continue to receive additional inflows of between one and 4m^3/s during April and May when the weir is spilling. This is likely to be beneficial to migrating fish mostly trout but also some cyprinid species, such as the chub and Colchic barbel, and towards maintaining a functional sediment regime. The hydrograph also shows possible timing and scale of flushing flows which will occur at least twice a year at around 7m^3/s. The timing and scale shown is for indicative purposes only as the specific regime will be determined by river flows and sediment accumulation which will vary from year to year.

5.2.4.2 Estimated downstream flow regime

Section Chi 1A, shown in Figure 17, receives inflow from two small tributaries in addition to spilling flows, flushing flows and ground water. Hydraulic studies in the ESIA show that over the course of an average year, the additional inputs will effectively increase the 10% environmental flow to approximately 20% of the current annual average. However, it is expected that flows will not exceed the 10% minimum during the low flow periods (approximately six months of the year).

Section Chi 1B benefits from the Modulistsqali River which joins the Chirukhistsqali approximately 6.5km downstream of the weir, providing significant inflows to the Chirukhistsqali as well as increasing flow variability from the confluence onwards. The estimated flows just downstream of the confluence will be approximately 45% of the long term annual average and will follow the natural river flow variability more closely, in both the high and low flows seasons.

Section Chi 1C and Chi 1D post-scheme flows are expected to be between 51% to 63% of the annual average flows (long term average). In addition, the flow pattern in this section of the river is anticipated to follow the natural pattern very closely.

5.2.5 Anticipated impacts to hydro geomorphology

It is likely that under the operational flow conditions the Chirukhistsqali will maintain a narrow single thread channel constrained by the existing boulder bed. It is likely that in most places the channel will be deep enough to maintain hydraulic connectivity to allow fish passage. In some locations, there may be a risk of braiding or the river splitting into multiple channels. There could be a risk of a single large boulder blocking the path of the river. There are occasional wider, flatter reaches over fine gravel where the river could spread and affect the ability of fish to migrate. In most areas where multiple channels are apparent there appears to be a single primary channel which the river is likely to follow. Remedial action may however be required to ensure that this occurs in practice. The risk of losing connectivity to lower tributaries is considered low.

To build an understanding of how the environmental flow will behave in the existing river channel we have used the Manning's equation to estimate the probable depth and velocity of the river[11]. To illustrate the range of outcomes we have chosen some typical cross sections and some high risk cross sections (i.e. where the river is wide and shallow). Table 4 shows the results:

Table 3 Chirukhistsqali River depth and velocity at different points under environmental flow conditions

Inputs

Section characteristic	Constrained, deeper	Wider, shallow	Suggested maximum width for trout migration	
Flow discharge	0.477	0.477	0.477	m^3/s
Bottom width	4	15	8	M
Side slope	2	5	3	
Bottom slope	0.02	0.01	0.015	m/m
Manning's n	0.05	0.04	0.045	
Normal flow depth	0.148	0.073	0.1	M
Normal flow velocity	0.75	0.428	0.573	m/s^{-1}
Normal Froude number	0.643	0.513	0.588	

Table 4 suggests that in the deeper, narrower sections of the river the flow depth could be around 0.15m, with a velocity of around 0.75 metres per second. In the wider shallower sections of the river, the depth could be closer to 0.07m with a velocity of around 0.5 metres per second. More discussion in given in section 5.2.7 regarding how this understanding will influence the channel modification.

5.2.6 Anticipated impacts to aquatic ecology[12]

On the Chirukhistsqali, the main impacts result from the reduction of the natural flows downstream of the weir. As discussed above there will be a major impact on the hydrology of

[11] http://onlinechannel.sdsu.edu/onlinechannel01.php

[12] Based on the project ESIA

the river and on the riverine habitats immediately downstream of the weir. The presence of several tributaries however reduces the magnitude of the hydraulic changes further downstream. The proposed scheme has the potential to result in the following impacts on the Chirukhistsqali:

- Permanent reduction in suitable riverine habitats
- Alteration in the bankside vegetation and associated shelter for some fish species
- Risk of fish mortality during downstream migration as result of entrainment into intake structure

All the above impacts may be experienced as a result of the Project. The following section describes site specific characteristics and sensitivities for each reach to determine more specifically where impacts may occur and overall impact significance.

5.2.6.1 River reach Chi 1A

The following characteristics, based on the baseline information, have been considered when defining the ecological sensitivity of this reach:

- No suitable spawning habitat for any species recorded in the river was recorded in this reach. This suggests that the presence of juvenile feeding grounds is also unlikely. Refer to baseline mapping shown in Appendix A of the EBR (which itself is an appendix to this report) which shows the absence of spawning for the six-species recorded in the reach. This Phase 2 Habitat Mapping shows the meso habitat mapping. The numbers on the map indicate the presence of spawning habitat or juvenile feeding grounds.
- Existence of the weir and hydropower scheme, despite the fish pass, may disrupt upstream and downstream migration
- The presence of a small tributary, not affected by the scheme, located downstream of Chi1 which will continue to provide some flows into the Chirukhistsqali and therefore maintain some suitable fish habitat and bankside vegetation
- Many of the cyprinids present in this stretch of the river can tolerate a range of flow conditions

The ecological sensitivity of this reach is low, as no spawning habitat has been identified during the fish surveys. The magnitude has been assessed as major and consequently the significance of impacts on fisheries is predicted to be **moderate adverse**.

5.2.6.2 River reach Chi 1B

The following characteristics have been considered when defining the ecological sensitivity of this reach:

- Presence of suitable spawning habitats
- The presence of several tributaries (Modulistsqali and Tbeti) which will continue to provide some flows into the Chirukhistsqali and therefore maintain some suitable fish habitat and bankside vegetation
- Many of the cyprinids present in this stretch of the river can tolerate a range of flow conditions

The ecological sensitivity of this reach is considered to be medium (given the presence of cyprinid spawning habitat) and the magnitude moderate, therefore the significance of impacts on fisheries is predicted to be **moderate adverse**.

5.2.6.3 River reach Chi 1C

Within this section spawning habitat is also present and suitable for cyprinid species. Flows in these sections are much improved due to several tributaries to the Chirukhistsqali. The ecological sensitivity of this reach is considered to be medium (given the presence of cyprinid spawning habitat) and the magnitude minor, therefore, the ecological impacts on the fisheries is predicted to be a **minor adverse**.

5.2.7 Committed mitigation

5.2.7.1 Channel modification

Given the importance of maintaining hydraulic connectivity on the Chirukhistsqali, the precautionary principle will be employed when undertaking the commissioning. The observed reality of the river under new flow conditions will dictate the best way to implement morphologically appropriate channel form during commissioning. This will be achieved by gradual reduction in river flow and expert guidance in real time.

At commissioning, the flow rate in the river will be gradually reduced from its natural flow to approximately 30% annual average flow. At this flow rate an appropriately qualified fluvial geomorphologist with experience of hydropower will be on site observing the river to check for breaks in hydraulic connectivity. If an issue is identified, a contractor will be instructed to address the issue before any further reduction in flow is implemented. Flow rate will be held at 30% for as long as required for any permits or contracting arrangements to be finalised and modification made. If the fluvial geomorphologist is satisfied that functional connectivity has been achieved at the 30% flow, then flow will be reduced to 20% of the annual average flow. Again, a survey will be undertaken to ensure hydraulic connectivity is maintained and a contractor will be instructed to address any issues arising before the flow can be further reduced. The process will be repeated at the final 10% flow.

To achieve the reduced flow of 30% annual average, the design environmental flow will be discharged though the fish pass and supplemented with additional flow discharged though flushing gate A4. It will not be possible to use the weir's radial gates, as they cannot be satisfactorily calibrated to control this magnitude of discharge. The commissioning plans will include a stage-discharge curve for flushing gate A4. This will indicate the gate position needed to provide the required discharge, determined by the water level in the head pond. Total discharge from the fish pass and flushing gate will be checked by the downstream hydrological monitoring station in real time. The same method will be used to reduce the river flow to 20% annual average for the next stage of the commissioning process.

There are no fixed rules for the channel or flow requirements for trout migration but Table 5 describes the channel parameters which should be maintained under the new flow conditions to facilitate fish movement. The modification should aim to achieve a minimum normal flow depth of 0.1m and velocity of greater than 0.2 ms^{-1}. Table 4 suggests that given the environmental flow, the desired depth and velocity should be achieved by a channel width less than 8 meters, however this assumes a standard side slope, bottom slope and manning n so in reality each reach will need be addressed on a case by case basis. The bed substrate should range between 8 - 128 mm, with fine sediment <1mm around 8-12% of the composition.

Table 4: Suggested parameters for channel modification

Parameter	Range to be achieved by channel modification
Velocity	0.2 – 0.75 m/s^{-1}
Depth	0.15 – 1.2 m (mean preference 0.65 m)
Substrate	8 - 128 mm (minimum fine sediment <1mm should be 8-12% composition)

Source: Armstrong, J.D., Kemp., P.S., Kennedy, G.J.A., Ladle, M. and Milner, N.J. (2003) Habitat requirements of Atlantic salmon and brown trout in rivers and streams. Fisheries Research, 62, pp. 143-170

In operation, the project will utilize natural channel forming processes to allow the river to find its new balance under the new flow conditions. After flushing or a flood event, a survey will be undertaken to ensure hydraulic connectivity is maintained and a contractor will be instructed to address any issues arising.

5.2.7.2 Fish monitoring and management

The function of the fish pass at Chirukhistsqali weir will be closely monitored, through direct observation by a suitably qualified ecologist, and through an automatic camera within the pass as described in Section 4.2.2. This will be in addition to the traditional up and downstream monitoring of fish populations in the river.

Stocking and/or trap and transport will be undertaken as described in Section 4.2.2 if required. However, given the presence of the fish pass, it is not anticipated that this will be necessary, and will only be utilised as a secondary measure.

5.2.8 Chirukhistsqali Conclusion

We consider that no residual adverse impact to biodiversity on the Chirukhistsqali can be achieved by:

- Gradual reduction of the downstream flow rate at commissioning, starting at 30% of the mean annual flow
- Monitoring changes in hydro geomorphology during commissioning and operation
- Implementation of minor channel modification where required
- Successful operation of the fish pass (sustained by regular maintenance and demonstrated by monitoring)
- Fish monitoring
- Stocking and/or trap and transport of fish upstream of the weir if required

5.3 Skhalta

5.3.1 Minimum standards to achieve no residual adverse impact to biodiversity

The Skhalta dam does not contain a fish pass so complete hydraulic connectivity to the dam[13] is not considered essential. As such, mitigation should focus on maintaining the abundance and diversity of fish species in the reaches above and downstream of the dam. It will also require the maintenance of access to the valuable flows and habitat provided by the downstream tributaries. Maintenance of aquatic habitat in the reach below the dam will also be required to

[13] It will be important to maintain hydraulic connectivity to the downstream tributaries, but not between the nearest viable tributary and the dam body.

provide resting and sheltering habitat for small fish including the Anatolian kramulya *Capoeta sieboldii* and colchic nase *Chondrostoma colchicum* and chub.

5.3.2 Description of river

The Skhalta valley is a sediment rich environment with deep deposits of fluvial glacial material. The valley has complicated, unstable geomorphology which remains dynamic. Figure 6 shows that the river is wider than the Chirukhistsqali with fewer large boulders constraining the channel. In-channel habitats in the unmodified river in low flow conditions are dominated by the faster habitat type F (broken and unbroken standing waves, steep surface gradient, fast surface velocity and shallow water depth).

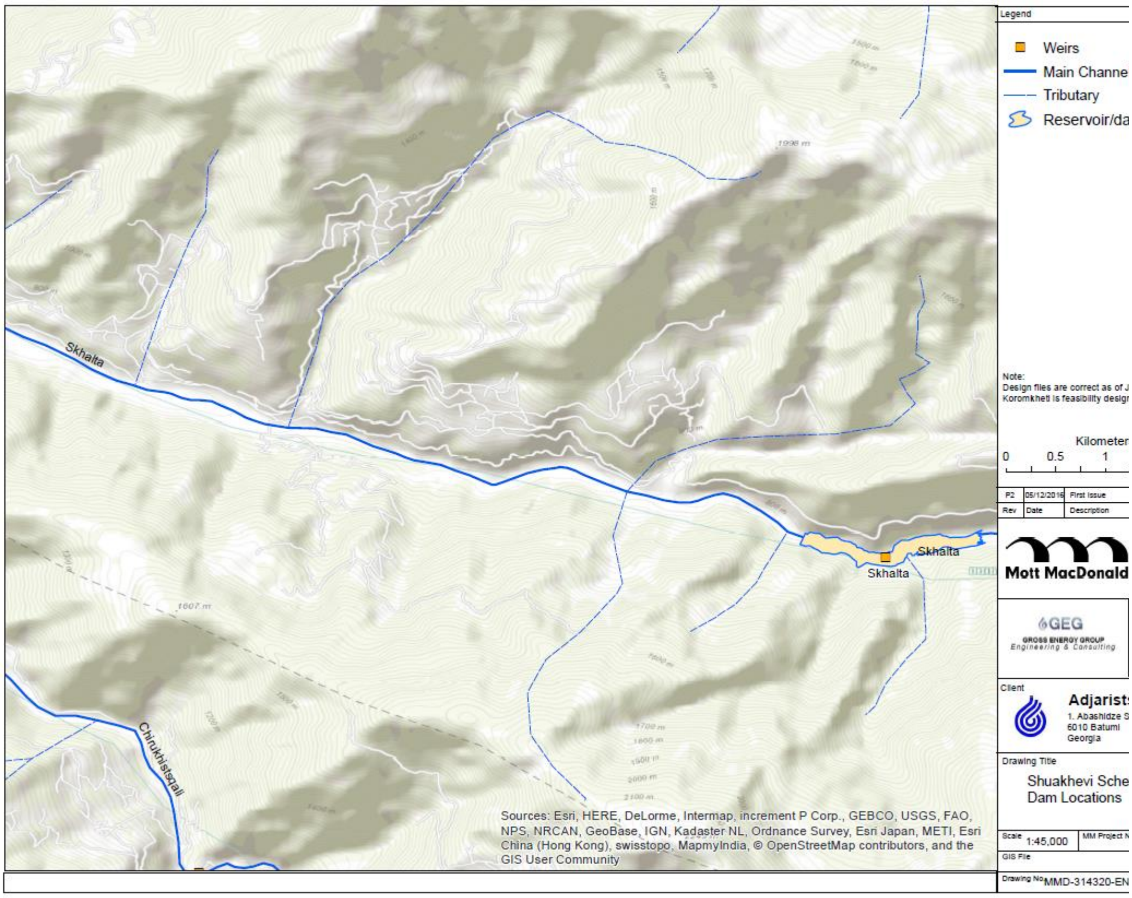
The river is regularly subject to landslides and river morphology is frequently changing as a result. It is characterised by a wide river bed with meandering channel. The volume of sediment in the channel is greater than can be moved by the river, resulting in flat open gravel sections with multiple thread channels. The valley experienced a substantial landslide 20 years ago which at the time blocked the river. The slide will continue to influence the sediment dynamic for the near future as a result of a bank of unconsolidated soil deposits approximately 50 metres high and 200 metres' long, adjacent to the main river channel.

The flow on the day of the photograph was approximately 3.5 m3/s; this is approximately six times the specified environmental flow.

Figure 6: Skhalta River, 700 metres below the dam, looking upstream

Figure 7 shows that a minor tributary joins the Skhalta River after 1.5 km and two further tributaries join after around 3 km. Each tributary provided approximately 0.5 m^3/s on the day of the survey and it was noted that the discharge increased quickly below the dam due to these inflows and, it is expected, from ground water.

Figure 7: Tributaries downstream of the Skhalta dam



5.3.3 Aquatic ecology survey results[14]

Downstream of the dam, fish populations included roach, barbell, colchic barbel and colchic nase. Apart from roach the species present are mostly rheophilic requiring clean, well oxygenated fast waters. Roach is a eurytopic cyprinid with more general habitat requirements. Although no trout was recorded at the sampled sites in 2012 and 2013 this species was recorded in 2015 and 2016 in low numbers (one specimen at each of the two locations). Within the reservoir footprint four fish species were recorded including roach, barbell, colchic barbel and the Anatolian Kramulya.

Although higher diversity in terms of fish species was recorded in this river compared with the Chirukhistsqali River at the start of the monitoring programme, this was not verified during 2015 and 2016 when only one species was recorded during each seasonal monitoring campaign after winter (first survey) 2015 (trout in the remainder of 2015 and spring 2016, and the cyprinid

[14] Detailed survey results are in the EBR. These results refer only to the most effected stretch downstream of the dam.

Luciobarbus escherichii in winter 2016). No species of conservation importance were recorded during the monitoring programme, apart from the presence of the Black Sea trout, which is classified as Vulnerable on the Georgia Red List.

There is a general decrease in macroinvertebrate numbers from downstream to upstream, which is common for upland sites. No diptera have been recorded at this site. The results show a decrease in Ephemerotera at site 4 in 2015 which could be due to construction. This change is not however thought to be permanent.

5.3.4 Anticipated Changes to Hydrology

5.3.4.1 Estimated regime at the dam location

Figure 8: Environmental flow and flushing flows compared with existing daily flows of Skhalta River (based on historical data)

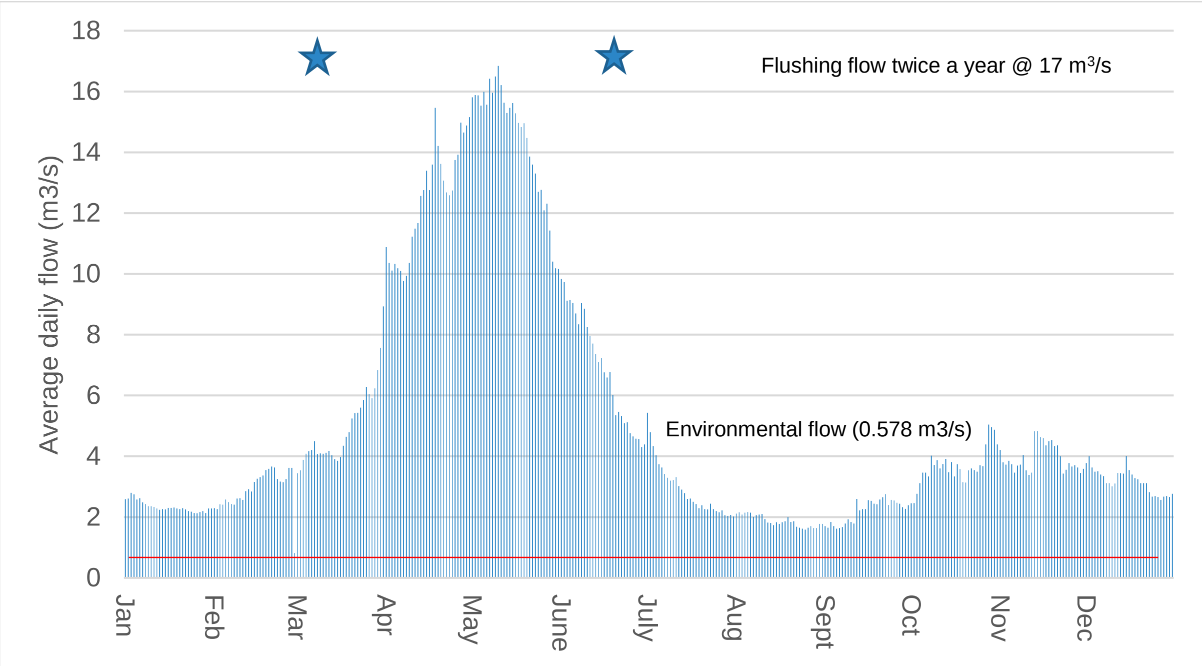


Figure 8 illustrates the proposed environmental flow and flushing flows in the context of the existing regime on the Skhalta River. The environmental flow of 0.578 m^3/s is less than half the average daily flows under natural low flow conditions.

The flushing flow of 17 m^3/s will be similar to the average annual peak flows. The timing and scale shown is for indicative purposes only as the specific regime will be determined by river flows and sediment accumulation which will vary from year to year.

Figure 9: New regime at Skhalta dam (Chirukhistsqali and Skhalta rivers) to show probable spilling regime (based on historical data of daily average flows)

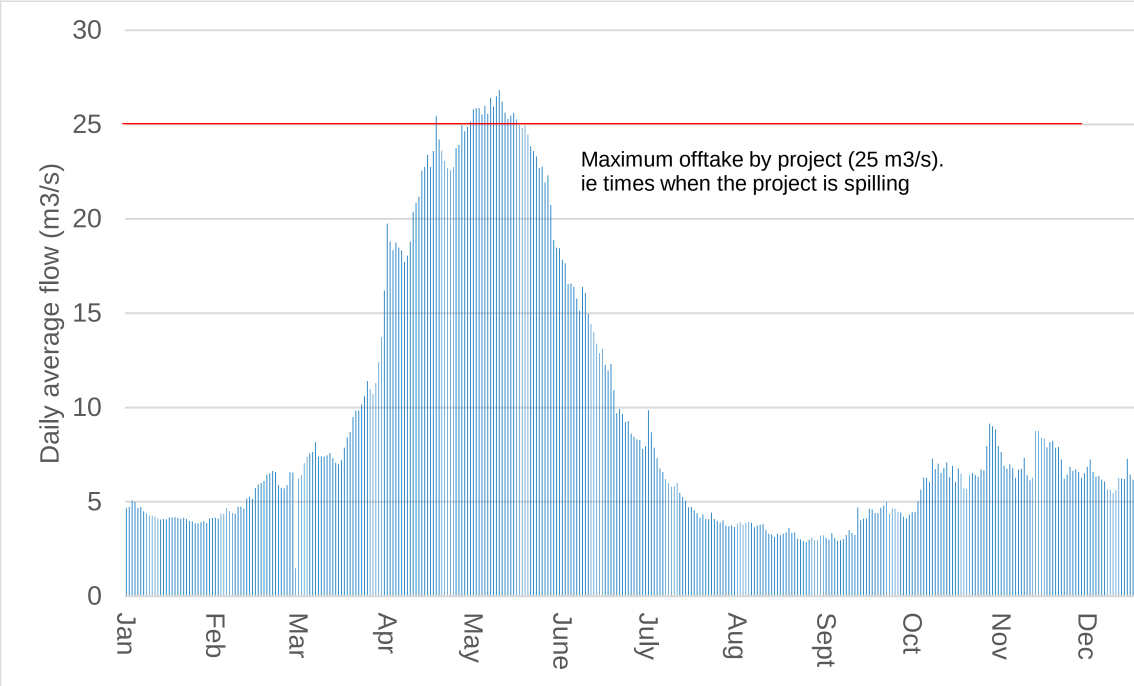


Figure 9 shows that in addition to the environmental and flushing flows, the Skhalta River will, on average, continue to receive additional flows of up to 2 m^3/s during May when the dam is spilling. It is important to note that the figure shows average conditions and that in reality there are likely to be irregular flood events that exceed these flows.

5.3.4.2 Estimated downstream flow regime

In Skh 1A, shown in Figure 17, the ESIA hydrological study estimates post-scheme flows to be 28% of the pre-scheme annual average (long term average). This is due to the dam spilling and ground water flows.

In Skh 1B several tributaries contribute to flows, so post-scheme flows gradually become closer to the pre-scheme conditions. in the upper extent of this section it is estimated that average flows will be approximately 37% of the annual average (long term). In this reach, post-scheme low flows are estimated to be between 1.0 and 1.2 m^3/s (values for August), approximately twice the proposed environmental flows.

In Skh 1C, flows will be approximately 42% of the annual average (long term) at the upper extent. There are tributaries within this reach that will add flows and variability to the flow pattern downstream.

5.3.5 Anticipated impacts to hydro geomorphology

The wider, flatter nature of the Skhalta River indicates a higher risk of spreading and splitting under the operational flow conditions. The visual survey suggested however that in most reaches, a primary channel will dominate and maintain a single flow. Flushing flows will continue to provide additional sediment to the reach and occasional flood events will continue to have a positive redistributive effect on sediment. The impact of sediment release from flushing activities is not of concern given the high sediment environment. Additional flows from flushing and spilling are likely to be beneficial to fish who need to reach downstream tributaries.

To build an understanding of how the environmental flow will behave in the existing river channel we have used the Manning's equation to estimate the probable depth and velocity of the river[15]. To illustrate the range of outcomes we have chosen some typical cross sections and some high risk cross sections (i.e. where the river is wide and shallow). Table 6 shows the results:

Table 5 Skhalta River depth and velocity at different points under environmental flow conditions

Inputs			
Section characteristic	Constrained, deeper	Wider, shallow	
Flow discharge	0.578	0.578	m3/s
Bottom width	6	15	m
Side slope	3	5	
Bottom slope	0.01	0.005	m/m
Manning's n	0.04	0.04	
Normal flow depth	0.14	0.1	m
Normal flow velocity	0.645	0.373	m/s^{-1}
Normal Froude number	0.567	0.382	

Table 6 suggests that in the deeper, narrower sections of the river the flow depth could be around 14 cm, with a velocity of around 0.65 metres per second. In the wider shallower sections of the river, the depth could be closer to 10 cm with a velocity of around 0.37 metres per second. More discussion is given in section 5.3.7 regarding how this understanding will influence the channel modification.

5.3.6 Anticipated impacts to aquatic ecology

The main impacts on the Skhalta River will result from a reduction of the natural flows. The proposed scheme has the potential to result in the following ecological impacts on the Skhalta River:

- Loss of spawning habitat for various Cyprinid species within reservoir area
- Reduction in flow and subsequent alteration/loss of riverine habitats downstream of the dam
- Alteration of the riparian vegetation and elimination of some slower backwater flood areas which shield some species from predation as well as providing important resting areas
- Increase in limnophilic species
- Risk of fish mortality during downstream migration as result of entrainment into intake structure
- Barrier to further upstream migration

All the above impacts may be experienced as a result of the Project. These potential impacts are different from the ones expected in the Chirukhistsqali as the Skhalta dam is larger with no

[15] http://onlinechannel.sdsu.edu/onlinechannel01.php

fish pass provision. Site specific characteristics and sensitivities are described below for each reach and taken into consideration in determining overall impact significance.

5.3.6.1 River Reach Skh 1A

From the dam site to Skh 1B, the following characteristics have been considered when defining the ecological sensitivity of this reach:

- Suitable cyprinid spawning habitat, so this section is considered to be of moderate sensitivity
- The river is subject to frequent landslides and river morphology is frequently changing

The reduced flows in this reach could result in significant changes to the riverine habitat and therefore the magnitude of the impact is major, which when combined with a moderate sensitivity is assessed to have a potentially **major adverse** impact on fisheries. The larger impact on the Skhalta River, compared to the Chirukhistsqali River, is due to the likely presence of suitable spawning habitat downstream of the dam site.

5.3.6.2 River Reach Skh 1B

In the Skh 1B reach the following characteristics have been considered when defining the ecological sensitivity of this reach:

- Suitable cyprinid spawning habitat, so this section is considered to be of moderate sensitivity
- The river is subject to frequent landslides and river morphology is frequently changing
- Some small streams contribute to available flows

The potential impacts predicted to result in this section are similar to the ones listed for Skh 1A. However, inflows will reduce the magnitude of the change and consequently reduce the loss of important habitat. The ecological sensitivity of this reach is considered to be medium and the magnitude moderate, therefore the significance of impacts on fisheries are assessed to be **moderate adverse**.

5.3.6.3 River Reach Skh 1C

In the furthest downstream section of the Skhalta River just before the confluence with the Adjaristsqali River, the sensitivity is considered to be medium. This is due to the potential presence of spawning habitat for cyprinids. The magnitude of the change is considered moderate. The impacts in this reach are therefore assessed as **moderate adverse**.

5.3.7 Committed mitigation

5.3.7.1 Channel modification

Below the Skhalta dam the focus will be on maintaining viable aquatic habitat rather than ensuring hydrological connectivity for fish migration. As such there will be no need for a gradual ramp down of flows during commissioning as required for the Chirukhistsqali River. Similarly, it is not considered necessary to specify a particular river depth or velocity to be achieved.

The usual riffle/pool and bar type features will not be able to form due to the restriction of flow through these reaches. The focus should be to maintain as much habitat as possible though varied depth and velocity. A canalised, square channel profile should be avoided. Instead a river bed profile of variable depth provides greater velocity and habitat heterogeneity. Avoid channel smoothing, i.e. maintain pebbles/boulders as roughness increases habitat heterogeneity through varied depth and velocity. Substrate should be as described in Table 5. Different substrate, velocities and depths will provide greater habitat for a wider range of species and thus maintaining stronger links (food web dynamics) between species, which in turn has greater resilience.

Given the realities of the site it is recommended to implement morphologically appropriate channel form during commissioning. An appropriately qualified fluvial geomorphologist with experience of hydropower will therefore be on site observing changes to the river during commissioning and instructing a contractor (through AGL) to make minor channel modifications as necessary. For example, some flat wide areas may benefit from a new deeper single channel to concentrate flow, or measures may need to be taken to stop water splitting over more than one channel.

Prior to commissioning, the Project will also need to infill a wide section of the channel just beyond the stilling basin (Figure 10). This channel area is currently heavily modified by construction work. The wide areas will be confined to leave the channel below the stilling basin in a relatively narrow and natural state.

Figure 10: Over widened reach 300 metres downstream of Skhalta dam which will require narrowing prior to commissioning

Post commissioning natural channel forming processes have been identified as the most appropriate means for facilitating achievement of a stable river morphology under the operational flow regime. Over the long term, regular channel modification will not be feasible or necessarily beneficial. Significant landslides will continue to strongly influence the river habitat and any physical mitigation would be unsustainable.

A fluvial geomorphologist will survey the river after flushing and high flow events to ensure that the shape of the channel is conducive to functional habitat, giving particular attention to locations at high risk of splitting.

5.3.7.2 Fish monitoring and management

Fish monitoring, stocking and/or trap and transport will be undertaken as described in Section 4.2.2. as required will ensure no residual adverse impact to biodiversity.

5.3.8 Skhalta Conclusion

We consider that no residual adverse impact to biodiversity on the Skhalta can be achieved by:

- Monitoring of changes in hydro geomorphology during commissioning and operation
- Implementation of minor channel modification
- Fish monitoring
- Stocking and/or trap and transport of fish upstream of the dam
- Ensuring the beneficial flows from downstream tributaries are maintained

5.4 Adjaristsqali (Didachara dam)

5.4.1 Minimum standards to achieve no residual adverse impact to biodiversity

The Didachara dam does not contain a fish pass so complete hydraulic connectivity to the dam is not considered essential. Mitigation will therefore focus on maintaining the quality of aquatic habitat in the river up and downstream of the dam, as assessed though the abundance and diversity of fish species. The Adjaristsqali River is important as a migratory route for some rheophilic species and flows should allow for the movement of fish up and down the main river to avoid isolation of populations in tributaries. Access to flows and habitat provided by downstream tributaries will also require to be maintained.

5.4.2 Description of Adjaristsqali and tributaries

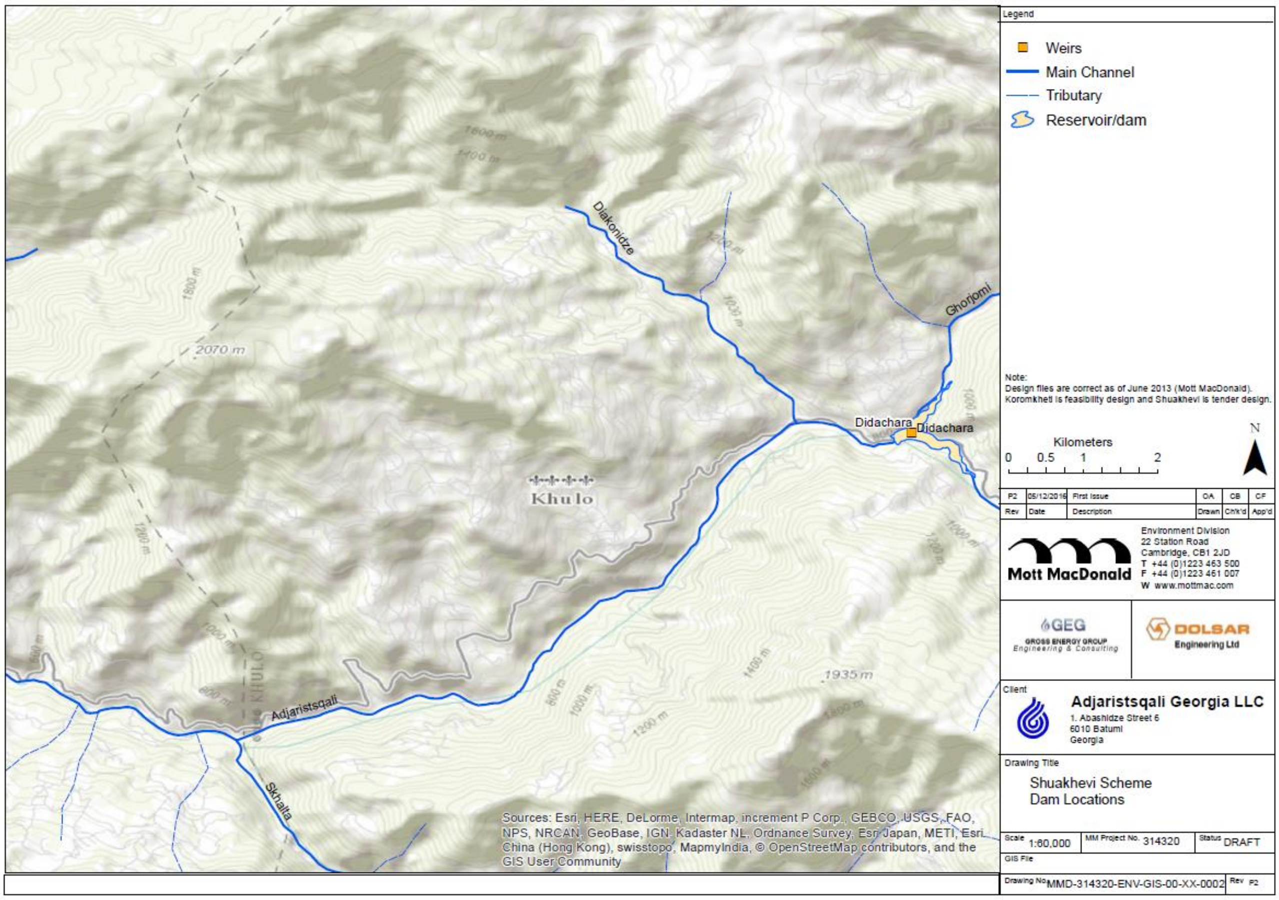
5.4.2.1 Adjaristsqali

The Adjaristsqali has the greatest discharge of the three rivers. It is constrained by a narrower valley than the Skhalta, providing it greater depth and velocity in many places (refer to Figure 11). The river bed is a mix of gravel and boulders. In-channel habitats in the unmodified river in low flow conditions are dominated by fast flowing F, G and B2 types (broken and unbroken standing waves, steep to moderate surface gradient, fast surface velocity and shallow water depth interspersed with smooth or rippled surface, moderate surface gradient, fast surface velocity and shallow water depth). On the day of the survey (as illustrated in Figure 11) the flow rate was approximately 5 m3/s, approximately seven times the specified environmental flow.

Figure 11: The Adjaristsqali, 400 metres downstream of the dam, looking upstream

The only significant tributary between the Didachara dam and the confluence of the Adjaristsqali River with the Skhalta River (approximately 15 kilometres downstream) is the Diakonidze River. The Adjaristsqali River meets the Diakonidze River approximately one kilometre downstream of the Didachara dam (refer to Figure 12). The Diakonidze River will provide supplementary flows to the Adjaristsqali River as well as a source of high quality habitat and a potential alternative migration route for fish.

Figure 12: Tributaries downstream of Didachara dam



5.4.2.2 Description of Diakonidze River

The Diakonidze River is a single thread river with bed rock control and multiple large boulders within a narrow, constrained channel, as shown in Figure 13. It is a healthy diverse stream, providing good quality habitat, spawning grounds and holding pools. Anecdotally, it is a popular place for fishing by local people.

On the day of the survey the flow rate was estimated to be approximately 1.5 m3/s.

Figure 13: The Diakonidze River on the day of the survey, approximately 500 metres upstream of the confluence with the Adjaristsqali River

5.4.3 Aquatic ecology survey results[16]

The Adjaristsqali River is considered rich in fish species. A total of 15 species were recorded in the Adjaristsqali River within the Project area of influence. The Transcaucasian spirlin, colchic barbel, Sakarya loach, mursa and common roach are represented in the most upstream section. Spawning and migratory habitat for trout and colchic barbel were recorded in the footprint of the Didachara dam and downstream reaches during surveys in summer 2016. The colchic barbel was the only species recorded in the reach containing the dam and reservoir footprint and is widespread in downstream reaches of this section. Fish diversity increases downstream, with roach, barbel and colchic nase also present. These species are mostly rheophilic cyprinids. No species of conservation importance have been recorded during the fish monitoring programme, apart from the presence of Black Sea trout, which is classified as Vulnerable on the Georgia Red List.

As with the Skhalta and Chirukhistsqali rivers the macroinvertebrate community is dominated by the EPT group, indicating good water quality. A sharp decrease in Ephemeropta numbers was observed between the 2015 spring and autumn surveys. This was recorded at all sites and

[16] Detailed survey results are in the EBR. These results refer only to the most effected stretch downstream of the dam.

consequently is thought to be a seasonal trend rather than a possible impact from the construction of the Didachara dam.

5.4.4 Anticipated Changes to Hydrology

5.4.4.1 Estimated regime at the dam location

Figure 14: Environmental flow and flushing flows compared with existing daily flows of Adjaristsqali River at the dam location (based on historical data)

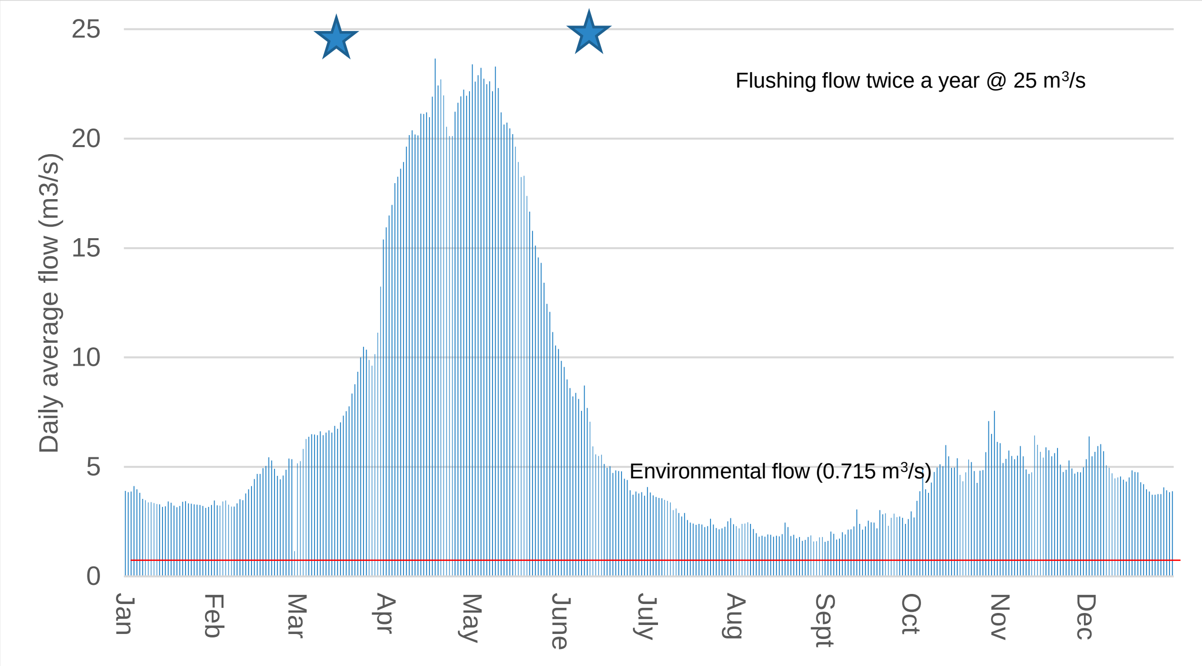
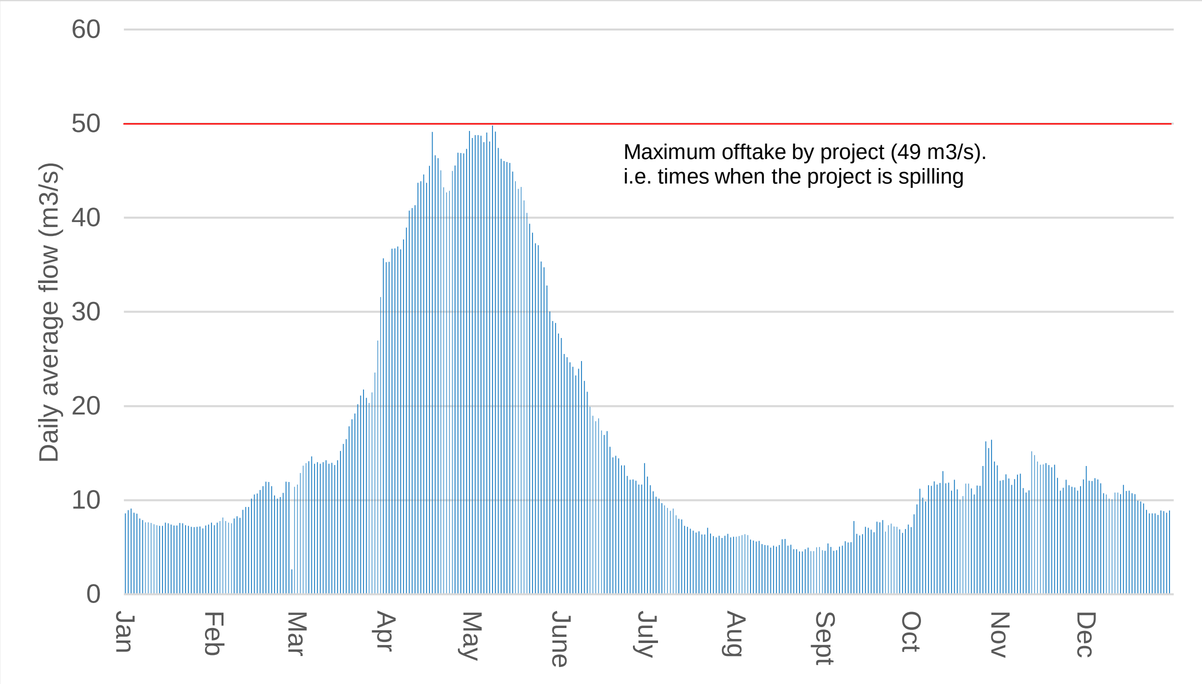


Figure 14 illustrates the proposed environmental flow and flushing flows in the context of the existing regime. The environmental flow of 0.715 m³/s is less half the average daily flows under natural low flow conditions.

The flushing flow of 25 m³/s will be a little higher than the average annual peak flows. The timing and scale shown is for indicative purposes only as the specific regime will be determined by river flows and sediment accumulation which will vary from year to year.

Figure 15: New regime at Didachara dam (Chirukhistsqali, Skhalta and Adjaristsqali rivers) to show probable spilling regime (based on historical data of daily average flows)



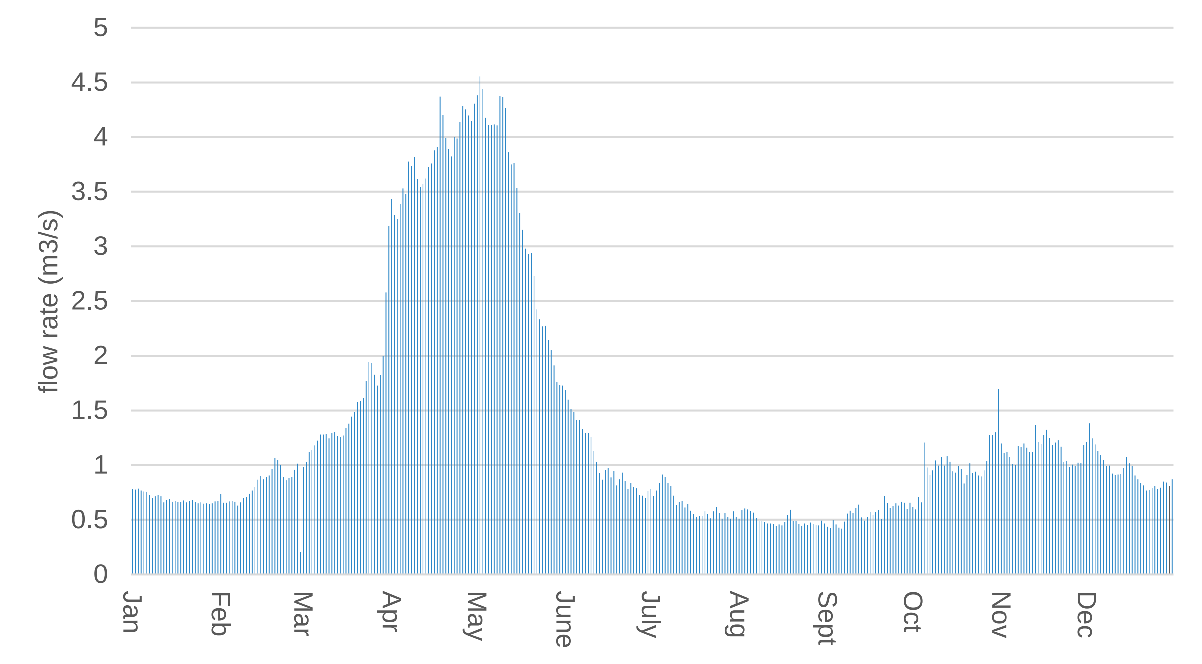
As illustrated in Figure 15 it is not expected that environmental and flushing flows from Didachara dam will be supplemented on a regular basis by flows from spilling. It is however important to note that Figure 15 shows average conditions and that in reality there are likely to be irregular flood events that do result in spilling.

5.4.4.2 Estimate of downstream flow regime

Adj 7A, shown in Figure 17, will receive on average, just the fixed environmental flow throughout the year. This will be supplemented by two flushing flows a year and occasional spilling.

Adj 7B flows are much improved due to inflow from the Diakonidze River and the Skhalta River further downstream. Figure 16 shows that throughout the year the Diakonidze will supplement the environmental flow from the Didachara dam by at least 0.5 m^3/s. This rises to around 4.5 m^3/s in April and May.

Figure 16: Diakonidze River - Daily Average flows (historical data)



Adj 7C flows are expected to be almost half the current annual average. The expected daily flows will follow a similar pattern to the pre-scheme conditions even during low flows.

5.4.5 Anticipated impacts to hydro geomorphology

The shape of the existing river bed suggests that the short stretch of river below the dam down to the confluence with the Diakonidze River is likely to remain in a single channel. At this point the environmental flow will be supplemented by the incoming Diakonidze River and ground water. In the new flow regime, this input will approximately double the discharge of the Adjaristsqali River after the confluence. Flushing flows will continue to provide sediment to the reach and occasional flood events will continue to have a positive redistributive effect on sediment.

To build an understanding of how the environmental flow will behave in the existing river channel we have used the Manning's equation to estimate the probable depth and velocity of the river[17]. To illustrate the range of outcomes we have chosen some typical cross sections and some high risk cross sections (i.e. where the river is wide and shallow). Results are presented in Table 7.

[17] http://onlinechannel.sdsu.edu/onlinechannel01.php

Table 6: Adjaristsqali River depth and velocity at different points under environmental flow conditions

Inputs

Section characteristic	Constrained, deeper	Wider, shallow	
Flow discharge	0.715	0.715	m3/s
Bottom width	7	15	m
Side slope	3	5	
Bottom slope	0.01	0.005	m/m
Manning's n	0.04	0.04	
Normal flow depth	0.145	0.114	m
Normal flow velocity	0.662	0.404	m/s
Normal Froude number	0.571	0.39	

The information in Table 7 indicates that in the deeper constrained sections of the river the flow depth could be around 14.5 cm, with a velocity of around 0.66 metres per second. In the wider shallower sections of the river, the depth could be closer to 11 cm with a velocity of around 0.4 metres per second. More discussion in given in section 5.2.7 regarding how this understanding will influence the channel modification.

5.4.6 Anticipated impacts to aquatic ecology

Impacts from the operation of the Didachara dam and subsequent effects on the river ecology are likely to be:

- Loss of riverine habitat from a reduction in flow downstream
- The dam acting as an obstruction to fish movement and the loss and fragmentation of aquatic habitats
- Loss of important feeding habitat

Fish survey monitoring results indicate that spawning does not occur on the main Adjaristsqali River downstream of the Didachara dam and therefore it is not expected that there will be any loss of downstream spawning habitat following start of operation. In the autumn however, fry present in the tributaries move into the Adjaristsqali River to feed. A reduction in food availability will impact species such as the Caucasian chub, Colchic kramulya and goby which have a lower prey diversity. Subsequently the impact of the Didachara dam on fisheries is assessed as **moderate adverse**.

5.4.6.1 River reach Adj 7A

The following characteristics have been considered when defining the ecological sensitivity of this reach:

- Presence of suitable feeding habitat for cyprinid species
- The Adjaristsqali River is important as a migratory route for some rheophilic species and flows should allow for the movement of fish up and down the main river to avoid isolation of populations in tributaries.

The section of the river between the dam and the Diakonidze confluence will continue to provide benefit to aquatic biodiversity, particularly as a resting ground for small salmonids during high flows. It is unlikely however that this reach will provide alternative spawning habitat as flushing flows would likely make the substrate unsuitable and destroy any physical modifications made.

The ecological sensitivity in this reach is considered medium due to the presence of feeding habitat for some species; the magnitude of hydraulic changes is expected to be major and consequently the impact is assessed as **major adverse.**

5.4.6.2 River reach Adj 7B and Adj 7C

The sensitivity criteria are the same as for the upstream reach. Impacts from the operation of the Didachara dam and subsequent effects on the river ecology in this reach are likely to include the following:

- Loss of riverine habitat from a reduction in flow downstream; however, flows are much improved after the confluence with the Diakonidze River, and 15 km later with the Skalta River
- Dam acting as an obstruction to fish movement and the loss and fragmentation of aquatic habitats
- Loss of important feeding habitat

The Diakonidze River will provide important additional flows to the Adjaristsqali to support suitable fish habitat and bankside vegetation. These additional inflows reduce the potential impact caused by the new regime and provide confidence that there will not be a hydrological connectivity issue downstream of the confluence with the Adjaristsqali River.

The ecological sensitivity in this reach is considered medium due to the presence of feeding habitat for some species. The magnitude of hydraulic changes is expected to be moderate as flows would be different from the pre-scheme conditions. Consequently, the impact is assessed as **moderate adverse.**

5.4.6.3 River reach Adj 7D

Impacts from the operation of the Didachara dam and subsequent effects on the river ecology in this reach are likely to include the following:

- Loss of riverine habitat from a reduction in flow downstream; however, flows are much improved due to the presence of some tributaries including the Skhalta and Chirukhistsqali River
- Loss of important feeding habitat

Consequently, the magnitude of the change in flows is considered to be minor and impacts in this section are assessed as **minor adverse**.

5.4.6.4 Shuakhevi powerhouse

At Shuakhevi power house there may be some impact from the release of a large volume of water at the tail race discharge point, which could result in a change in the river morphology, loss of vegetation and macroinvertebrates but no loss of spawning habitat. The magnitude of hydraulic impacts downstream of the Shuakhevi powerhouse is predicted to be major. As the sensitivity of habitats in this section is considered moderate, the ecological impacts are assessed as **moderate adverse**.

5.4.7 Committed mitigation

5.4.7.1 Channel modification

The short stretch of river between the Didachara dam and the confluence with the Diakonidze River will not be of value to migratory fish due to the barrier presented by the dam. As such it is not considered necessary to specify a particular river depth or velocity to be achieved. Hydraulic connectivity in this reach is therefore not required to achieve the minimum standards. As such, rather than focusing on hydraulic connectivity, mitigation actions in this river section will focus on, maintaining aquatic habitat which will benefit the river's biodiversity (for example through providing resting / sheltering areas for small fish).

The usual riffle/pool and bar type features will not be able to form due to the restriction of flow through these reaches. The focus should be to maintain as much habitat as possible though varied depth and velocity. A canalised, square channel profile should be avoided. Instead a river bed profile of variable depth provides greater velocity and habitat heterogeneity. Avoid channel smoothing, i.e. maintain pebbles/boulders as roughness increases habitat heterogeneity through varied depth and velocity. Substrate should be as described in Table 5. Different substrate, velocities and depths will provide greater habitat for a wider range of species and thus maintaining stronger links (food web dynamics) between species, which in turn has greater resilience.

A gradual reduction in flows is not required at commissioning. Immediately after commissioning, a fluvial geomorphologist will survey the reach to identify adaptive management measures that might be required to maintain the river's functional habitat. For example, some minor in channel works may be required to concentrate flows, or blockages may need removing. The key focus will be ensuring that the environmental flow from the dam connects with the inflow from the Diakonidze River at the confluence, but works will align with the overall philosophy of low intervention to create a sustainable river system.

Works are not expected to be required after the confluence with the Diakonidze river, although surveys will be carried out downstream from the confluence in accordance with the precautionary principle to confirm that flows behave as predicted during operation.

An appropriately qualified fluvial geomorphologist will survey the river after flushing and high flow events to ensure that the shape of the channel is conducive to functional habitat, giving particular attention to locations at high risk of splitting.

5.4.7.2 Fish monitoring and management

Fish monitoring and management will be undertaken as described in Section 4.2.2 in order to achieve the minimum standards.

5.4.7.3 Future development on the Diakonidze River

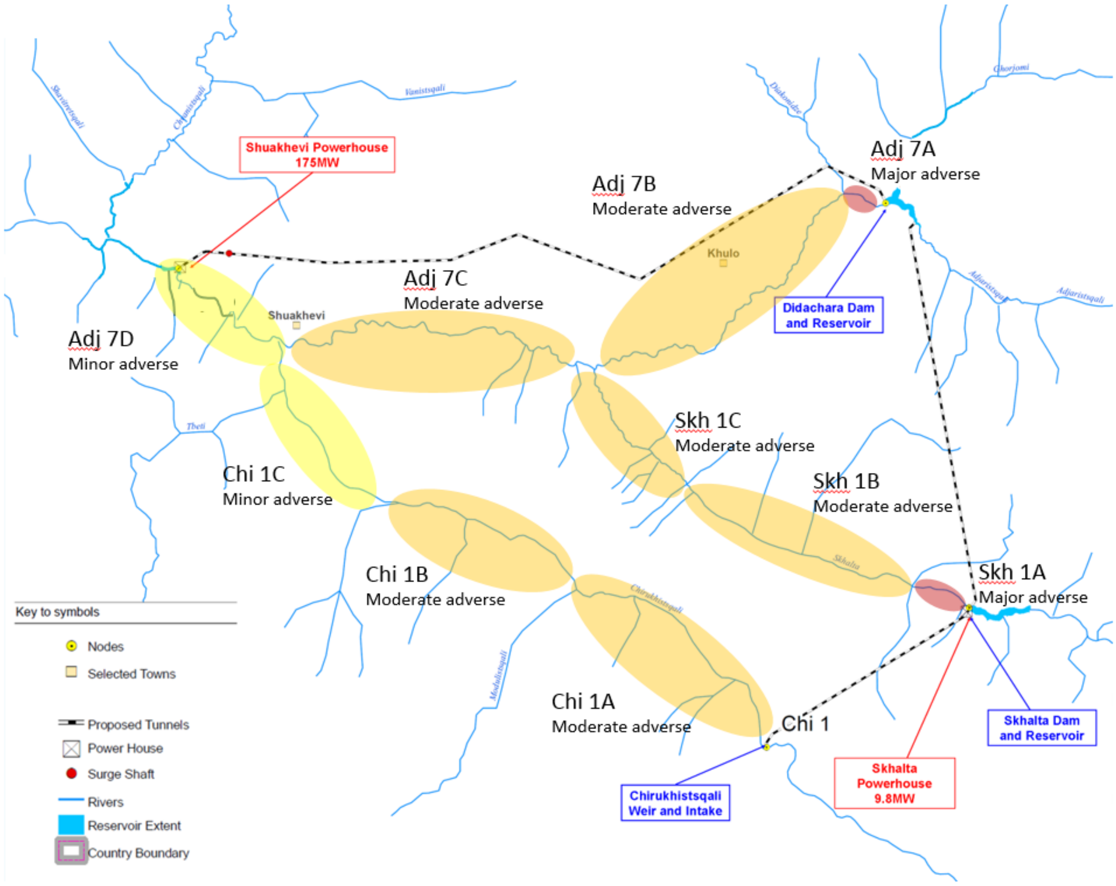
The Diakonidze River offers upstream habitat and downstream flows which reduce the biodiversity impacts of the Didachara dam. The presence of this tributary reduces the need for extensive mitigation measures downstream of the dam. It should be noted that in the longer term there are plans to divert most of the flow from the Diakonidze River into the Shuakhevi scheme. Diversion of the Diakonidze are anticipated to extend the aquatic biodiversity impacts of the Shuakhevi scheme to the confluence with the Skhalta river, a further 15 km downstream.

5.4.8 Adjaristsqali conclusion

We consider that no residual adverse impact to biodiversity for the Adjaristsqali River can be achieved by:

- Monitoring changes in hydro geomorphology during commissioning and operation
- Implementing minor channel modification where required
- Monitoring of fish
- Stocking and/or trap and transport of fish upstream of the dam
- Maintaining the habitat and flow inputs of the Diakonidze River

Figure 17: Map showing the anticipated environmental impact of the new flow regime



6 Conclusion

The purpose of this report was to set out a strategy to mitigate the potential impacts caused by reduced flows downstream of the dams and weirs that form part of the Project, as will be required to achieve the minimum environmental standards and particularly no residual adverse impact to biodiversity. The report considered ecological, hydraulic, and geomorphological factors to determine a sufficiently robust programme of mitigation, monitoring and adaptive management. Mitigation, monitoring and adaptive management measures were defined considering the minimum standards for each river.

Details of the mitigation and adaptive management measures that have been committed to by AGL to achieve the minimum environmental standards for each river are detailed in sections 5.2.7, 5.3.7 and 5.4.7. A summary is also provided in chapter 7.

Going forward AGL will develop a detailed plan of the mitigation and management (including monitoring) requirements. The detailed mitigation plan will capture the commitments presented in this report for implementation by the Project commissioning and operations and maintenance teams. Assuming this plan will be prepared as required we conclude that the Project can achieve the minimum standards (no residual adverse impact to aquatic biodiversity) during operation.

7 Summary of minimum standards, impacts and mitigation measures

Table 7 Chirukhistsqali River summary

Minimum Standard	Specific impacts to be mitigated	Committed mitigation
• Channel downstream of the fish pass must maintain full hydraulic connectivity • Species abundance and diversity will not be reduced	**Hydrogeological** • Risk of braiding and river splitting into multiple channels • Risk of a single large boulder blocking the path of the river • Occasional wider, flatter reaches over fine gravel where the river could have low depth **Ecological** • Reduction in suitable riverine habitats • Alteration in the bankside vegetation and associated shelter for some fish species • Risk of fish mortality during downstream migration as result of entrainment in intake structure • Impacts on reach Chi 1 A&B classified as 'moderate adverse' • A barrier effect to tributaries (if water level and velocity are not sufficient for individuals to move upstream)	• Gradual reduction of the downstream flow rate at commissioning, starting at 30% of the mean annual flow • Monitoring changes in hydro geomorphology during commissioning and operation • Implementation of minor channel modification where required • Successful operation of the fish pass (sustained by regular maintenance and demonstrated by monitoring) • Fish monitoring • Stocking and/or trap and transport of fish upstream of the dam if required

Table 8 Skhalta River summary

Minimum Standard	Specific impacts to be mitigated	Committed mitigation
• No fish pass so complete hydraulic connectivity to the dam beyond the closest tributary is not considered necessary to achieve the minimum standards • No reduction in species abundance and diversity • Maintenance of access to the valuable flows and habitat provided by the downstream tributaries • Maintenance of the quality of aquatic habitat in the reach below the dam	**Hydrogeological** • Wider, flatter reaches over fine gravel where the river could have low depth • Higher risk of spreading and splitting • Risk of reduced flows preventing fish movement to valuable habitat provided by tributaries • Risk of sediment build-up due to lower flows **Ecological** • Loss of spawning habitat for various Cyprinid species within reservoir area • Reduction in flow and subsequent alteration/loss of riverine habitats downstream of the dam • A barrier effect to tributaries (if water level and velocity are not sufficient for individuals to move upstream) • Alteration of the riparian vegetation and elimination of some slower backwater flood areas which shield some species from predation as well as providing important resting areas • Increase in limnophilic species • Risk of fish mortality during downstream migration as result of entrainment into intake structure • Barrier to further upstream migration	• Monitoring of changes in hydro geomorphology during commissioning and operation • Implementation of minor channel modification • Fish monitoring • Stocking and/or trap and transport of fish • Ensuring the beneficial flows from, and access to downstream tributaries are maintained

Table 9 Adjaristsqali River summary

Minimum Standard	Specific impacts to be mitigated	Committed mitigation
• No fish pass so complete hydraulic connectivity to the dam beyond the closest tributary is not considered necessary to achieve the minimum standards • Maintenance of the quality of aquatic habitat in the reach between the dam and first tributary (Diakonidze River) • No reduction in species abundance and diversity • Flows should allow fish to move up and down the main river to avoid isolating populations in the tributaries • Maintenance of access to the flows and habitat provided by the downstream tributaries	**Hydrogeological** • Wider, flatter reaches over fine gravel where the river could have low depth • Risk of spreading and splitting • Risk of reduced flows preventing fish movement to alternative habitat provided by tributaries • Risk of sediment build-up due to lower flows **Ecological** • Loss of riverine habitat from a reduction in flow downstream • The dam acting as an obstruction to fish movement and the loss of aquatic habitats • Loss of important feeding habitat • A barrier effect to tributaries (if water level and velocity are not sufficient for individuals to move upstream)	• Monitoring changes in hydro geomorphology during commissioning and operation • Implementing minor channel modification where required • Fish monitoring • Stocking and/or trap and transport of fish • Maintaining flow inputs from, and access to habitats in, the Diakonidze River

Appendix: Ecological Baseline Review

Shuakhevi Hydropower Project

Ecological Baseline Review (annex to low flow mitigation strategy)

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Shuakhevi Hydropower Project

Ecological Baseline Review (annex to low flow mitigation strategy)

10 July 2017

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	10/10/16	C Figueira	Z Trent M Barnard	J Prytherch	First issue (pre low-flows data)
B	23/11/16	C Figueira	Z Trent M Barnard S Howard	J Prytherch	Updated to include results of available flow and mesohabitat data from 2016 surveys
C	20/12/16	S Howard	M Barnard	J Prytherch	For client review. Revised to form annex to aquatic mitigation strategy
D	03/02/17	C Figueira	S Howard	J Prytherch	Minor update to fish spawning details
E	10/07/17	C Figueira	S Howard	J Prytherch	Addressing lender comments

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Contents

1 Introduction

Commissioning of the Shuakhevi Hydropower Project (the Project) is expected in the first quarter of 2017. Prior to commissioning it is a requirement of the Lenders (the European Bank for Reconstruction and Development (EBRD), Asian Development Bank (ADB) and International Finance Corporation (IFC)) that the Project has developed a sufficiently robust mitigation and adaptive management strategy to ensure that the Project can achieve the minimum environmental standards, including no residual adverse impact on biodiversity.

The mitigation and adaptive management strategy is presented in the main body of this report. To inform the identification of an appropriately robust suite of mitigation measures a full review was carried out of the results from the Project's pre and during construction aquatic ecology monitoring programme. The findings of the review constitute an update to the aquatic ecology baseline presented in the Adjaristsqali Hydropower Cascade Environmental and Social Impact Assessment (ESIA) in so far as it relates to the Project.

This report presents the detailed methodology used to define the aquatic ecology baseline and the complete baseline results that have informed the mitigation and adaptive management strategy. The following baseline information is presented:

- Hydrological conditions in the AoI
- Mesohabitats, macroinvertebrate and fish survey results from 2012 – 2016, and analysis of:
  - The existing fish populations present in the catchment influenced by the Project. Fish species diversity, distribution and movements along the Skhalta, Chirukhistsqali and Adjaristsqali rivers were assessed with a focus on improving understanding of fish migration between the main rivers and their tributaries
  - Macroinvertebrate populations present in the catchment influenced by the Project. Macroinvertebrate community structure and distribution along the Skhalta, Chirukhistsqali and Adjaristsqali rivers were analysed
  - Mesohabitat survey data from 2012, 2013 and 2016 (qualitative and quantitative analysis) with regards to potential changes in river habitats as a function of flow changes
- Description of predicted river flow and aquatic habitat changes under different flow conditions during operation of the Project for each of the rivers that will feature a Project impoundment structure

In addition to informing the mitigation and adaptive management strategy, the updated aquatic baseline data has been integrated into the Project's critical habitat assessment. Under the Lender's standards more stringent mitigation criteria would be applicable if critical habitat is assessed as present. The updated assessment has concluded that critical habitat is not triggered for aquatic ecology. The fully revised critical habitat assessment incorporating the updated aquatic ecology baseline is presented in the Project Biodiversity Action Plan (BAP).

2 Methodology

2.1 Overview

A range of surveys including mesohabitat mapping, flow measurements, fish surveys and macroinvertebrate surveys were carried out between 2012 and 2016.

The survey work was constrained by the large scale of the Project and safety considerations, primarily the need for survey locations to be safely accessible during low and high flow conditions. The survey team comprised an ecologist and a hydrologist from Mott MacDonald, three local ichthyologists (independent specialists sourced through the Black Sea Monitoring Agency) and local hydrology technicians (provided by Gross Energy Georgia (GEG)). Atle Harby of CEDREN also participated in the 2012 surveys.

2.2 Mesohabitat survey

Meso-scale habitat units are broadly similar in concept to 'functional habitat' and are defined as areas where an animal can be observed for a significant portion of their diurnal routine (Kemp et al., 1999 in Parasiewicz, 2007).

Unlike detailed microhabitat surveys which involve sampling over short distances at a limited number of sites, mesohabitat survey techniques enable mapping and description of river habitat characteristics and availability in large river sections. Mesohabitat methods rely on the classification of hydro-morphological units (HMUs) based on hydraulic attributes such as water depth, velocity, and physical characteristics.

The mesohabitat method selected for the Project is based on the Norwegian Mesohabitat Classification Method (the Norwegian Method, see below). The Norwegian Method builds on and provides more detail than commonly used riffle-run-pool-methods, classifying river sections into a maximum of ten physical meso-scale morphological (mesohabitat) classes by visual observation. The Norwegian Method has previously been applied in Norway, Albania and the Rhône River. These studies have shown the methodology to have characteristics that make it particularly suitable to the Project (Harby et al., 2007; Borsányi et al., 2004) as follows:

- Mesohabitat classes can be applied with success to different types of rivers
- Rapid in application, flexible and more objective than previous approaches
- Applied successfully to a large river
- Describes habitat availability for invertebrate and fish communities at two contrasting discharges (or in other situations at low and high flows)
- Describes habitat characteristics and relates these to the ecological preferences of invertebrates and fish

Fish surveys were conducted at the same time as the mesohabitat surveys for the Shuakhevi Project. This was necessary as:

- Transposing fish preferences from other locations can introduce error as different fish preferences may occur in different geographic regions, even within the Adjara Rivers
- Within the same species, different size classes of fish can present different preferences
- To link mesohabitat characteristics and ecological preferences of fish, information is required on habitat use by different species at different life cycle stages in different mesohabitats

The methodology adopted allows fish preferences within different mesohabitat classes to be assessed with confidence and supports the long term monitoring and evaluation of mitigation measures developed during the Phase II assessment.

2.2.1 The Norwegian Method

The Norwegian Method is a mesohabitat methodology that involves the classification of rivers into HMUs (hereafter referred to as mesohabitats). Mesohabitats are classified using four parameters:

- Surface flow type (wave height)
- Channel gradient (surface longitudinal gradient)
- Surface water velocity
- Water depth

Classification enables a robust assessment of impacts associated with changes to the flow regime. It enables:

- Changes in mesohabitats through the Project construction and operational phases to be predicted
- The relative importance of different HMUs within the catchment to be estimated

The surface of the river is divided into triangular and quadratic mesohabitats based on the four parameters outlined above. Identification of mesohabitats is carried out by visual observation and simple measurements following the decision tree provided in Table 1. By combining this information, ten different classes are obtained (impossible combinations are discounted). The factors are generalised for a wet area of at least one river width in the length direction. A maximum of three classes across the river can be recorded (Harby et al., 2004).

The decision tree criteria set out in Table 1 are open to subjective interpretation and criteria limits needed to be defined for the Project. The criteria limits used in this study are set out in Table 2. The selected criteria limits have been used in other studies carried out using the Norwegian Method. They were assessed as suitable for this study based on the local ecosystem, local fish species and other user interests.

Following the setting of criteria limits, a mesohabitat classification of all significantly impacted reaches of the Adjara Rivers was carried out. Representative “control” sites were included to enable review of the environmental flows for the Project.

Table 1 Norwegian Method decision tree criteria for classifying mesohabitats

Surface Pattern	Surface Gradient	Surface Velocity	Water Depth	Code
smooth/rippled	steep	fast	deep	A
			shallow	-
		slow	deep/shallow	
	moderate	fast	deep	B1
			shallow	B2
		slow	deep	C
			shallow	D
Broken/ unbroken standing waves	steep	fast	deep	E
			shallow	F
		slow	deep/shallow	-
	moderate	fast	deep	G1

		shallow	G2
	slow	deep	-
		shallow	H

Source: Borsányi et al., 2004

Table 2 Criteria limits

Principle		
Surface Pattern	Smooth/Rippled Right	Wave Height <0.05m
	Broken/Unbroken Standing Waves	Wave Height >0.05m
Surface Gradient	Steeper	Slope > 4‰
	Less step	Slope < 4‰
Surface Velocity	Fast	>0.5m/s
	Slow	<0.5m/s
Water Depth	Deep	>0.7m
	Shallow	<0.7m

Source: Borsányi et al., 2004

The Norwegian Method involves the obtaining of survey results for low and higher flow conditions to provide clear information on the potential extent and magnitude of impacts, as required, to inform the proposal of adequate mitigation measures. Important information obtained through the analysis of data sets for different flow levels includes:

- Changes in the mesohabitat classes
- Changes in habitat diversity under different flow conditions
- Important areas for fish such as spawning, feeding or refuge grounds with potential to be lost

To increase the likelihood that low and higher flow conditions and relevant fish data would be captured, the timing of the surveys in 2012, 2013 and 2016 took into account historical flow data and the need to carry out simultaneous fish surveys. Despite these efforts, flow conditions experienced at the Skhalta and Chirukhistsqali sites did not match survey requirements and were not sufficiently low to inform potential mitigation (refer to Section 3.3.1).

Surveys in 2016 in the Adjaristsqali River were carried out at lower flows (between 19% and 23% of the annual average flow). The surveys were successful in describing changes with a reduction in flows. Although the mesohabitat changes reported are not contrasting with previous surveys they allowed for an increased understanding of how the habitats may potentially change once the environmental flows are in place. Results are sufficiently robust to enable a more granular analysis and extrapolation (although limited) to further lower flow conditions. In addition, surveys were are also successful in describing the mesohabitats in further detail using the results of the microhabitat analysis (described below) and linking this with the presence of sensitive habitats (for example spawning habitats).

2.2.2 Microhabitat Analysis

To validate the mesohabitats classification carried out on site and to provide a detailed description of the physical characteristics, microhabitat analysis was carried out by collecting the following physical data from a limited number of mesohabitats and at fish survey locations:

- In-situ water quality testing for:
  - pH
  - temperature
  - dissolved oxygen
  - electrical conductivity
  - turbidity (total suspended solids)
- Substrate composition
- Site photographs
- Cross sectional profile

Each survey site was marked up in the field using the best available scale 'Russian' ordnance survey map (1:50 000). A GPS reading and series of photographs were also taken.

As with the mesohabitat surveys, flow conditions experienced on site were not sufficiently low to inform detailed analysis and potential mitigation. Conditions during the 2016 surveys on the Adjaristsqali River varied between 19% and 23% of the annual average flow and were generally lower than the conditions in 2012 and 2013.

2.3 Fish Surveys

2.3.1 Techniques

Fish surveys were carried out at the same time as the mesohabitat surveys and within important mesohabitats at locations where safety considerations allowed. Fishing equipment included the following:

- Cast net
- Seine net with fish bag
- Hand net
- Arc-net with stainless metal frame
- Fishing rod and line with accessories

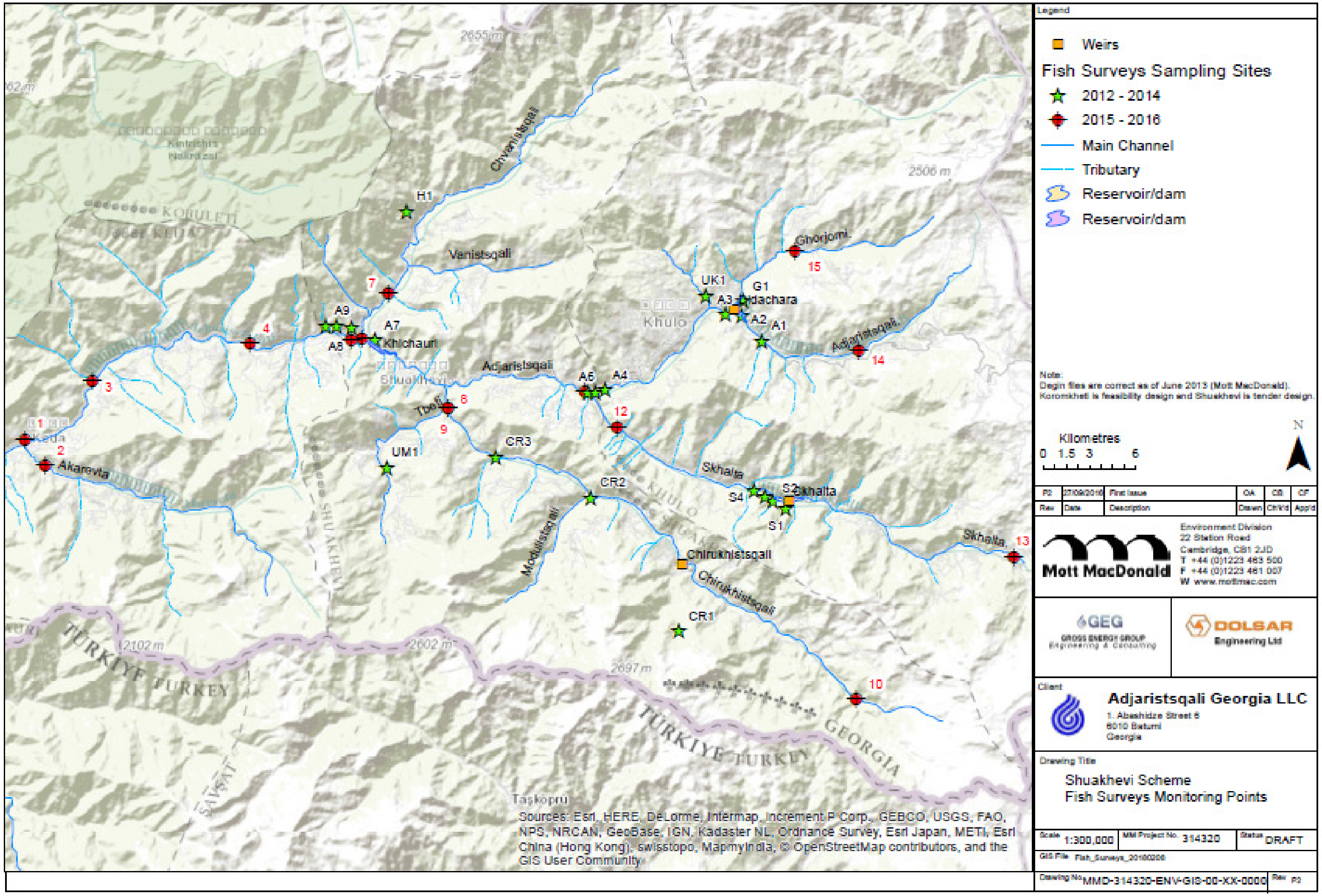
The fishing equipment was selected taking into account Georgian regulations. No fishing permits were required.

2.3.2 Fish Survey Sites (2012 – 2016)

Fish surveys have been undertaken for the Shuakhevi Project since 2012 and are still being carried out. However, site locations have not always been consistent. During 2012 and 2013 surveys were carried out at the same time as mesohabitat surveys. In 2013 and 2014 surveys were undertaken at the same locations apart from a few new sites in tributaries not influenced by the Project.

The 2012-2014 surveys were carried out by the independent consultant Dr. Rezo Goradze, surveys carried out in 2015 and 2016 were carried out by Fauna and Flora Association.

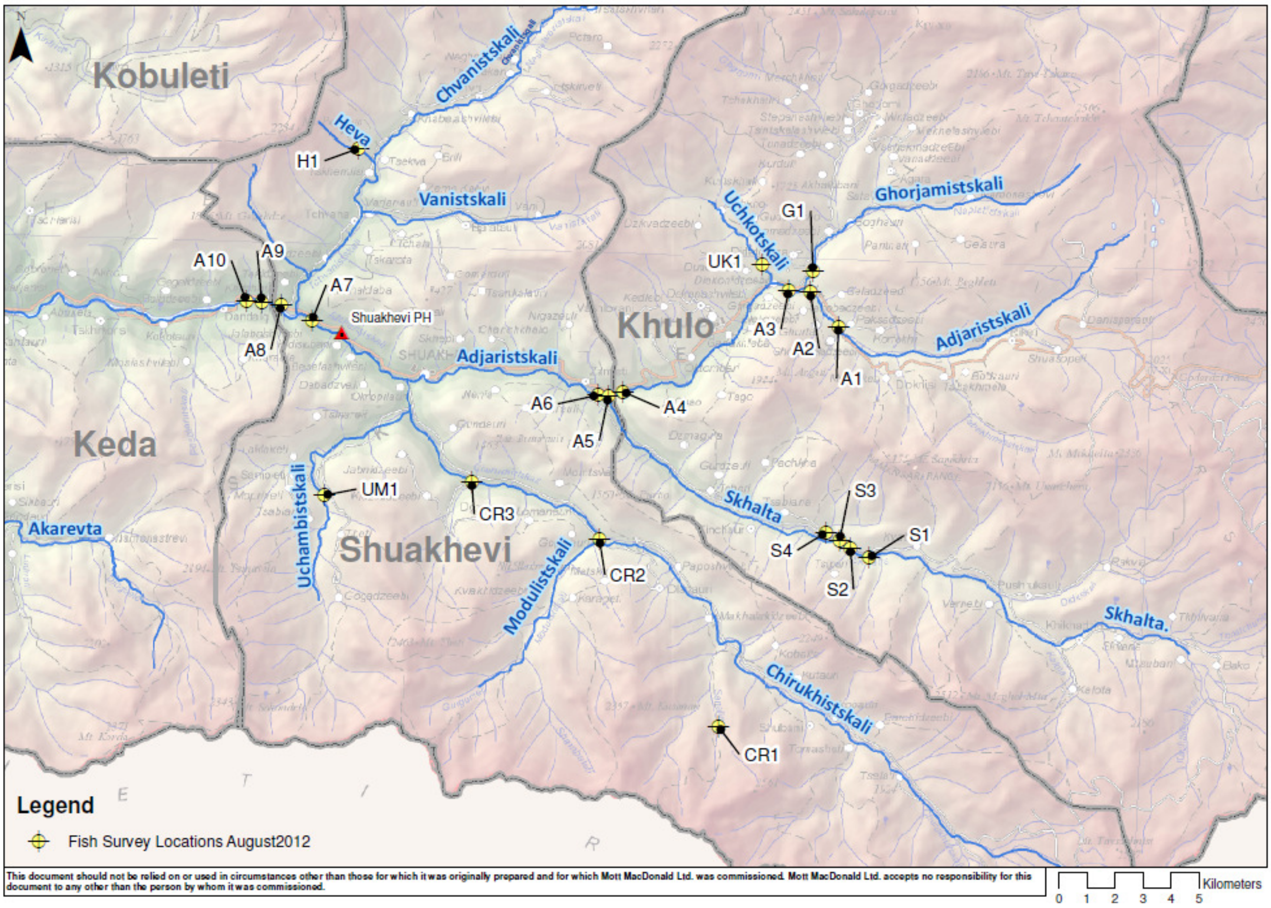
Figure 1: Fish survey site locations



2.4 Macroinvertebrate Surveys

The macroinvertebrate surveys were conducted at 22 sites within the Adjaristsqali river basin and its tributaries. For the macroinvertebrate surveys, hand nets were used. The net enables sampling in the edges of the river, as well as relatively deeper points (50-130cm). Sampling of macroinvertebrates in the Adjaristsqali River and its tributaries were conducted in 2013, 2014 and 2015 (Figure 2). Additionally, at the same time the riverbed substrate, riverbank structure, river mesohabitats and land use types were described.

Figure 2: Macroinvertebrate survey sites location (2013 - 2016)



On a couple of occasions in the shallow fast flowing areas, sampling was completed using the Sadowski bentho-meter.

The hand net method includes a manual search and a kick sample. Sampling was done according to the International methodology suggested by Mott MacDonald.

2.4.1 Manual Search

The manual search includes two parts:

- A 30 second visual search for surface dwelling animals was carried out prior to the kick sample (visual search and sweep for animals on the water surface, such as whirligig beetles and pond skaters)

- A 30 second manual search of stones for attached animals was carried out after the main three minute kick sample (search for animals which may not be freed from the substrate during normal sampling e.g. caddis pupae, leeches, and could be attached to logs, stones, solid objects, vegetation, floating leafed plants)

The two parts together must last for one minute, although the time on each part can vary depending on the habitat being sampled.

2.4.2 Kick sample

The net was held vertically on the riverbed downstream of the operator's feet with the lower edge held against the substrate. The substratum should be disturbed forcefully with the toe or heel of the boot and the released material should be caught in the net. The surveyor must move upstream and diagonally across the river.

Each invertebrate habitat in the sampling area must be sampled with an effort proportional to its cover. This is to ensure that all habitats present are sampled representatively (i.e. most time spent in the habitat which is most abundant). For example: if the substrate is 50% silt and 50% gravel, half the sampling time must be allocated to silt, and half to the gravel substrate type.

2.4.3 Preservation of samples, transportation and analysis

The samples were placed in air-tight glass and plastic container of 200-300 gr. volume, filled with 70% ethanol as a preservative.

All invertebrate specimens in the sample were preserved and later identified in the laboratory. Some inadvertently picked up specimens, such as fish, crayfish, were recorded and returned to the river before the sample was preserved.

The samples were washed and organisms separated from the substrate. The taxonomic and species composition of organisms were determined by two hydrobiologists - macroinvertebrate specialists, Professor Rezo Zosidze and Doctor Eteri Mikashavidze. The Leica and KRUSS MSZ 5600 binocular microscopes were used along with Adjara river fauna identification guide.

3 Results

3.1 Hydrology

This section provides a summary of the water resources and environmental flows in the Adjaristsqali River catchment.

3.1.1 Catchment

The Adjaristsqali River originates in the western part of the Arsiani mountain range, 2435m above sea level (ASL). The total length of the river is 90km, the total fall 2,397m and the average inclination 2.66%. The catchment area is 1,540km² and average elevation is 1,400mASL. The river joins the River Chorokhi from the northern side some 17km upstream of the outfall of the Chorokhi River into the Black Sea.

Most of the Adjaristsqali catchment area is covered by forests. In the downstream area, at 1,000-1,200mASL elevation, deciduous forest dominates; whereas at higher elevations, 1,200-2,000 mASL, conifer forest is present. About 15-20% of the total basin area is above the treeline and has alpine conditions.

River Adjaristsqali inflows are provided by snow, rain and groundwater. The primary input is rainfall which is the main source of river water inflow (44%) with groundwater and snow respectively making up 30% and 26% of the inflow respectively. There are no glaciers in the catchment.

The melting of winter snow feeds a major period of higher flows in spring through to early summer. A second period of higher flows occurs in late autumn driven by rain storms – this flooding season is shorter than the melt driven flood period. The main characteristics of the hydrological regime are therefore flooding in spring and autumn, with low flows in summer and winter.

In the higher part of the catchment, almost constant low flows persist from December through to February as precipitation falls largely as snow, while in the lower part of the catchment the flow is higher and shows rainfall driven flood events.

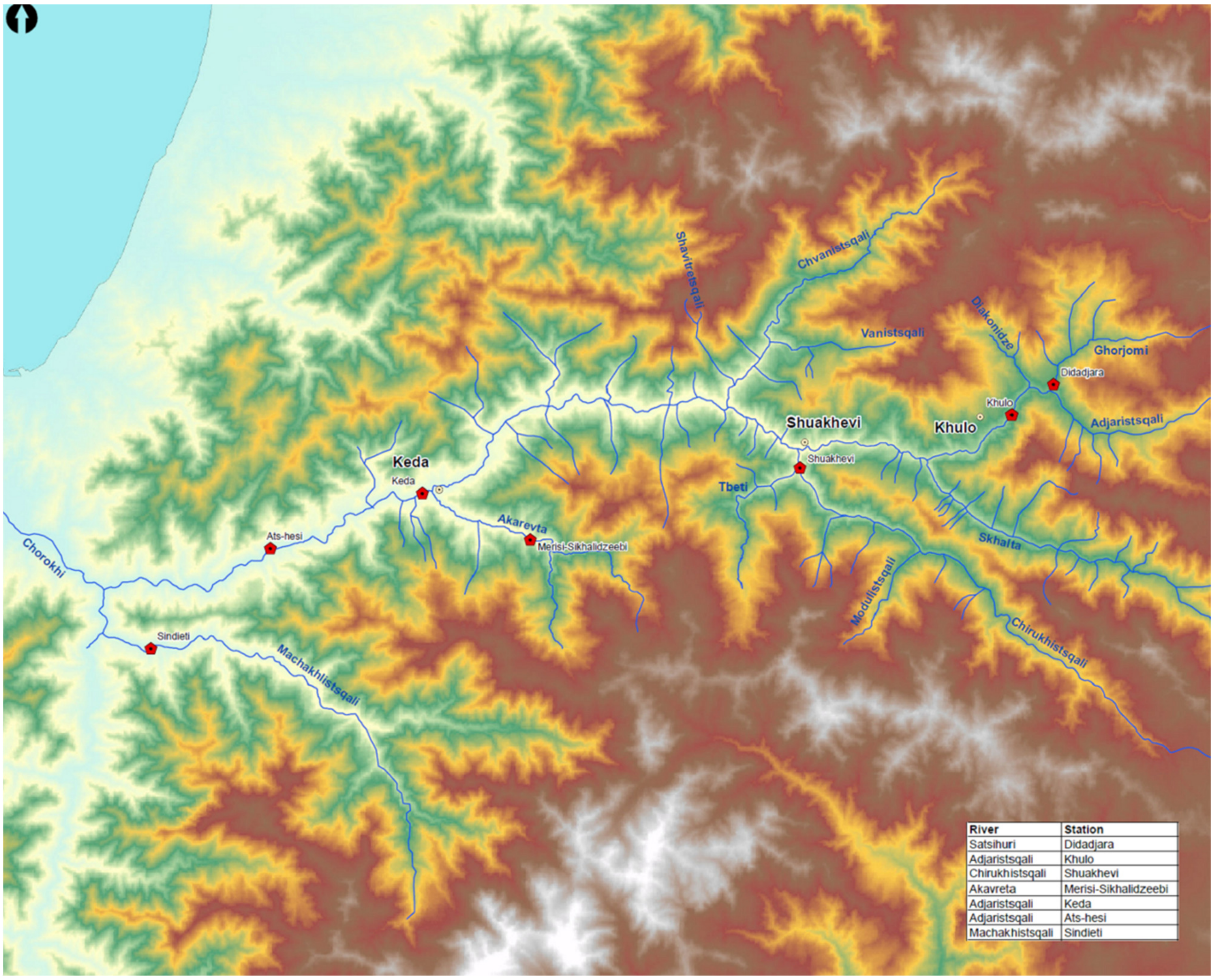
The steep upper catchment is very responsive to rainfall events. The river system is very active with erosion, transport and deposition of sediments creating a wide range of channel morphology along the length of the Adjaristsqali River and its tributaries. Some parts of the catchment, for example the Skhalta River tributary, have many active landslides which add large quantities of sediment to the river.

3.1.2 Hydrological data

At present there is no active hydrometric measurement being undertaken anywhere in the Adjaristsqali catchment by the National Environment Agency (NEA) through its regional department in Batumi. The last records appear to have been water level records at Keda up to December 2009. There is very little river flow data for the period after 1992. Before 1992, however, the catchment was relatively well served by river gauging stations which covered both the Adjaristsqali River and its main tributaries. Records are available for river flows at seven sites in the catchment with over 48 years of daily data; locations are shown in Figure 3.

Table 4 presents the average annual, monthly and environmental flows at the site of the Skhalta, Chirukhistsqali and Didachara (Adjaristsqali River) impoundment structures. Figure 4, Figure 5 and Figure 6 present the average monthly flows at the same sites. The table and figures are based on historical daily flow data for the period 1942 to 1986. As no historical flow data were available at each impoundment site, flows from nearby gauging stations (Shuakhevi and Khulo) were used and an areal factor applied. Areal factors of 0.52 and 0.43 were applied to flow data from Shuakhevi gauging station to produce flows at Skhalta dam and Chirukhistsqali weir, respectively. An areal factor of 0.84 was applied to flow data from Khulo gauging station to produce flows at Didachara dam site.

Figure 3: Location of river gauges



The data illustrates that flow is strongly influenced by seasonal factors; with spring snow melt contributing substantially to flows from March to June. As the sites are situated in the upper catchment they are not as affected by autumn rainfall as sites in the lower catchment. The month with the lowest flows is August. The environmental flow (at 10% of the annual average flow) is substantially lower than the average flows in August. The environmental flow is also much lower than flows with a 90% probability of exceedance (Table 4 and Table 5)

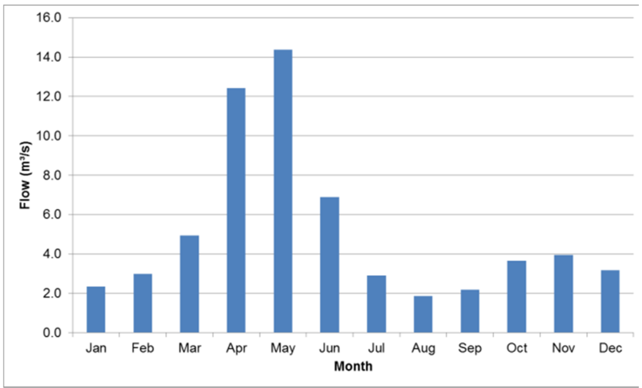
Table 3 Area and mean annual flow at gauging stations

Gauging station	Area (km²)	Mean annual flow (m³/s)
Didachara	98	4.1
Sindieti	362	21
Khulo	251	8.26
Shuakhevi	326	10.2
Keda	1360	46.32

Table 4 Average annual, monthly and environmental flows at the Skhalta, Chirukhistsqali, Didachara dam sites (1942-1986)

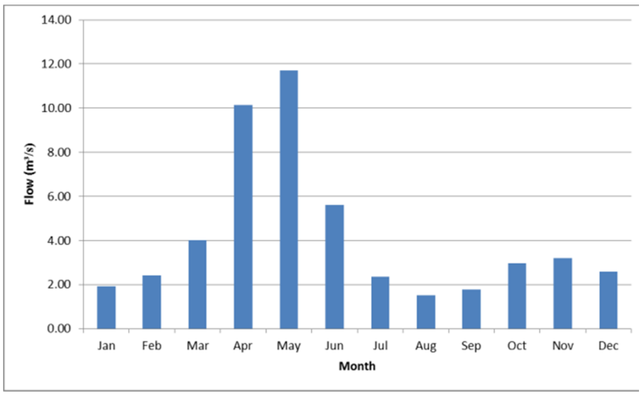
Month	Flow (m³/s)		
	Skhalta	Chirukhistsqali	Didachara
Jan	2.3	1.9	3.4
Feb	3.0	2.4	4.2
Mar	4.9	4.0	8.1
Apr	12.4	10.1	20.4
May	14.4	11.7	18.4
Jun	6.9	5.6	6.1
Jul	2.9	2.4	2.8
Aug	1.9	1.5	2.0
Sep	2.2	1.8	2.4
Oct	3.7	3.0	4.9
Nov	3.9	3.2	5.4
Dec	3.2	2.6	4.6
Annual average flow (m³/s)	5.1	4.2	6.9
Environmental flow (m³/s)	0.51	0.42	0.69

Figure 4: Mean monthly flow at the site of the Skhalta dam



Source: Historical data (1942-1986)

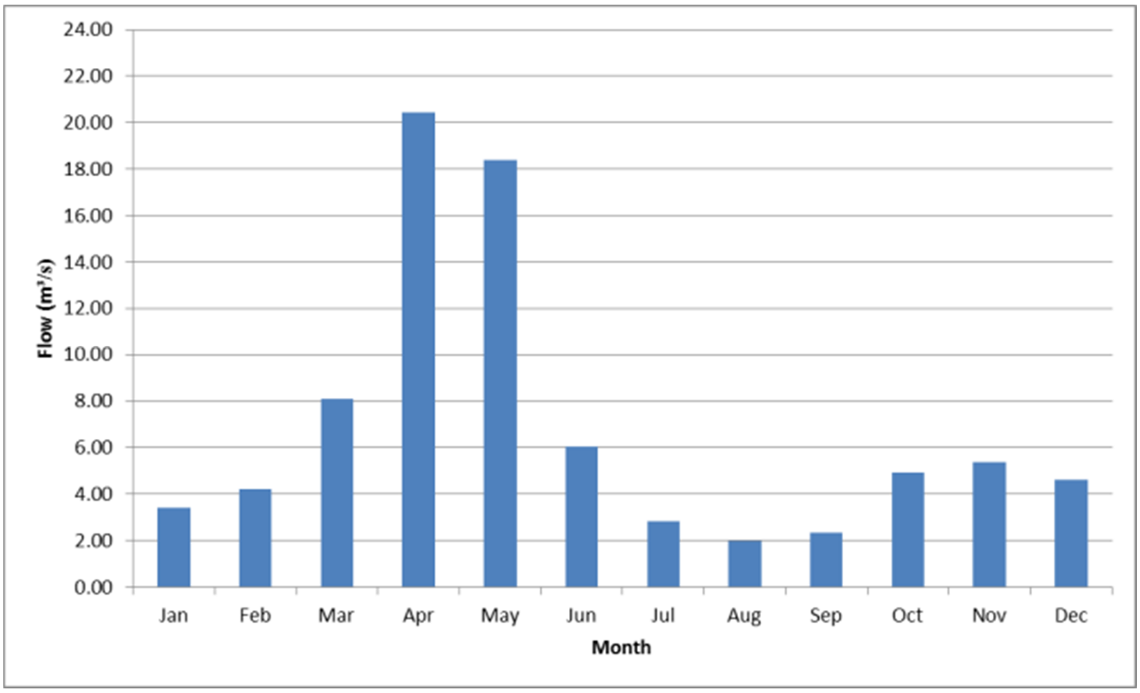
Figure 5: Mean monthly flow at the site of the Chirukhistsqali weir



Source: Historical data (1942-1986)

The mean monthly flow pattern is the same in both graphs as they result from the same set of data (flows from nearby gauging stations (Shuakhevi and Khulo) were used with an areal factor applied, as no historical flow data were available at the Projects themselves).

Figure 6: Mean monthly flow at the site of Didachara dam



Source: Historical flow data (1942-1986)

Table 5 Flow duration analysis at the Skhalta, Chirukhistsqali and Didachara dam sites (1942-1986)

Probability of exceedance (%)	Flows (m^3/s)		
	Skhalta	Chirukhistsqali	Didachara
0	102.7	83.7	96.9
10	11.8	9.6	17.5
20	7.2	5.8	10.1
30	5.0	4.0	6.8
40	3.8	3.1	4.9
50	3.0	2.5	3.6
60	2.5	2.0	2.9
70	2.1	1.7	2.4
80	1.7	1.3	1.8
90	1.2	1.0	1.3
95	1.0	0.8	1.0
96	0.9	0.8	0.9
97	0.9	0.7	0.8
98	0.8	0.6	0.7
99	0.7	0.6	0.6
100	0.2	0.1	0.2

Source: Based on historical data (1942-1986)

3.1.3 Environmental Flows

It is a requirement of the Environmental Permit that environmental flows are released into the downstream watercourses at each of the intake sites. The environmental flow discharges for each structure have been set at 10% of the long term annual average for each site. The environmental flow releases may, if required, be part of the fish pass flow and/or sluicing flow and/or flushing flow.

The environmental flow release must be continuously discharged downstream of each intake. Where flows upstream of the intake are less than or equal to the minimum flow, all water will be discharged downstream. Storage in the reservoirs will not be used to make up for any shortfall in the environmental discharge. Table 6 details the environmental flows set for each dam/weir proposed for the Project.

Table 6 Environmental flow rules

Location	Flow (m^3/s)
	10% of annual average[1]
Chirukhistsqali Weir	0.477
Skhalta Dam	0.578
Didachara Dam	0.715

3.1.4 Low Flows

Table 7presents analysis of historic summer low flow periods at the sites of the Adjaristsqali, Skhalta and Chirukhistsqali impoundment structures, based on the 1942-1986 synthesised historic flow series for the locations described above. The summer months consist of July, August and September.

Two criteria for the categorisation of a low flow period have been used for this analysis:

- Consecutive days with flow below the 90th percentile of the annual daily average flow
- Consecutive days with flow below the 75th percentile of the annual daily average flow

The number of summer low flow periods (from Table 7) is approximately three, during the period 1942-1986 at all three locations, whether the low flow limit is set at the 90th or 75th percentile of the annual daily average flow. The average number of low flow days is approximately 20 at all three sites when the low flow limit is set at the 90th percentile of the annual daily average flow. This increases to about 30 when the low flow limit is set at the 75th percentile of the annual daily average flow. The mean duration of summer low flow periods increases from 5-6 days to 8-10 days if the low flow limit is raised from the 90th to the 75th percentile of the annual daily average flow.

[1] As defined in the Environmental Permit and incorporated in to the design

Table 7 Summary of summer low flow periods at the Adjaristsqali, Skhalta and Chirukhistsqali dam sites (1942-1986)

	Adjaristsqali		Skhalta		Chirukhistsqali	
Low flow limit (percentile of the annual daily average flow)	75th %ile	90th %ile	75th %ile	90th %ile	75th %ile	90th %ile
Average number of summer low flow periods	3.3	2.8	3.0	2.6	3.0	2.6
Average number of summer low flow days	29.5	21.1	30.6	21.7	30.6	21.7
Mean duration summer low flow (days)	7.9	5.1	10.0	6.4	10.0	6.4

Figure 7, Figure 8 and Figure 9 present the minimum monthly flows at the same locations. The minimum monthly flows (based on an analysis of minimum median flows) show that August and September have the lowest flows at all three locations, with the lowest flow of all recorded in September. These flows are still higher than the proposed environmental flow (10% of mean annual flow) at all three locations. Figure 7, Figure 8 and Figure 9 also show the three day minimum and seven-day minimum flow for comparison.

Figure 7: Minimum monthly flows at Adjaristsqali at the site of the Didachara dam

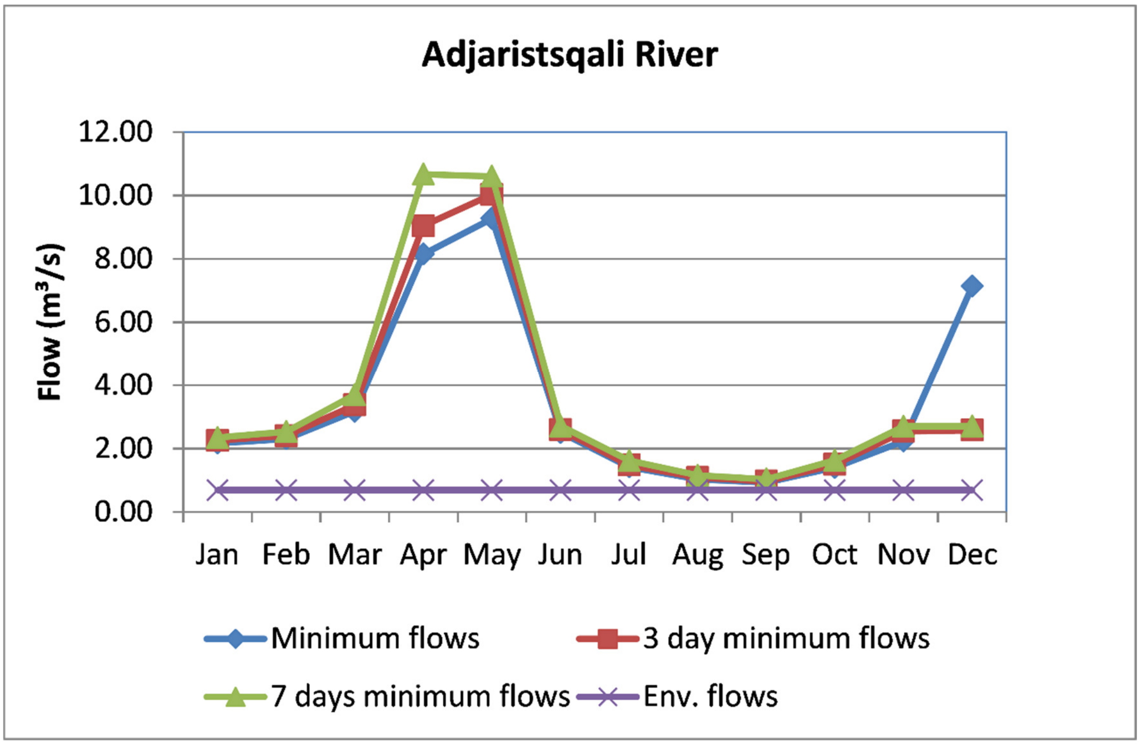


Figure 8: Minimum monthly flows at Skhalta at the site of the Skhalta dam

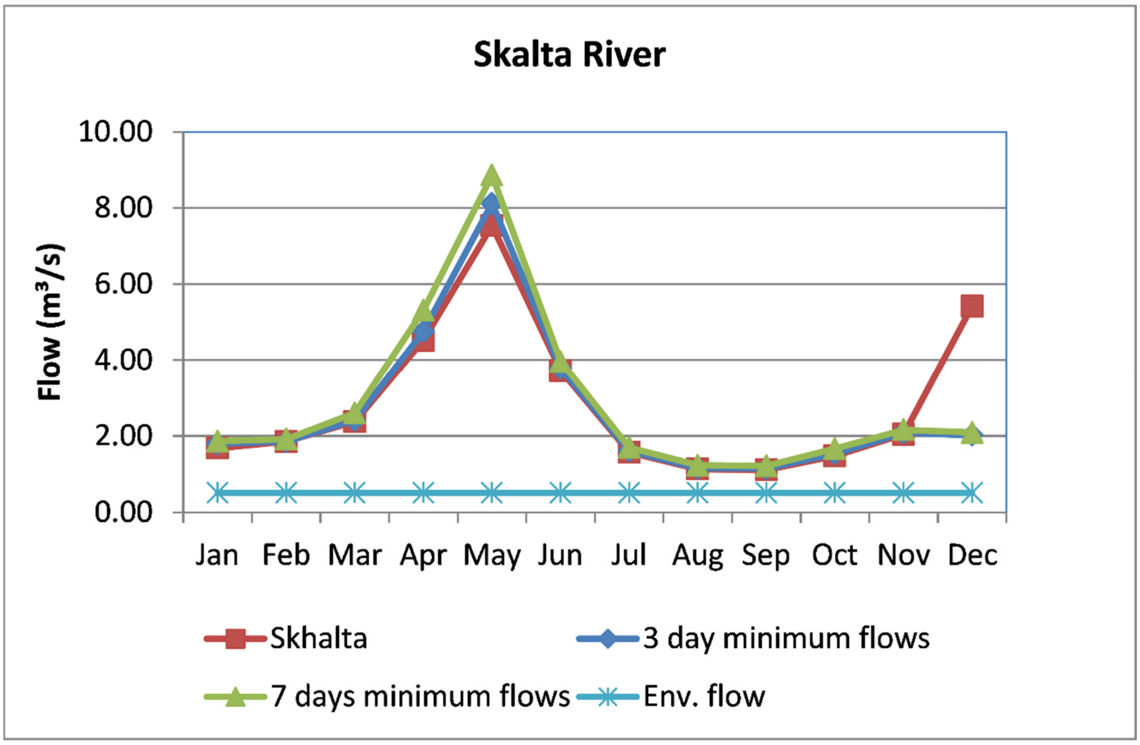
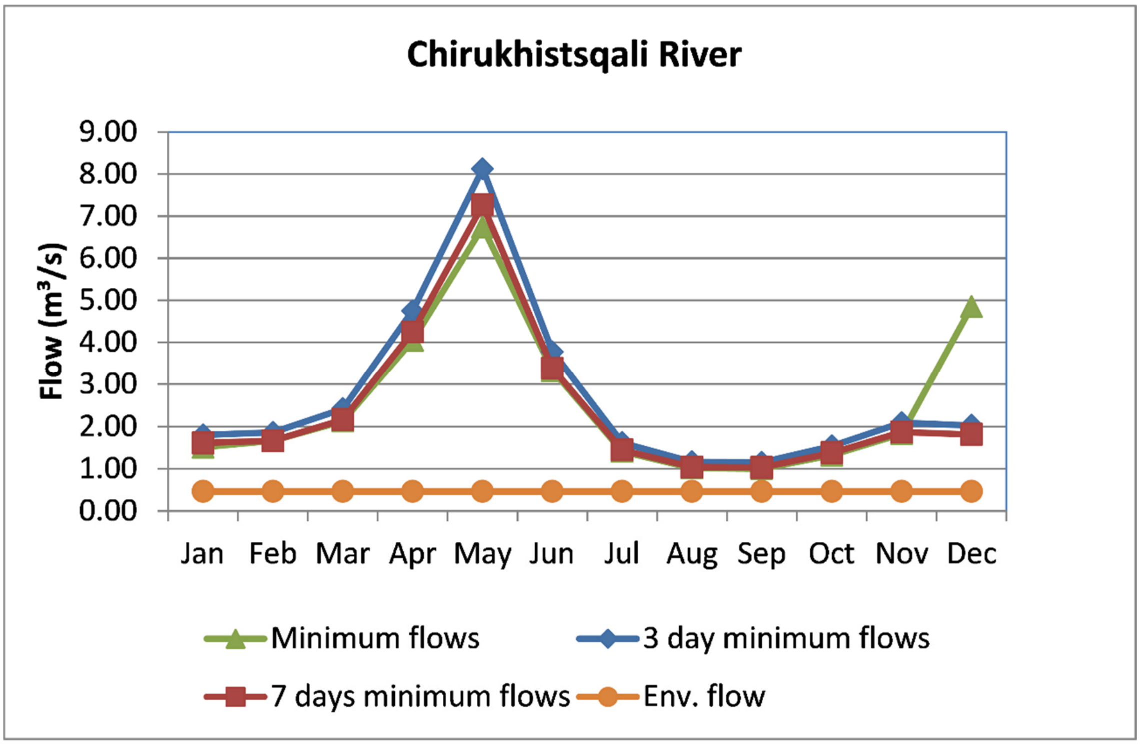


Figure 9: Minimum monthly flows at Chirukhistsqali at the site of the Chirukhistsqali weir



Source: Historical flows (1942-1986)

3.1.5 Spot flows (2012, 2013 and 2016)

Table 8 shows flows recorded in August 2012 and in July 2013 at various locations on the Adjaristsqali River and its tributaries. The nearest fish survey monitoring site to each gauging location has been included for information (with reference to Figure 1). The flows are generally much higher than the average flows in August (based on the synthesised historical flows in Table 8). Conditions during the 2016 surveys on the Adjaristsqali River varied between 19.7% and 23.1%(measured in the Adjaristsqali River downstream of the Didachara Dam)[2] of the annual average flow and were lower than the conditions in 2012 and 2013.

[2] Data collected during mesohabitats surveys is limited to water depth and flow velocity. This is in line with data collected in previous years. Discharge was monitored by AGL in the Adjaristsqali River downstream of the Didachara Dam.

Table 8 Summary of spot flows (2012 and 2013), compared with historical flow data

	Location description	Nearest fish survey location (Figure 3.1)	Spot flows (m³/s) (Aug 2012)	2012 spot flow as % of historical annual average flow*	Spot flows (m³/s) (Jul 2013)	2013 spot flow as % of historical annual average flow*	Annual average flow (m³/s) - historical data*	August average flow (m³/s) - historical data*	Location of historical data
1	Skhalta Reservoir	S2	3.02	59	2.58	51	5.1	1.9	Skhalta
2	Unukchaskhali (Thebi)	UM1	1.11	-	1.65	-	-	-	Historical data not available at this location.
3	Modulistskali	CR2	1.35	-	0.90	-	-	-	Historical data not available at this location.
4	Chirukhistsqali 50m upstream of confluence with Moduhstskali (220812002001) @1315	CR2	1.68	40	1.71	41	4.2	1.5	Chirukhistsqali
5	Chirukhistsqali	CR1	1.58	38	1.59	38	4.2	1.5	Chirukhistsqali
6	Skhalta River at Bridge	S4	3.17	62	2.46	48	5.1	1.9	Skhalta
7	Adjaristsqali River at road bridge to Skhalta (old arch bridge)	A6	6.05	-	-	-	-	-	Historical data not available at this location.
7	Adjaristsqali River at road bridge to Skhalta (old arch bridge)	A6	5.85	-	-	-	-	-	Historical data not available at this location.
7	Adjaristsqali River at road bridge to Skhalta (old arch bridge)	A6	6.21	-	-	-	-	-	- Historical data not available at this location.
8	Adjaristsqali River downstream of Didachara	UK1	1.66	24	1.59	23	6.9	2.0	Didachara Reservoir
9	Diakonezebi	UK1	0.15	-	0.51	-	-	-	Historical data not available at this location.
10	Didachara Reservoir (left tributary)	G1	2.50	72	0.64	18	3.5	1.0	It has been assumed that each tributary will be half the flow at Didachara Reservoir
10	Didachara Reservoir (left tributary)	G1	0.49	14		0	3.5	1.0	As above

	Location description	Nearest fish survey location (Figure 3.1)	Spot flows (m³/s) (Aug 2012)	2012 spot flow as % of historical annual average flow*	Spot flows (m³/s) (Jul 2013)	2013 spot flow as % of historical annual average flow*	Annual average flow (m³/s) - historical data*	August average flow (m³/s) - historical data*	Location of historical data
11	Didachara Reservoir (right tributary)	A1	1.88	54	2.24	65	3.5	1.0	As above
11	Didachara Reservoir (right tributary)	A1	0.76	22		0	3.5	1.0	As above
12	Downstream of weir site (22081204001) at upper map extent	-	1.58	-	-	-	-	-	Historical data not available at this location.
13	Adjaristsqali River upstream of confluence with Skhalta	A5	-	-	3.10	-	-	-	Historical data not available at this location.

3.2 Microhabitat analysis

Microhabitat analysis was carried out at a number of locations to inform and validate the mesohabitat analysis. Microhabitat analysis involves depth and velocity surveys, which were undertaken in 2012, 2013 and 2016 using Flowtracker (flow meter). The results of these surveys are presented in Figure 10 and Figure 11. The depth and velocity measurements were taken at approximately 30 random points at each survey site to characterize the depth and velocity range.

Surveys undertaken in 2016 only covered the Adjaristsqali and a couple of tributaries (Diakonidze and Ghorjamistsqali).

From a hydrological perspective, there is no clear relationship between depth and velocity. However, the aim of taking these measurements is to describe the microhabitats within each mesohabitat to check transferability and to validate the classification. Mesohabitat classifications are shown in Table 1.

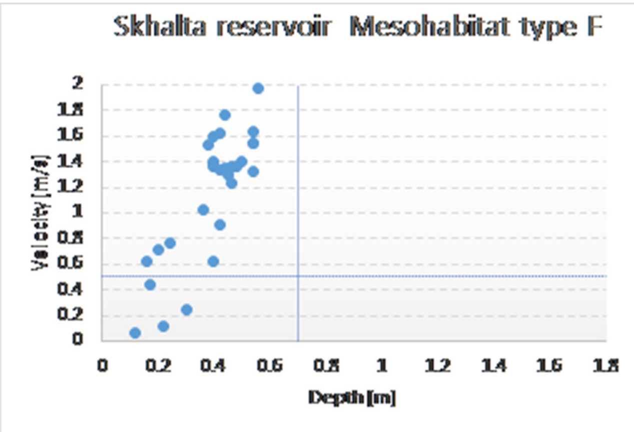
The mesohabitats recorded are mostly those with fast flowing/shallow microhabitats. The physical characteristics are:

- Surface velocity: >0.5m/s
- Water depth: <0.7m

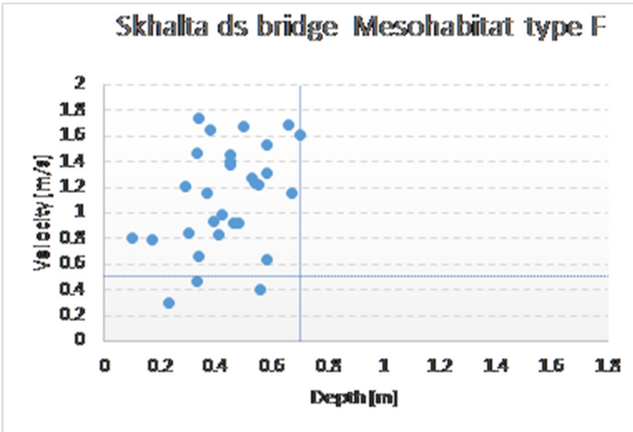
Although there is some variability within each habitat as expected, the microhabitat analysis results generally validate the habitat classification carried out on site in 2012, 2013 and 2016. In the B2 mesohabitat (during the 2012 surveys) the variability in this habitat suggests some overlap with the slower mesohabitat D. The same is observed in mesohabitat G2 with some overlap with H (see Table 1 for definitions).

Figure 10: Mesohabitats velocity and depth measurements in 2012, showing the depth and velocity boundaries (red line) for the fast flowing/shallow mesohabitat category.

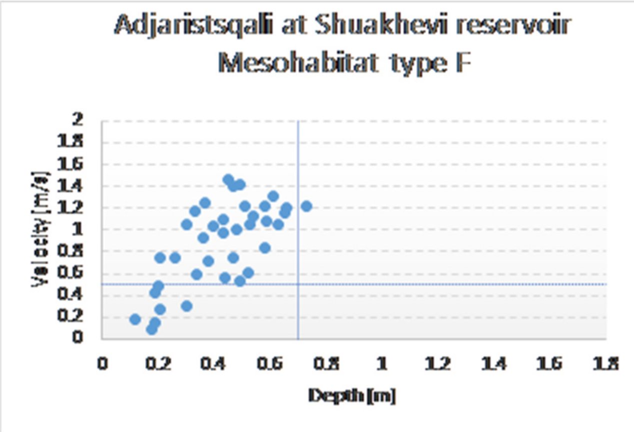
At the Skhalta dam site on the Skhalta River - Mesohabitat type F



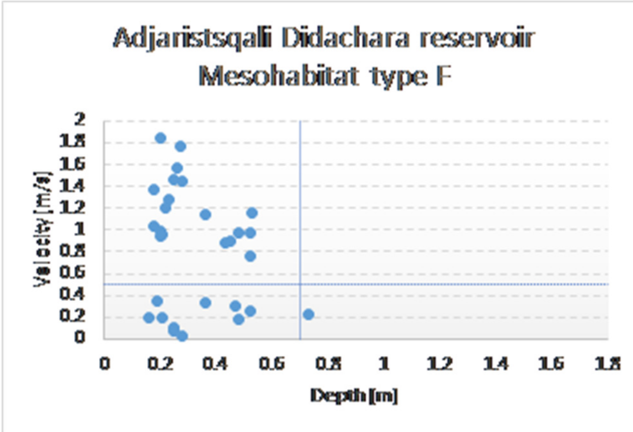
At Skhalta bridge on the Skhalta River - Mesohabitat type F



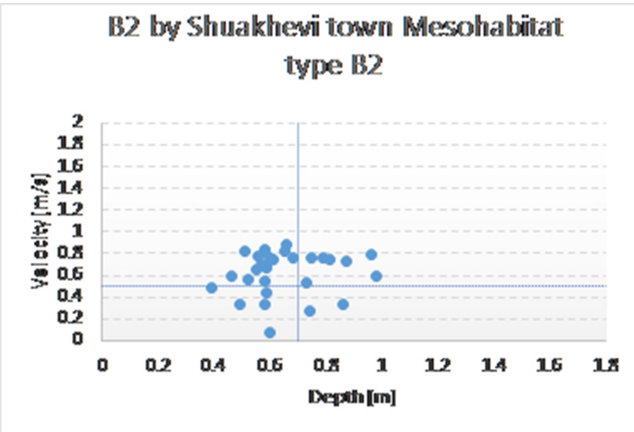
At the Shuakhevi HPP site on the Adjaristsqali River- Mesohabitat type F



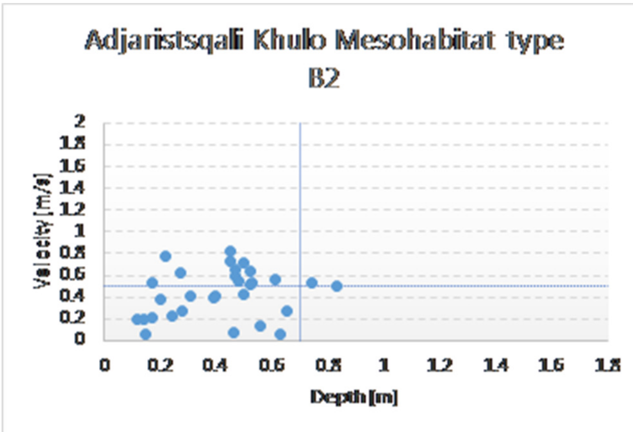
Downstream of the Didachara dam site on the Adjaristsqali River- Mesohabitat type F



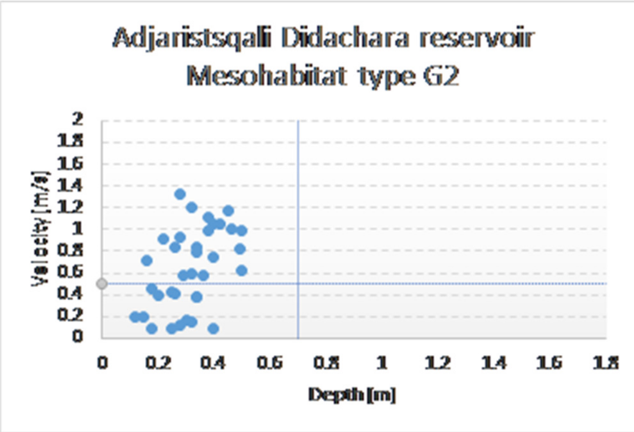
By Shuakhevi town in the Adjaristsqali River- Mesohabitat type B2



By Khulo on the Adjaristsqali River Mesohabitat type B2



At the Didachara dam site on the Adjaristsqali River –Mesohabitat type G2



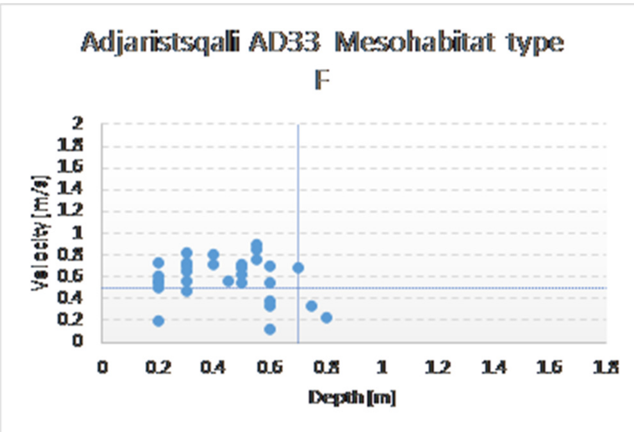
A- steep gradient/fast/deep
B1 - moderate gradiente/fast/deep
B2 - moderate gradient/fast/shallow
C - moderate gradient/slow/deep
D- moderate gradient/ slow/shallow
E- steep gradient/fast/deep
F- steep gradient/fast/shallow
G1 - moderate gradiente/fast/deep
G2 - moderate gradient/fast/shallow
H - moderate gradient/slow/shallow

During 2013, water depth and velocity were only measured at F habitats. Records were less variable with flow velocity almost always recorded below 0.5m/s consistent with slow mesohabitats. Water depth was consistent with shallower habitats and below 0.7m.

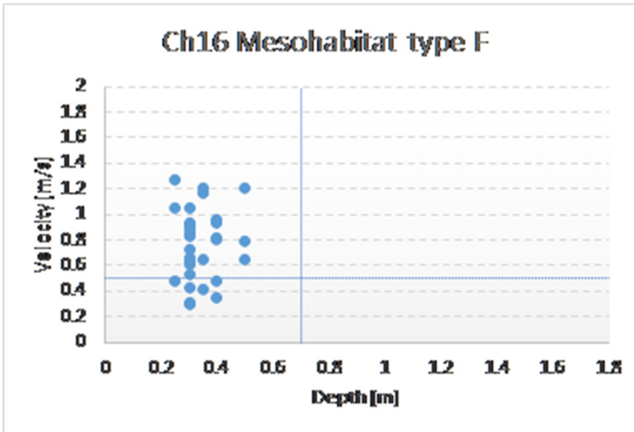
The 2012 and 2013 results suggest that in the tributaries, habitats are less variable within the same mesohabitat with flow velocity and depth recorded within a more constricted range. Conversely, flow and depth recorded values in the Adjaristsqali River within the F mesohabitat presented a greater variability. This is consistent as well with 2016 results. This will have consequences once flows are decreased in the rivers as a result of the Project. One likely impact will be the reduction of this variability. The classification of the mesohabitat would however remain the same. Results from the microhabitat analysis confirms the records from 2012 and 2013 and is presented in Figure 12.

Figure 11: Mesohabitats velocity and depth measurements in 2013

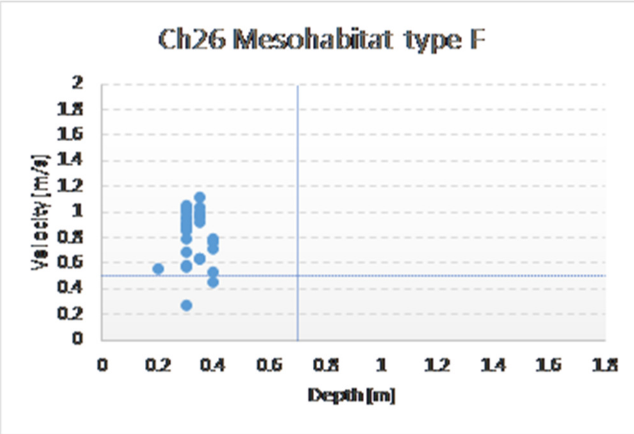
Velocity and depth, Adjaristsqali - Mesohabitat type F



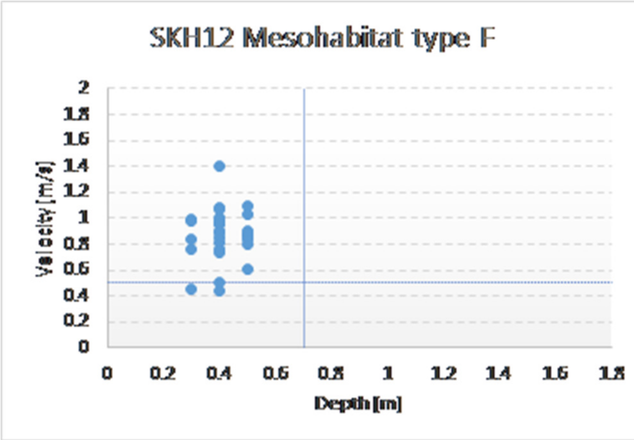
Velocity and depth, Chirukhistsqali (CH16) - Mesohabitat type F



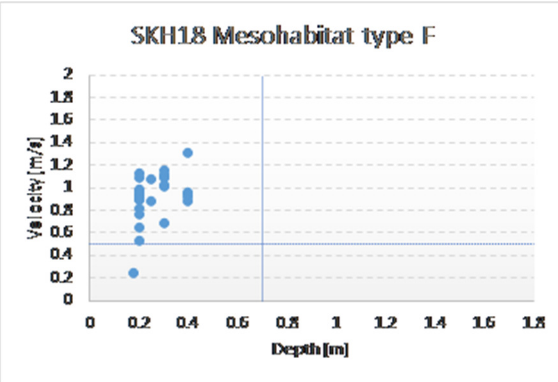
**Velocity and depth, Chirukhistsqali (CH25)
Mesohabitat type F**



**Velocity and depth, Skhalta (SKH12)
Mesohabitat type F**

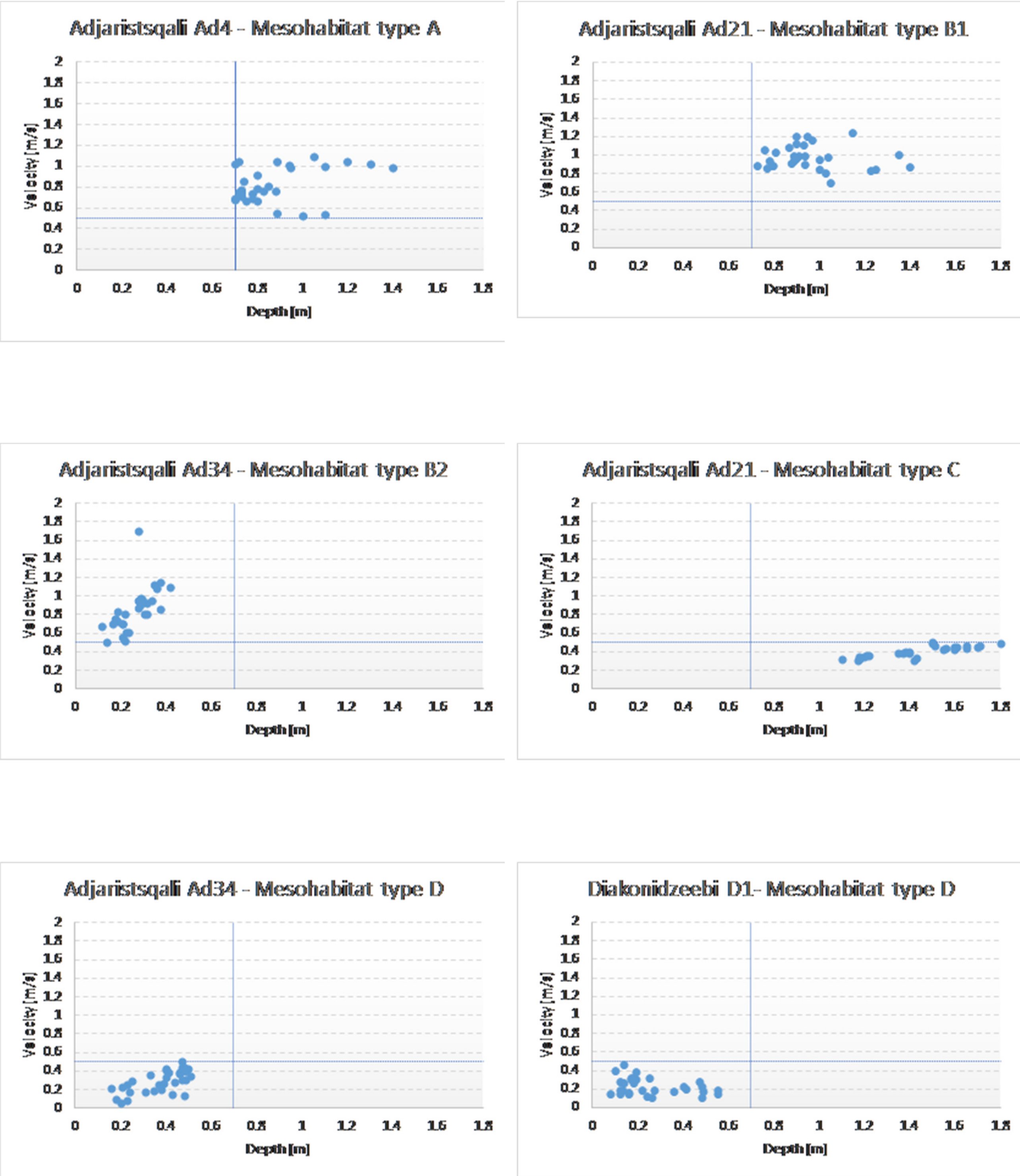


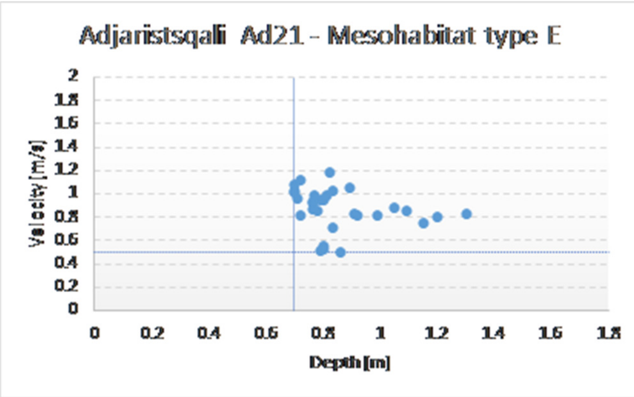
**Velocity and depth, Skhalta (SKH18)
Mesohabitat type F**

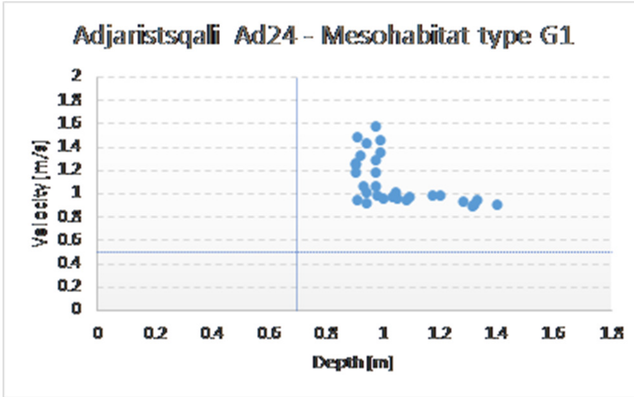


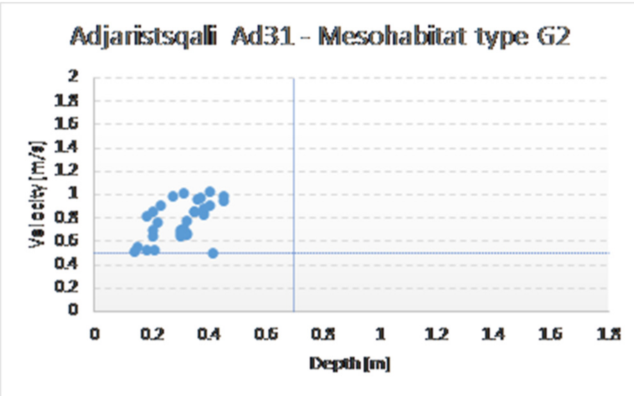
A- steep gradient/fast/deep
B1 - moderate gradiente/fast/deep
B2 - moderate gradient/fast/shallow
C - moderate gradient/slow/deep
D- moderate gradient/ slow/shallow
E- steep gradient/fast/deep
F- steep gradient/fast/shallow
G1 - moderate gradiente/fast/deep
G2 - moderate gradient/fast/shallow
H - moderate gradient/slow/shallow

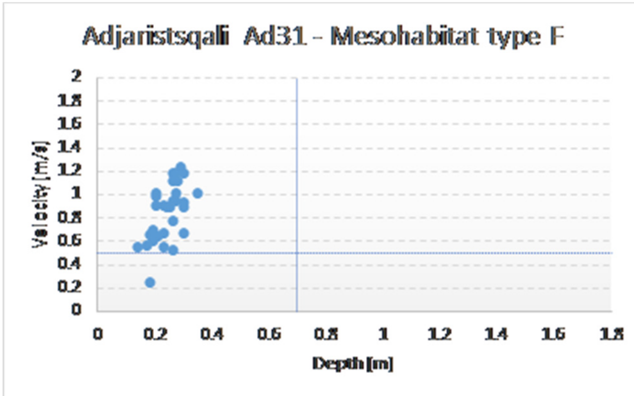
Figure 12: Mesohabitats velocity and depth measurements in 2016

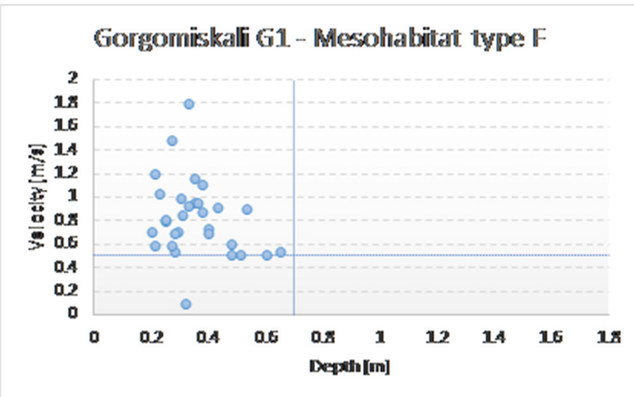


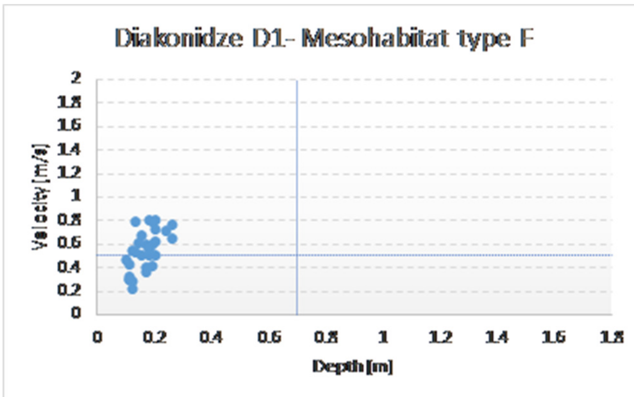

Adjaristsqali Ad21 - Mesohabitat type E
Velocity [m/s]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Depth [m]

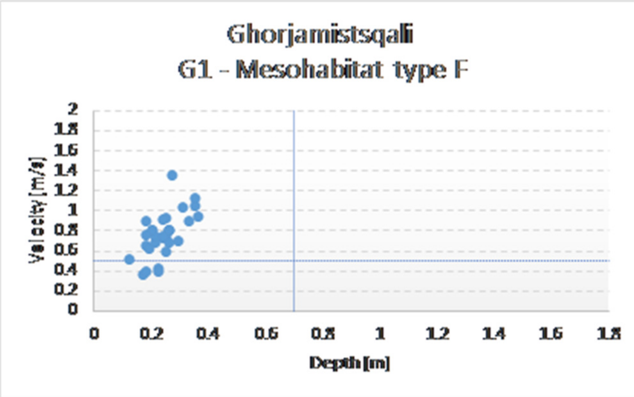

Adjaristsqali Ad24 - Mesohabitat type G1
Velocity [m/s]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Depth [m]

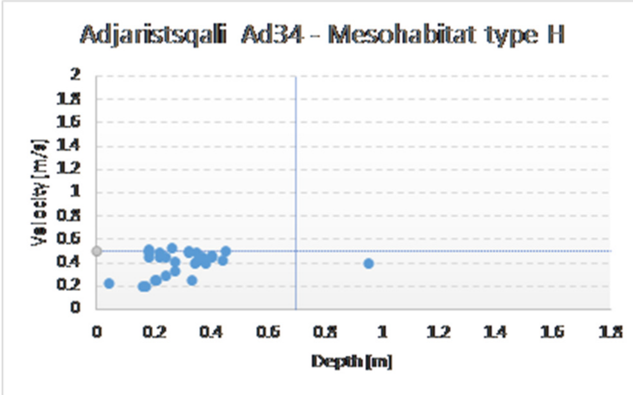

Adjaristsqali Ad31 - Mesohabitat type G2
Velocity [m/s]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Depth [m]


Adjaristsqali Ad31 - Mesohabitat type F
Velocity [m/s]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Depth [m]


Gorgomiskali G1 - Mesohabitat type F
Velocity [m/s]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Depth [m]


Diakonidze D1- Mesohabitat type F
Velocity [m/s]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Depth [m]





A- steep gradient/fast/deep

B1 - moderate gradient/fast/deep

B2 - moderate gradient/fast/shallow

C - moderate gradient/slow/deep

D- moderate gradient/ slow/shallow

E- steep gradient/fast/deep

F- steep gradient/fast/shallow

G1 - moderate gradient/fast/deep

G2 - moderate gradient/fast/shallow

H - moderate gradient/slow/shallow

3.3 Mesohabitat Analysis

3.3.1 Introduction

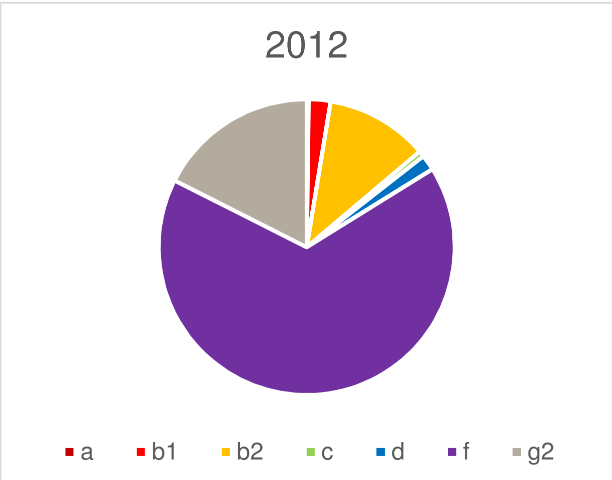
Mesohabitat surveys were carried out in late August 2012, late July/beginning of August 2013 and August 2016. A total of 50km of river length was surveyed in 2012 and 45km during the 2013 surveys. In 2016 only the Adjaristsqali River and two smaller tributaries were mapped. This was due to flow conditions not being suitable for all of the sampling period[3]. The flow conditions at the time of the surveys are summarised in Table 8.

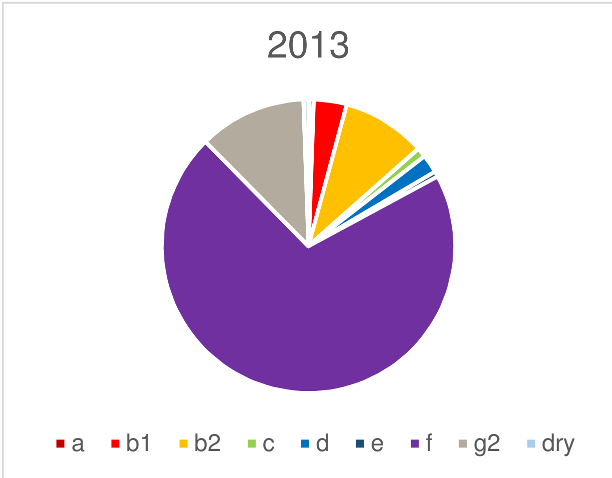
In total eight mesohabitats were recorded in all rivers during both 2012 and 2013. Mesohabitats G1 and H were not recorded in either the 2012 or 2013 surveys but were present in 2016 in the

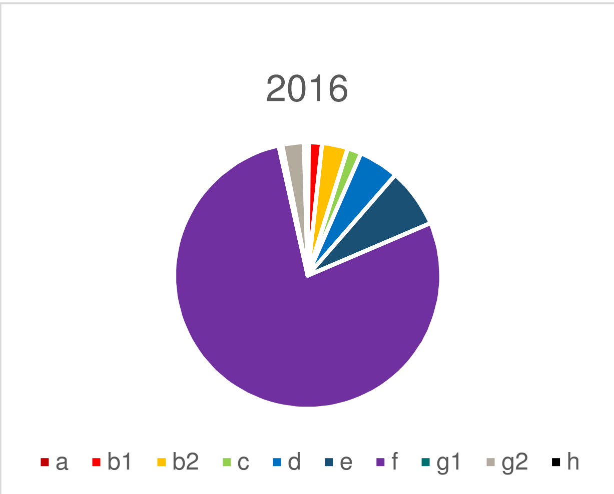
[3] The objective of the 2016 was to capture low flow conditions in the rivers influenced by the scheme. Conditions were appropriate (19% to 23% of the of historical annual average flow) when undertaking surveys in the Adjaristsqali River. Flows subsequently returned to higher levels before the survey effort could be expanded to the other river reaches (Skhalta and Chirustiskali Rivers).

Adjaristsqali River. Figure 13 shows the proportion of each habitat area as recorded during the 2012, 2013 and 2016 surveys over the whole survey area. However, it is important to note that the figure shown for 2016 does not represent the same area and therefore the values are not exactly comparable, but do provide an indication of the potential changes in the Adjara catchment as flows decrease.

Figure 13: Mesohabitats recorded in the study area in 2012, 2013 and 2016.







A- steep gradient/fast/deep
B1 - moderate gradient/fast/deep
B2 - moderate gradient/fast/shallow
C - moderate gradient/slow/deep
D- moderate gradient/ slow/shallow
E- steep gradient/fast/deep
F- steep gradient/fast/shallow
G1 - moderate gradient/fast/deep
G2 - moderate gradient/fast/shallow
H - moderate gradient/slow/shallow

Little change in habitats was recorded between 2012 and 2013. Mesohabitats F and G2 were dominant in both years with an increase in mesohabitats B1, D and E in 2013. There has been a bigger change in habitats between 2012/13 and 2016. The most noticeable is the continued increase in mesohabitat F and the decrease in G2 and B2. An increase in D and B2 mesohabitats has also been recorded in 2016.

Detailed analysis of the mesohabitats present in 2012, 2013 and 2016 is provided below. Data was analysed separately for the Adjara River, Skhalta and Chirukhistsqali Rivers. This allows identification of differences between the three rivers from 2012 and 2013 in terms of river habitats present.

Calculation of diversity indices was also carried out for each mesohabitat to understand the distribution of habitats among the three rivers. Two configuration metrics used in landscape ecology were also calculated to measure the spatial distribution of patterns in mesohabitats. The following indices were calculated:

- Shannon's diversity index (Shannon and Weaver, 1962)
- Simpson's index of diversity (Simpson, 1949)
- Li's and Reynolds' contagion index (Li & Reynolds, 1993)
- O'Neill's dominance index (O'Neill et al., 1988)

Li's and Reynolds' contagion index describes how fragmented the distribution of mesohabitats is, while O'Neill's dominance index expresses if one or more mesohabitat types dominate the patch landscape. These indices are described in detail in Appendix B. The results of the indices are presented in Figure 14 and discussed in the following sections.

Figure 14: Diversity and configurations indices results

*ds = downstream

3.3.2 Mesohabitats in the Adjaristsqali River

Mesohabitats in the Adjaristsqali River were analysed in two sections:

1. Upstream section, from Didachara to the confluence with Skhalta River
2. Downstream of the confluence with Skhalta River as far as the proposed location for the Shuakhevi Powerhouse

Approximately 23.5km of river was surveyed in 2012 and 2013 of a total of 40km (upstream of the Shuakhevi Power station location). In 2016 mesohabitats in the Adjaristsqali River were analysed in the same two sections with the addition of approximately 2km of the Diakonidze River and 2km of the Ghorjamistsqali River.

Downstream of the Didachara dam section (as far as the confluence with the Skhalta River), mesohabitats were dominated by shallow and fast flowing habitats in 2012 (F, G2 and B2) which covered approximately 75% of the river area. B1 was also recorded in 2012 indicating the presence of deeper areas. In 2013 a significant increase in G2 extent (area of mesohabitat recorded during surveys) was recorded, most likely replacing mesohabitats B1 and B2 (Figure 15). In 2013, habitats characterized by slower surface velocity (C and D) were present but with very low coverage.

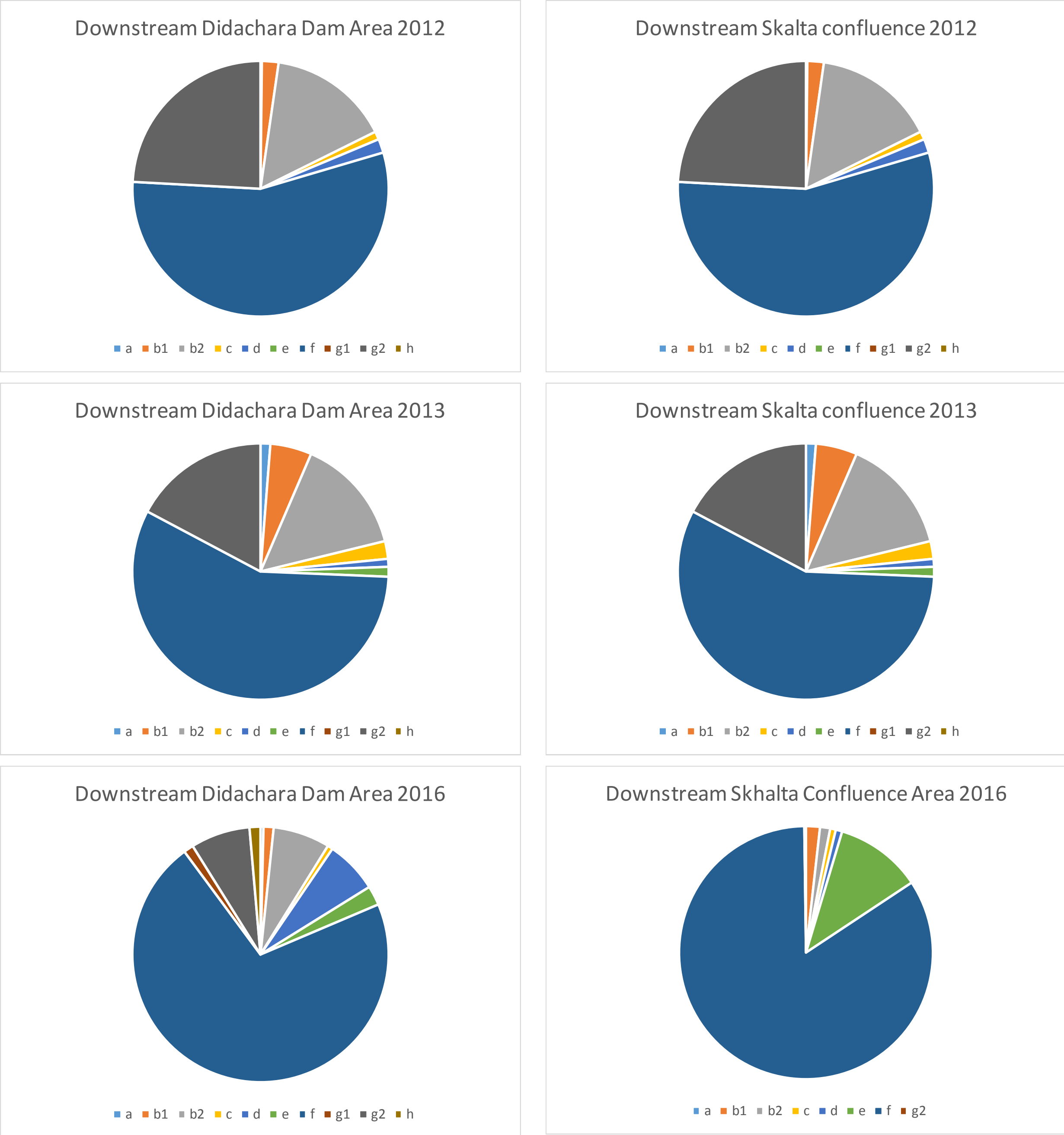
Downstream of the confluence with the Skhalta River, although mesohabitats were also dominated by F, G2 and B2, the coverage of less representative habitats was higher compared with the Adjaristsqali River section, upstream of the confluence with the Skhalta River (downstream of Didachara Dam). This indicates greater habitat diversity in this section of the river.

In 2016, both upstream and downstream of the confluence with the Skhalta River the dominant mesohabitat was F (shallow and fast flowing) as in previous years. Mesohabitat F covered approximately 84% of the river area downstream and 71% of the river area upstream. Upstream, mesohabitats G2 and B2 each covered approximately 7% of the river area, indicating further shallow fast flowing reaches. Downstream, mesohabitat E covered approximately 11% of the river area, indicating areas of deep fast flowing habitats.

All ten mesohabitats occurred upstream of the confluence with the Skhalta River in 2016, indicating an increase in habitat variability. This is represented by the number of habitats recorded in 2016 in this section of the river compared with 2012 and 2013. The Shannon-Wiener and Simpson diversity indices however indicate that habitat diversity in the river decreases as flows decrease. The new mesohabitats recorded in 2016 (specifically mesohabitat H, (slow and shallow) reflect a decrease in water levels as well as the flow velocity expected under lower flow conditions.

The observed increase in the O'Neil index reflects the increased dominance of F mesohabitats both upstream and downstream of the Skhalta River confluence. The decrease in the Li and Reynolds contagious index downstream of the Skhalta confluence suggests a decrease in habitat fragmentation.

Figure 15: Area of different mesohabitats recorded in the Adjaristsqali River in 2012, 2013 and 2016



The results of the diversity indices (Figure 14) confirm the mesohabitat survey results pointing to a similar situation in both 2012 and 2013. 2013 results suggest slightly higher dominance of F and G2 habitats as well as slightly higher “clumpiness” in mesohabitat distribution.

At the Didachara Dam location and along the future inundation area of the reservoir, mesohabitats were also dominated by fast flowing types (Photo 1) These will be permanently lost once the dam is built and the reservoir is in operation. The mesohabitat diversity and dominance in these reaches was similar in upstream and downstream reaches. It is not considered that key habitats will be lost with the construction of the Project that are not represented elsewhere in the Adjaristsqali River. Photo 1 shows the dam and reservoir sites during the 2012 mesohabitat surveys.

In 2016 an analysis of the presence of sensitive habitats to fish was also carried out along with mesohabitats surveys. The presence of spawning, feeding, growing and migratory route areas was identified along with mesohabitats in the Adjaristsqali River. Migratory routes were also recorded along the surveyed section in 2016 and identified in mesohabitats B1, E and F. Very few growing areas and a limited number of spawning areas were identified in mesohabitat F. The spawning habitats identified are described in section 3.4.4 of this report. Feeding areas were associated with mesohabitats F and E.

Upstream tributaries also mapped during 2016 showed less diversity, particularly the Diakonidze River where only mesohabitats C, E and F were recorded. The Ghorjamistsqali River presented more diversity however both rivers were dominated by F mesohabitats.

Photo 1: Didachara Dam location

Within the Didachara Dam footprint

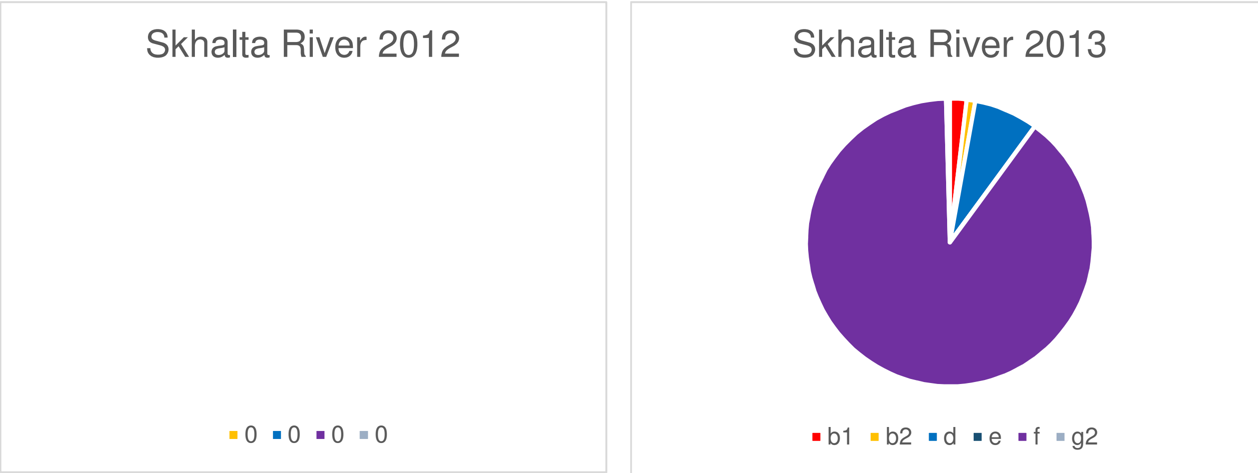
Within the reservoir inundation area

3.3.3 Skhalta River

The Skhalta River runs for approximately 26km. During the 2012 surveys 12.5km were surveyed while in 2013 a total of 15km were surveyed. The area surveyed (in both years) included the future dam and reservoir footprints and reaches downstream.

In the Skhalta River, mesohabitats were less diverse compared to the Adjaristsqali River, but were also dominated by the faster habitat type F. Habitat B2 (smooth, fast and shallow) was recorded both in 2012 and 2013; however, its extent decreased in 2013. Conversely habitat D (smooth, slow, and shallow) increased in area from 2012 to 2013 (Figure 16).

Figure 16: Area of different mesohabitats recorded in Skhalta River in 2012 and 2013



The diversity indices confirm the mesohabitat survey results; habitat diversity was lowest in the Skhalta River compared with the Chirukhistsqali and Adjaristsqali rivers, and decreased slightly from 2012 to 2013. This reflects both the higher dominance of some mesohabitats types such as D as well as the absence of mesohabitat B1.

Mesohabitats in the footprint of the Skhalta Dam and the reservoir were dominated by type F. Just downstream of the dam there is a braided reach also dominated by type F.

Photo 2: Skhalta Dam location

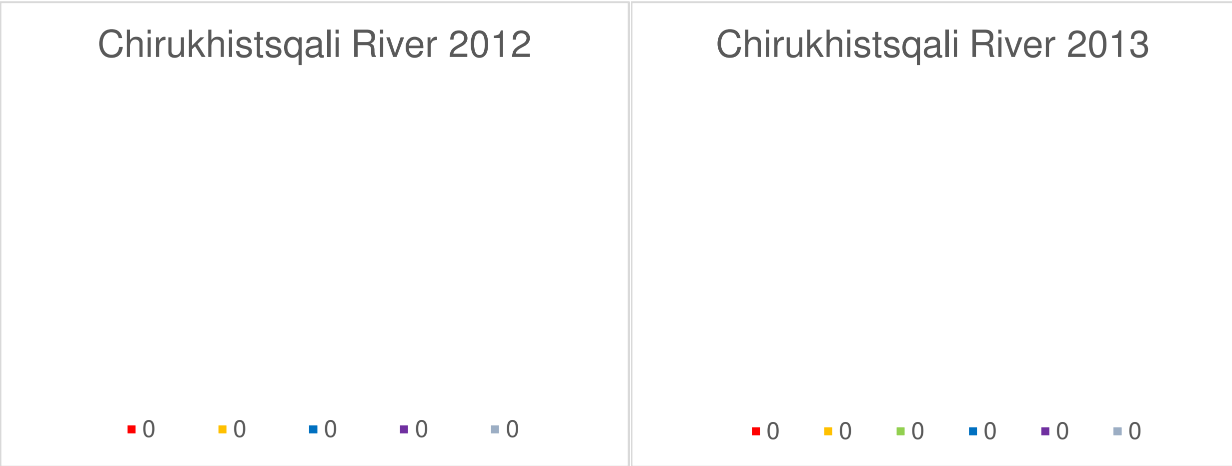
Just downstream of the Skhalta Dam footprint (2013)

Within the reservoir inundation area (2013), habitat within the dam footprint is very similar

3.3.4 Chirukhistsqali River

The total length of the Chirukhistsqali River is approximately 35km, of which 14km were surveyed in 2012 and 7km in 2013. The area surveyed included the future dam and reservoir footprints and reaches downstream. The mesohabitat survey results on the Chirukhistsqali River showed similar results to Skhalta; however, mesohabitat G2 was present in both 2012 and 2013 (see Figure 17). From 2012 to 2013 an increase in B2 habitat area was recorded. Mesohabitat F decreased slightly, suggesting an increase in slower habitats but with dominance of faster habitats (types F and G2).

Figure 17: Mesohabitats recorded in Chirukhistsqali River in 2012 and 2013



Within the dam footprint, mesohabitat F was recorded in 2012 and 2013 surveys.

In the Chirukhistsqali River, habitat diversity was higher than in the Skhalta River, with slightly less dominance from mesohabitat type F. Photo 3 shows the Chirukhistsqali at the confluence with the Modulistsqali and Adjaristsqali rivers.

Photo 3: Chirukhistsqali Dam location

At the confluence with Modulistsqali River

At the confluence with Adjaristsqali River

3.4 Fish Surveys

3.4.1 Overview

Fish surveys were carried out between 2012-2016 by Association of Flora and Fauna and the independent consultant Dr. Rezo Goradze, with results presented in a series of reports. During the 2012 and 2013 fish surveys, mesohabitat surveys were undertaken in parallel by Dr. Rezo Goradze.

A total of 17 species were found in the Adjaristsqali River basin during the surveys. Two of these species were not recorded in the Project area (Eel and Colchic minnow). Table 9 shows the distribution of fish species found across the Adjaristsqali, Chirukhistsqali and Skhalta Rivers and in smaller tributaries.

Black Sea salmon *Salmo labrax pallas* is endemic to the Black Sea's basin and included on Georgia's Red list (Status - Endangered).

The Black Sea salmon is considered to be a sub-species of the European trout. It is similar to the sea trout of NW Europe as it migrates to sea to feed and returns to freshwater to spawn. Resident trout populations are reported in the most upstream reaches of the Adjaristsqali catchment. The Black Sea salmon and freshwater trout, where they live together they form a single freely inter-breeding population (Solomon *et al*., 2000). This is now believed to be the non-migrating ecotype. Recently the classification of two subspecies has been revised and the two ecotypes are denominated as[4]:

- The Black Sea salmon *Salmo labrax pallas*
- The Black Sea trout [5]*Salmo labrax fario*

This is the nomenclature followed in this report. The Black Sea trout (*fario* ecotype) presents seasonal migration in freshwater but does not migrate to sea. Before smoltification every Black Sea salmon individual presents the same behaviour with no clear differences between the two different ecotypes. The reason for which some of the juveniles undergo migration to the sea while others do not remain unclear (Aksungur *et al*., 2011). Most likely the key difference lies in the physiology characteristics with the migrating Black Sea salmon undergoing physiological changes to be able to adapt to the marine environment.

Historically, the Adjaristsqali River and tributaries have been used by spawning Black Sea salmon (*Salmo labrax pallas*), and they were recorded in 2013 by Association of Flora and Fauna in the lower sections of the Adjaristsqali River and in the Akavreta River. None were recorded within the Shuakhevi Project area. The presence of the Atsi dam in the Adjaristsqali River could act as a barrier to fish migration and may explain why this species has not been recorded in most upstream reaches of the Adjaristsqali River and its tributaries, in recent years.

Table 9 Fish species distribution in the Adjaristsqali river basin recorded between 2012 – 2016

Species	Conservation Status	Adjaristsqali	Chirukhistsqali	Skhalta
Anguilla anguilla Eel	**IUCN Red List status: Critically Endangered**	✓[1]	**-**	**-**
Alburnus derjugini Colchic Shemaia	-	✓	-	-
Alburnoides fasciatus Transcaucasian spirlin	Endemic to the Kolkheti region; IUCN Red List status: Least Concern	✓	✓	✓
Barbus mursa Mursa	IUCN Red List status: Least Concern	✓	-	✓
Capoeta sieboldii Colchic Kramulya	IUCN Red List status: Least Concern	✓	✓	-

[4] Source: Black Sea Monitoring Agency, personal communication

[5] Common name 'freshwater trout'.

	Endemic to the Kolkheti region;			
Capoeta tinca Anatolian Kramulya	IUCN Red List status: Least Concern Endemic to the Kolcheti-Anatolian region	✓	✓	✓
Chondrostoma colchicum Colchic nase	IUCN Red List status: Least Concern Endemic to the Kolkheti region	✓	✓	✓
Cobitis satunini Transcaucasian loach	**IUCN Red List status: Least Concern**	✓	-	-
Gobio lepidolaemus caucasica Caucasian gudgeon	-	✓	✓	✓
Luciobarbus escherichii Colchic barbel	IUCN Red List status: Least Concern Endemic to the Kolcheti-Anatolian region	✓	✓	✓
Oncorhynchus mykiss Rainbow trout	Invasive, stocked fish species	✓	✓	-
Oxynoemacheilus angorae Angora/Sakarya loach	IUCN Red List: Least Concern **Endemic to the Kolcheti-Anatolian region**	✓	✓	✓
Phoxinus colchicus Colchic minnow	Endemic to the Kolkheti region; IUCN Red List status: Least Concern	✓[1]	-	-
Ponticola constructor Caucasian goby	IUCN Red List status: Least Concern	✓	✓	✓
Rutilus rutilus Common roach	IUCN Red List status: Least Concern	✓	-	✓
Salmo labrax fario Trout	Georgia Red List: Vulnerable IUCN Red List: Least Concern	✓	✓	✓
Squalius cephalus Chub	IUCN Red List status: Least Concern	✓	✓	✓
Total		18	11	12

Note: 1 – not recorded within the Shuakhevi Project area

Trout (*Salmo labrax fario*) was found in all three rivers from 2012 to 2016.

Rainbow trout (*Oncorhynchus mykiss*) is an invasive species and bred for fish farming in the area. They were found in both the Adjaristsqali and Chirukhistsqali rivers in 2013 and 2016 only. Chub (*Squalius cephalus*), Colchic nase (*Chondrostoma colchicum*), Caucasian gudgeon (*Gobio lepidolaemis*), Colchic barbel (*Luciobarbus escherichii*), Transcaucasian spirlin (*Alburnoides fasciatus*), Angora loach (*Oxynoemacheilus angorae*) and Caucasian goby (*Ponticola constructor*) were found in all three rivers and are widespread in the region.

Colchic minnow (*Phoxinus colchicus*) was only found in the Adjaristsqali River near the town of Keda in 2013 (not in the Project area). Colchic khramulya (*Capoeta sieboldii*) were widespread in the Adjaristsqali River, and also found in the Chirukhistsqali River. This species was recorded in 2013 and again in 2014 and 2015.

Anatolian khramulya (*Capoeta tinca*) were recorded in Georgia only in the Chorokhi River basin. They were found in all three rivers. Colchic shemaia (*Alburnus derjugini*) was found only in the Adjaristsqali River from the source of the Chorokhi to the town of Keda.

Transcaucasian loach (*Cobitis satunini*) was found only in the Adjaristsqali River from the mouth of the Chorokhi to the town of Keda; European eel (*Anguilla anguilla*) was found only in the Adjaristsqali River in 2013, in the vicinity of Keda. They were not recorded in the Shuakhevi Project area.

A summary of all species recorded during the survey years 2012 to 2016 is provided in Table 10.

Table 10 Fish species recorded from surveys between 2012 - 2016

Species	2012	2013	2014	2015	2016
Alburnus derjugini Colchic Shemaia	-	√	-	-	-
Alburnoides fasciatus Transcaucasian spirlin	-	√	-	√	√
Anguilla anguilla Eel	-	√[1]	-	-	-
Barbus mursa Mursa	√	√	√	-	-
Capoeta sieboldii Colchic Kramulya	√	√	√	√	√
Capoeta tinca Anatolian Kramulya	√	√	-	√	√
Chondrostoma colchicum Colchic nase	√	√	√	√	√
Cobitis satunini Transcaucasian loach	√	√	-	-	-
Gobio lepidolaemus caucasica Caucasian gudgeon	√	√	-	√	√
Luciobarbus escherichii Colchic barbel	-	√	-	√	√
Oncorhynchus mykiss Rainbow trout	-	√	-	-	√
Oxynoemacheilus angorae Angora/Sakarya loach	-	√	√	-	-
Phoxinus colchicus Colchic minnow	-	√[1]	-	-	-
Ponticola constructor Caucasian goby	-	√	-	√	√
Salmo labrax fario Trout	√	√	√	√	√
Squalius cephalus Chub	√	√	√	-	-

Species	2012	2013	2014	2015	2016
Rutilus rutilus Common roach	√	√	√	-	-

Note: 1 – not recorded within the Shuakhevi Project area

The distribution of fish species in the Adjara catchment is described below in Section 3.4.2.

3.4.2 Fish species distribution

This section presents the results of the fish surveys carried out between 2012 and 2016. During 2012 and 2013 the surveys were carried out simultaneously with the mesohabitat surveys.

3.4.2.1 Adjaristsqali River

A total of 15 species were recorded in the Adjaristsqali River between 2012 and 2013. However, the maximum number of species recorded in any year was ten (in 2012). The number of species recorded was fairly constant during the sampling period (between seven and ten). Table 11 shows the distribution of the species in the Adjaristsqali River (R – restricted distribution; W- wide distribution).

The fish community is dominated by cyprinid species: Transcaucasian spirlin, colchic barbel, Anatolian kramulya, and chub. Although with a restricted distribution the species colchic kramulya and colchic nase were present all years. Both species are endemic to the Kolkheti region.

The trout was only recorded in 2016 (winter and spring). The species Caucasian goby was recorded in 2015 and found widely distributed in the Adjaristsqali River (within the area sampled) but was not recorded in any other years. As well, common roach was recorded only during the first years of the monitoring programme (2012, 2013 and 2014) albeit with a very restricted distribution. No Black Sea salmon were recorded in any year.

Most of the sites along the Adjaristsqali were 'F' habitats: shallow water with a fast surface velocity with broken or unbroken standing waves and steep surface gradient.

Table 11 Fish distribution and presence in surveys 2012-2016

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016 Sp
Alburnoides fasciatus			R	W	W	W	W	W	W
Luciobarbus escherichii	W	W	W	W	W	W	W	W	W
Barbus mursa	R	R	R						
Capoeta tinca	R	R		W	W	W	W	R	R
Capoeta sieboldii	W	R	R	R	R	R	R		R
Chondrostoma colchicum	R	R	W	W	R	R	R	R	R
Cobitis satunini	R								
Gobio lepidolaemus caucasica	R	R		R	R	R	R	R	R
Ponticola constructor				W	W	W			R
Oxynoemacheilus angorae	R								
Oncorhynchus mykiss								R	
Rutilus rutilus	R	R	R						

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016 Sp
Salmo labrax fario								R	R
Squalius cephalus	R	R	R	W	W	W	R	W	R
Total number of species	10	8	7	8	8	8	7	8	9

Wi = winter, Sp = spring, Su = Summer

R – restricted distribution; W- wide distribution

Sensitive areas have been reported during the summer 2016 mesohabitat surveys and are illustrated in Appendix A. A description is further provided in Table 12 along with the location and mesohabitat where they have been recorded. Spawning areas for Colchic nase, common roach and chub have been recorded throughout the length of the Adjaristsqali river up to Adj 14; From this section upstream spawning habitats for the species Transcaucasian spirlin, colchic kramulya (both endemic to the Kolkheti region) and colchic barbel (endemic to Russia) were also recorded. The two areas of spawning habitat do not seem to overlap.

Upstream and downstream of the Diakonidze confluence at the Didachara dam location, spawning habitat for trout (*Salmo labrax fario*) was found, this section is also reported as a migratory route for this species (as well in some reaches in the Diakonidze River).

Table 12 Sensitive habitats in the Adjaristsqali River and two tributaries

Location of sensitive areas for fish populations	Type of habitats (mesohabitat type)	Species	Mesohabitat Map-sheet number (See Appendix A)
Adjaristsqali River			
Confluence of Adjaristskali/ Chvanistskali rivers	Spawning habitat	*Chondrostoma colchicum*, *Rutilus rutilus* and *Squalius cephalus*	Ad 2
Upstream of Chvanistskali confluence	Spawning habitat	*Chondrostoma colchicum*, *Rutilus rutilus* and *Squalius cephalus*	Ad 4
Upstream and downstream of Shuakhevi Power House	Spawning habitat	*Chondrostoma colchicum* and *Capoeta sieboldii*	Ad 5
Upstream of Shuakhevi Power House	Spawning habitat	*Chondrostoma colchicum*, *Rutilus rutilus* and *Capoeta sieboldii*	Ad 7
Upstream of the Chirukhistsqali confluence	Spawning habitat	*Chondrostoma colchicum*, *Rutilus rutilus* and *Capoeta sieboldii*	Ad 9
Upstream of the Chirukhistsqali confluence	Spawning habitat	*Chondrostoma colchicum*, *Rutilus rutilus* and *Capoeta sieboldii*	Ad 11/Ad 12
Rocky canyon	Spawning habitat	*Luciobarbus escherichii*	Ad 14
Upstream Rocky canyon	Spawning habitat	*Luciobarbus escherichii*	Ad 15, Ad 16, Ad 17, Ad18
Downstream from the confluence of Skhalta	Spawning habitat	*Alburnoides fasciatus*, *Capoeta sieboldii* and *Luciobarbus escherichii*	Ad 19
Downstream and upstream from the confluence of Skhalta	Spawning habitat	*Alburnoides fasciatus*, *Capoeta sieboldii* and *Luciobarbus escherichii*	Ad 21
Upstream from the confluence of Skhalta	Spawning habitat	*Alburnoides fasciatus*, *Capoeta sieboldii* and *Luciobarbus escherichii*	Ad 23,Ad 24

Location of sensitive areas for fish populations	Type of habitats (mesohabitat type)	Species	Mesohabitat Map-sheet number (See Appendix A)
Upstream and downstream of the Chao Bridge	Spawning habitat	*Luciobarbus escherichii*	Ad 25/Ad 26
Upstream of the Chao Bridge	Spawning habitat	Spawning area for *Luciobarbus escherichii*	Ad 27, Ad 2
Upstream and downstream of the Tago Bridge	Spawning habitat	Spawning area for *Luciobarbus escherichii*	Ad 29, Ad 30
Upstream and downstream of the bridge Elelidzeebi	Spawning habitat	Spawning and growing areas for *Luciobarbus escherichii*	Ad 31,Ad 32
Upstream and downstream of the confluence Diakonidzeebi	Spawning habitat Migration route	*Salmo labrax fario*	Ad 33,Ad 34
Didachara dam	Migration route	*Salmo labrax fario* and *Luciobarbus escherichii*	Ad 35,Ad 36
Ghorjomi River			
Upstream of the bridge Ghorjomi	Migration route	*Salmo labrax fario*	Ch 1,Ch 2
	Spawning area	*Luciobarbus escherichii*	Ch 1,Ch 2
Upstream of the river Ghorjomi	Spawning and growing areas	*Luciobarbus escherichii*	Ch 3
	Migration ways	*Salmo labrax fario*	Ch 3
Diakonidzeebi River			
Upstream of the bridge-Uchkhostskali (village Diakonidzeebi)	Spawning area	*Luciobarbus escherichii*	Dia 1
Confluence of Diakonidzeebi with Adjaristskali	Migration route and growing area	*Salmo labrax fario*	Dia 2
	Spawning habitat	*Luciobarbus escherichii*	Dia 2
Up to the village Uchkho	Migration route, spawning and growing habitats	*Salmo labrax fario*	Dia 3

3.4.3 Skhalta River

Table 13 shows the presence and distribution of fish species in the Skhalta River from 2012 to 2016.

Three species were recorded in 2012 and six in 2013 and three in 2014 (highest diversity recorded during the duration of the sampling period). This includes the species Anatolian kramulya and colchic nase (which are both endemic to the Kolkheti region). From 2015 a sharp decrease in diversity was recorded with trout and chub being the only species recorded during 2015 and 2016. Trout is a salmonid species and sensitive to changes in flows and water quality particularly sediments in suspension. The very low numbers recorded is also relevant (one or two specimens per survey). For this reason, the change in diversity with species recorded before (particularly colchic barbel) could indicate that this change may not be necessarily linked with the construction of the Project. However, changes in the sites' characteristics have been reported by the surveyors during site construction. These include riverbed and bank modifications, narrowing of the channel and changes in mesohabitats (affecting sampling sites from S1 to S4 sampling sites).

Site S4 had the greatest abundance of fish in 2012 and site S2 in 2013. Abundance in 2012 at S4 was a lot higher than for all other sampling occasions. Colchic barbel was the most frequently species occurring in both years of surveys between 2012 and 2016.

All Skhalta sites were ‘F’ habitats: shallow water with a fast surface velocity with broken or unbroken standing waves and steep surface gradient (during 2012 and 2013 surveys).

Table 13 Fish distribution and presence in surveys 2012-2016 in Skhalta River

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016 sp
Alburnoides fasciatus			+						
Luciobarbus escherichii	+	+	+	+				+	
Barbus mursa		+							
Capoeta tinca		+							
Capoeta sieboldii		+							
Cobitis satunini	+								
Chondrostoma colchicum		+							
Nemacheilus angorae			+						
Rutilus rutilus	+	+	+	+					
Salmo labrax fario				+	+	+	+		+
Total	3	6	4	3	1	1	1	1	1

3.4.3.1 Chirukhistsqali River

Six species were recorded in the Chirukhistsqali River during the monitoring period: colchic kramulya, colchic barbel, Transcaucasian spirlin and trout. All sites along the Chirukhistsqali were ‘F’ habitats: shallow water with a fast surface velocity with broken or unbroken standing waves and steep surface gradient. Downstream reaches of this river are more diverse (based on 2015/2016 data, where a higher number of species was recorded at site 9 (Figure 1).

Black sea trout was present in almost all years but absent in 2012 and from some catches in 2015 (spring and winter and in 2016 (winter). These populations are most likely resident to the Chirukhistsqali River as no trout were found on the Adjaristsqali River during the mesohabitat and fish surveys. The Association of Flora and Fauna (2013) refer to the presence of trout in the Adjaristsqali River reporting that this species is mainly spread throughout the Adjaristsqali River’s tributaries. It is possible that genetic exchange occurs between the tributary populations (a genetic test could confirm this). In this case the alteration to flows imposed by the Chirukhistsqali weir has the potential to isolate populations. However, it is also possible that trout migrate in the river at higher flows (most likely) and in this case the populations would not be isolated.

Table 14 Fish distribution and presence in surveys 2012-2016 in Chirukhistsqali River

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016 sp
Alburnoides fasciatus	+					+	+	+	+

Fish species	2012	2013	2014	2015Wi	2015Sp	2015Su	2015Au	2016Wi	2016sp
Luciobarbus escherichii	+	+	+	+	+	+	+	+	+
Gobio lepidolaemus caucasica				+					+
Ponticola constructor				+					+
Salmo labrax fario		+	+			+	+		+
Squalius cephalus						+			
Total number of species	2	2	2	3	1	4	3	2	5

3.4.3.2 Tributaries

During the monitoring period surveys have been carried out in a few tributaries:

- Ghorjamistsqali River - tributary of the Adjaristsqali River
- Uchkotsqali River - tributary of the Adjaristsqali River
- Chvanistslcali - tributary of the Adjaristsqali River
- Heva Rive - tributary of the Adjaristsqali River
- Uchambistskali River (tributary of the Chirukhistsqali River)

However, these were not consistent in each year. In addition, different teams have carried out the surveys and different methods may have been used, so data comaprison needs to be carried out with caution. The diversity of the tributaries' fish community is generally very small and comparable to Skhalta and Chirukhistsqali Rivers. Between one to seven species were recorded in the different rivers.

Of the tributaries monitored the species Transcaucasian spirlin is only present in the Tsvanistskali River, a tributary of the Adjaristsqali River. Colchic barbel was recorded in most tributaries.

Trout was recorded in a number of tributaries: Uchambistskali, Gorjomistskali, Heva, Tsvanistskali and Keda Rivers although not in consecutive years. The data suggest that the trout is present in Adjaristsqali River tributaries but not in the Adjaristsqali itself.

The species colchic kramulya and Anatolian kramulya, both endemic to the Kolkheti region are present in some tributaries including the Tsvanistskali River (Anatolian kramulya), the Uchambistskali and Keda Rivers (colchic kramulya).

Table 15 Fish distribution and presence in surveys 2012-2016 in Tributaries

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016sp
Alburnoides fasciatus				Tsv	Tsv		Tsv	Tsv	Tsv

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016sp
Luciobarbus escherichii	UK G	G UM K CHE	UK G	Tsv	Tsv	Gor	Tsv	Tsv	Tsv
Capoeta tinca				Tsv	Tsv				
Capoeta sieboldii		K UM							
Cobitis satunini				Tsv					
Gobio lepidolaemus caucasica					Tsv				
Ponticola constructor					Tsv				
Rutilus rutilus		K UM							
Salmo labrax fario	UM H	TS H			G		G		
Squalius cephalus			UM H UK		Tsv		Tsv		
Total number of species UK	1		2						
Total number of species Gor	1	1	1		1	1	1		
Total number of species UM	1	3	1						
Total number of species K	2								
Total number of species TS		1							
Total number of species H		1	1						
Total number				4	6		3	2	2

Fish species	2012	2013	2014	2015 Wi	2015 Sp	2015 Su	2015 Au	2016 Wi	2016sp
of species Tsv									

Note: UM- Uchambistskali; Tsv – Tsvanistskali; Gor- Gorjomistskali; Che – Chvanistslcali; H – Heva; K- Keda; UK – Uchkotsqali.

3.4.4 Spawning areas

Table 16 lists fish species that spawn in the Adjaristsqali River and tributaries. Apart from only a few species, all other species spawn in main rivers (including in the Skhalta and Chirukhistsqali Rivers and their tributaries; however, many species only spawn in the upper reaches, above 900m from sea level as shown in Table 17. Colchic minnow and colchic shemaia spawn in the downstream sections of the catchment, in reaches above 250m above sea level. All other species spawn in habitats located above 850m from sea level. In particular the trout spawns in reaches at high altitude and above 1500m. The results therefore show that none of the species is limited to a particular river to reproduce. Rather spawning habitats are available in tributaries of the Adjara catchment and limited by altitude. In addition, tributaries that will not be influenced by the Project also contain spawning habitats.

The elevation at which the weirs and dam are located are as follows:

- Chirukhistsqali weir: full supply level: 916.0mAD; downstream level: 910.0mAD
- Didachara dam: full supply level: 780.0mAD; downstream level: 744mAD
- Skhalta dam: full supply level: 792.0mAD; downstream level: 778mAD

Based on this it is assumed that in the main rivers' spawning areas are mostly located upstream of the dams. During the surveys loss of spawning habitat at the footprint of the weirs and reservoirs has been reported by the surveyors.

Table 16 Spawning areas in the Adjaristsqali River and tributaries

	Spawning areas					
Species	Adj	Ak	Chi	Chv	Sk	Gor
Salmo labrax pallas	Since 1940s spawning has not been noticed in the basin of Adjaristsqali					
Salmo labrax fario	-	X	X	X	X	X
Oncorhynchus mykiss	Does not reproduce in the natural conditions. From fish farms they are becoming distributed in the natural environment					
Squalius cephalus	X	X	X	X	X	X
Chondrostoma colchicum	X	X	X	X	X	X
Phoxinus colchicus	X	X	-	-	-	-
Gobio lepidolaemus caucasica	X	X	X	X	X	-
Capoeta sieboldii	X	X	X	X	-	-
Capoeta tinca	X	X	X	X	X	X
Luciobarbus escherichii	X	X	X	X	X	X
Alburnus derjugini	X	-	-	-	-	-
Alburnoides fasciatus	X	X	X	X	X	X
Cobitis satunini (Gladkov, 1935)	X	X	-	-	-	-
Oxynoemacheilus	X	X	X	X	X	X
Ponticola constructor	X	X	X	X	X	X

Note : X – presence of spawning habitat; Adj – Adjaristsqali; Ak – Akavreta; Chi – Chirukhistsqali; Chv – Chvanistskali; Sk – Skhalta: Gor - Gorjomistskali

Table 17 Location of spawning areas for fish species and spawning season

Species	Spawning habitats (altitude[1])	Spawning period
Salmo labrax fario	In a main river and tributaries 1500m away from the sea level (S/L), in streams 1000m away from S/L	September to January
Oncorhynchus mykiss	Does not naturally reproduce in the catchment but is becoming distributed in the Adjaristsqali rivers and tributaries from fish farms.	N/A
Squalius cephalus	Upstream confluence of Adjaristsqali/Chorokhi (900m)	April to August
Chondrostoma colchicum	Upstream confluence of Adjaristsqali/Chorokhi (900m)	April to July
Phoxinus colchicus	Upstream confluence Adjaristsqali/Chorokhi (900m)	April to August
Gobio lepidolaemus caucasica	Upstream confluence of Adjaristsqali/Chorokhi (900m)	April to August
Capoeta sieboldii	Upstream confluence of Adjaristsqali/Chorokhi (500m)	May to August
Capoeta tinca	Upstream confluence of Adjaristsqali/Chorokhi (850m)	May to August
Luciobarbus escherichii	Upstream confluence of Adjaristsqali/Chorokhi (1000m)	April to July
Alburnus derjugini	Upstream confluence of Adjaristsqali /Chorokhi (220m)	May to August
Alburnoides fasciatus	Upstream confluence of Adjaristsqali/Chorokhi (1000m)	April to August
Cobitis satunini	Upstream confluence of Adjaristsqali/Chorokhi (220m)	April to August
Oxynoemacheilus angorae	Upstream confluence Adjaristsqali/Chorokhi (1000m)	April to August
Ponticola constructor	Upstream confluence of Adjaristsqali/Chorokhi (900m)	April to August
Salmo labrax	Since 1940s spawning has not been noticed in the basin of Adjaristsqali	

1 – Minimum altitude at which spawning habitats were recorded

In addition to this information surveyors have also mapped sensitive habitats including spawning habitats in the mesohabitats maps (Appendix A):

- 1 – Spawning area
- 2 – Feeding area
- 3 – Growing area
- 4 – Migration ways

3.4.5 Fish species requirements

A desk study was carried out to collect information on the fish species habitat requirements. Most of the species recorded in the Adjara Rivers are native to this area with only a few studies available to inform on their ecology. Consequently, little detailed information was found on these species. The main sources of information used included:

- Freyhof, J. 2011. *Salmo trutta*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 13 March 201
- Encyclopedia of Life (2014). www.eol.org (Accessed 14 March 2014)
- Fishbase at: www.fishbase.org
- www.loaches.com
- Bogutskaya, N. (2013). Western Transcaucasia [Online]. Available from http://www.feow.org/ecoregions/details/western_transcaucasia (Accessed 14 March 2014)

Results of this review are provided below for each species.

Anatolian khramulya *Capoeta tinca*

- Conservation Status: Endemic to the Kolcheti-Anatolian region; IUCN Red List – Least Concern
- Habitat requirements: swift flowing water, with cobble and pebble substrate (which could include fast-flowing habitat types including A, B1, B2, E, F, G1 and G2)
- Feeding requirements: Little or no information available

Black Sea salmon *Salmo labrax pallas*

- Conservation Status: included on Georgia's Red list status - Endangered, IUCN Red List - Least Concern, endemic to the Black Sea's basin
- Habitat requirements: spawns in rivers and streams with swift water (could include fast habitat types including A, B1 and B2, E or F, and G1)
- Feeding requirements: young feed on drifting and benthic invertebrates; adults feed on small fish and large crustaceans
- Migration patterns: Lacustrine populations migrate to tributaries and lake outlets. Spawning sites are usually characterized by downward movement of water into gravel. Spawns between late October and March. The anadromous morph (sea trout) migrates between the ocean, where it spends most of its life, and freshwater spawning grounds

Trout *Salmo labrax fario*

- Conservation Status: Georgia's Red list status – Vulnerable, IUCN Red List - Least Concern
- Habitat requirements: Brown trout spawns in rivers and streams with swift water (could include fast habitat types including A, B1 and B2, E or F, and G1)
- Feeding requirements: the young feed on drifting and benthic invertebrates; adults feed on small fish and large crustaceans
- Migration patterns: Lacustrine populations migrate to tributaries and lake outlets. Spawning sites are usually characterized by downward movement of water into gravel. Brown trout spawns between September to January

Caucasian chub *Squalius cephalus*

- Conservation Status: IUCN Red List status - Least Concern
- Habitat requirements: small rivers and large streams of barbel zone with riffles and pools (could include habitat types E, G1 or G2). Also present along shores of slow-flowing lowland rivers, and in large lakes. Larvae and juveniles inhabit shallow shoreline habitats
- Feeding requirements: feeds on a variety of aquatic and terrestrial animal and plant material. Large adults feed mainly on other fish
- Migration patterns: Migrates to inflowing streams to spawn in fast-flowing water above gravel bottom, rarely among submerged vegetation. Spawns from April to August, when temperatures are above 12°C

Caucasian goby *Ponticola constructor*

- Conservation Status: IUCN Red List - Least Concern
- Habitat requirements: suitable habitat includes a variety of flowing freshwaters from cold hill to foot hill streams. Not found in brackish water. Eggs are laid in gravel or rocky cavities

Colchic barbel *Luciobarbus escherichii*

- Conservation Status: IUCN Red List - Least Concern
- Habitat and feeding requirements: no information available on this species

Colchic bleak *Alburnus derjugini*

- Conservation Status: IUCN Red List – Least Concern
- Feeding requirements: Little or no information available on this species' ecology

Colchic khramulya *Capoeta sieboldii*

- Conservation Status: IUCN Red List – Least Concern, Endemic to the Kolkheti region
- Habitat and feeding requirements: no information available on this species

Colchic minnow *Phoxinus colchicus*

- Conservation Status: Endemic to the Kolkheti region; IUCN Red List status - Least Concern
- Habitat requirements: suitable habitat includes a range of cold and well oxygenated habitats, from small, fast-flowing streams to large rivers (could include A, B1, B2, E, F, G1 and G2; all fast-flowing habitat types). Spawns over clean gravel areas in flowing water
- Feeding requirements: invertebrates, algae and detritus

Colchic nase *Chondrostoma colchicum*

- Conservation Status: Endemic to the Kolkheti region; IUCN Red List – Least Concern
- Habitat and Feeding requirements: Little or no information available on this species ecology

Rainbow trout *Oncorhynchus mykiss*

- Conservation Status: Invasive species, stocked in Adjara catchment
- Habitat requirements: cold headwaters, creeks, small to large rivers, and lakes. Stocked in almost all water bodies where it is present
- Feeding requirements: feeds on a variety of aquatic and terrestrial invertebrates
- Migration patterns: Anadromous and lake forms may migrate long distances to spawning streams. They require gravel beds to lay their eggs. Some populations of this species do not make significant seasonal migrations at all

Roach *Rutilus rutilus*

- Conservation Status: IUCN Red List status - Least Concern
- Habitat requirements: mainly in lowland areas, nutrient-rich lakes and large to medium sized rivers and backwaters. In fast-flowing rivers, it is restricted to stretches where backwaters or shelters allow for overwintering (which could include habitat types that are deep and slow, including habitat type C). Spawns among dense submerged vegetation in backwaters or lakes, flooded meadows or in shallow, fast-flowing river habitats on plant or gravel bottoms (which could include habitat types F, G2 or H)
- Feeding requirements: benthic invertebrates, zooplankton, plant material and detritus
- Undertakes short spawning migrations. Spawns in April and May, when temperature rises above 12°C. Spawns in shoals
- Overwinters in backwaters or in deep parts of lakes

Sakarya loach *Oxynoemacheilus angorae / Nemacheilus angorae*

- Conservation Status: IUCN Red List – Least Concern
- Habitat requirements: shallow stream beds (could include B2, D, F or G2 habitat types)
- Feeding requirements: feeds on fish eggs and fry

Satunini loach *Cobitis satunini*

- Conservation Status: IUCN Red List – Least Concern
- Habitat requirements: stagnant to slowly running waters, with sandy or silty substrate (could include habitat types C or D)

- Feeding requirements: Little or no information available on this species' ecology

Mursa Barbus mursa *Luciobarbus mursa*

- Conservation status: IUCN Red List – Least Concern
- Habitat requirements: Inhabits a wide range of streams and rivers with fast to moderately fast running water. Also inhabits lakes and reservoirs from which it migrates to rivers and streams to spawn
- Feeding requirements: Little or no information available on this species' ecology

Transcaucasian sprilin *Alburnoides fasciatus*

- Conservation status: IUCN Red List – Least Concern
- Habitat requirements: Rivers and streams with fast running shallow water, often over gravel, pebble or rocks
- Feeding requirements: Little or no information available on this species' ecology

3.5 Macroinvertebrate Surveys

3.5.1 Overview

Under the ESIA and Biodiversity Action Plan, AGL is required to collect benthic macroinvertebrate data from the Adjaristsqali River and its tributaries. It is necessary to obtain a detailed understanding of the macroinvertebrate communities in the study area prior to construction to provide a baseline against which, during and post-construction survey findings can be evaluated. Macroinvertebrates respond to changes in habitat quality, water quality and flows and provide important information on changes in river ecology. Macroinvertebrate surveys are a cornerstone activity of the environmental monitoring programme for the Project.

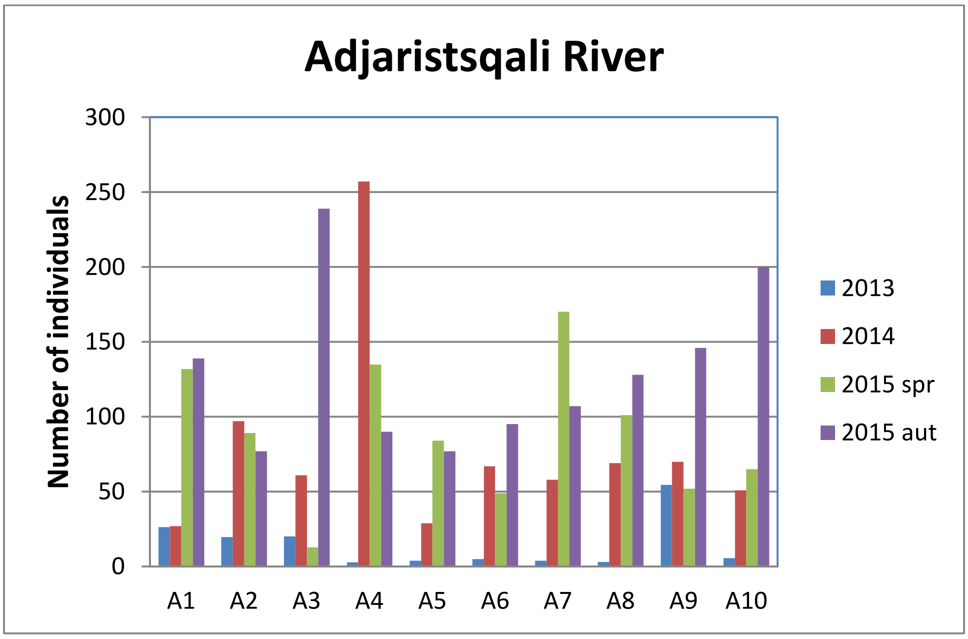
Macroinvertebrate surveys were carried out in August 2013, December 2014 and in spring and autumn 2015. To ensure that data is relevant and comparable, macroinvertebrate surveys were carried out at the same monitoring locations as the mesohabitat and fish surveys for the Project.

3.5.2 Results

3.5.2.1 Adjaristsqali River

A total of 10 locations were surveyed in the Adjaristsqali River. In total 13 families (belonging to seven different orders) of macroinvertebrates were present in all surveys. The highest abundance was recorded 2014 at A4. Lowest densities were recorded in 2013 across all sites (Figure 18.

Figure 18: Macroinvertebrate total number of individuals – Adjaristsqali River



The percentage of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) groups (EPT) was constantly above 50% indicating the dominance of EPT species abundance (Figure 22). The EPT group is a good indicator of the water quality conditions in the Adjaristsqali River. Overall, the macroinvertebrate community is not very diverse (number of species ranged from 8 and 15, throughout the sampling period. There was an increase in the dominance of the Ephemeroptera group in 2015 at almost all sites.

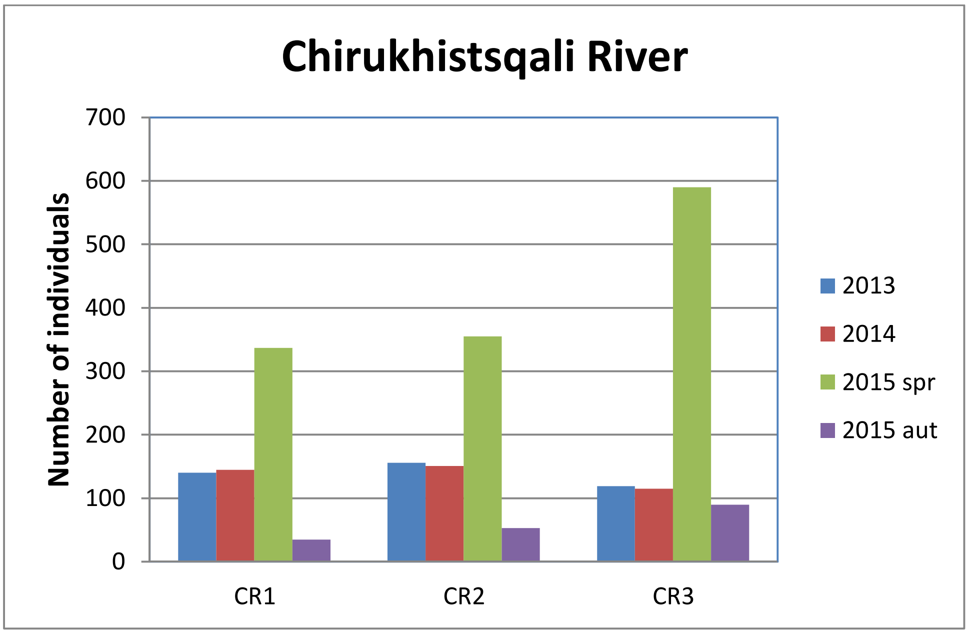
There is no clear trend between sites from upstream to downstream but it is clear that within the survey area, the middle sections of the river presented lower macroinvertebrate abundance.

A good indicator of water quality is the ratio between the abundance of EPT and true flies (Chironomidae) (C) shown in Figure 22.

3.5.2.2 Chirukhistsqali River

Sites in this part of the catchment were CR1 to CR3. Macroinvertebrate abundance was generally higher and significantly higher in spring 2015 compared with other seasons; however, a sharp decrease was recorded in autumn 2015 at all sites. This contrasts with the trend in other rivers in the catchment where a decrease in macroinvertebrate numbers was not observed in autumn 2015. In particular numbers were much reduced in autumn 2015 which could be attributed to the construction of the Project. This decrease is also seen in the percentage of Ephemeroptera, which could be a reflection of higher suspended solids. However, the decrease was also recorded at site CR1 which is not influenced by the construction of the Project (before construction) and therefore within the populations’ natural range.

Figure 19: Macroinvertebrate total number of individuals Chirukhistsqali



As in the Adjaristsqali River and tributaries the EPT group is dominant; however, within this the Plecoptera have the highest abundance in the Chirukhistsqali River (Figure 23). An increasing trend in the Ephemeroptera group was recorded from upstream to downstream sites and tributaries. Although the percentage of EPT groups in within the values recorded in the Adjaristsqali River the percentage of the Ephemeroptera alone is lower showing that this group of invertebrates is less represented in this river.

Diversity as measured by the number of taxa is slightly higher than in the Adjaristsqali River. The number of taxa ranged between 12 and 14 species during the sampling period. There is an increase in taxa less tolerant to pollution, Ephemeroptera, when moving upstream to downstream in this set of samples.

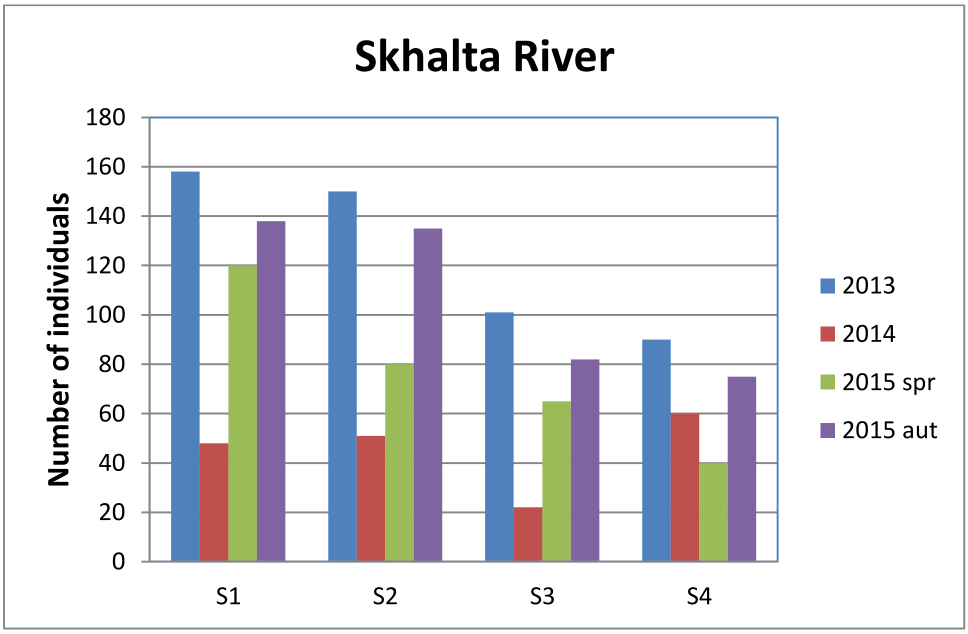
3.5.2.3 Skhalta River

A total of 10 taxa were recorded in the Skhalta River. Total number of taxa is within the range recorded in other rivers in the catchment. Generally, the EPT group abundance decreased from S1 to S4 (downstream to upstream), but overall dominance remained consistent.

A clear trend in the increase in dominance in the samples at all sites for the group Ephemeroptera from 2013 to 2015 was observed, as well as an increase in the percentage of this group from S1 to S4.

There is a decrease in EPT and an increase in more tolerant Diptera in this set of sites, moving upstream to downstream. This is consistent with the ratio EPT/C results which are very small showing the greater contribution to community abundance by Diptera in downstream reaches. In fact, on some occasions no Diptera species were recorded at the most upstream site S5. Of note is also the difference between the percentage of Ephemeroptera at S4 (not influenced by construction as it is located upstream of the construction site) and downstream sites. The lower percentage recorded at the downstream sites may be a reflection of a possible increase in suspended sediment which can affect the gills of these larvae. The fact that this trend is not observed in the percentage of the EPT groups may be a reflection of the more sensitive nature of the Ephemeroptera.

Figure 20: Macroinvertebrate total number of individuals – Skhalta River



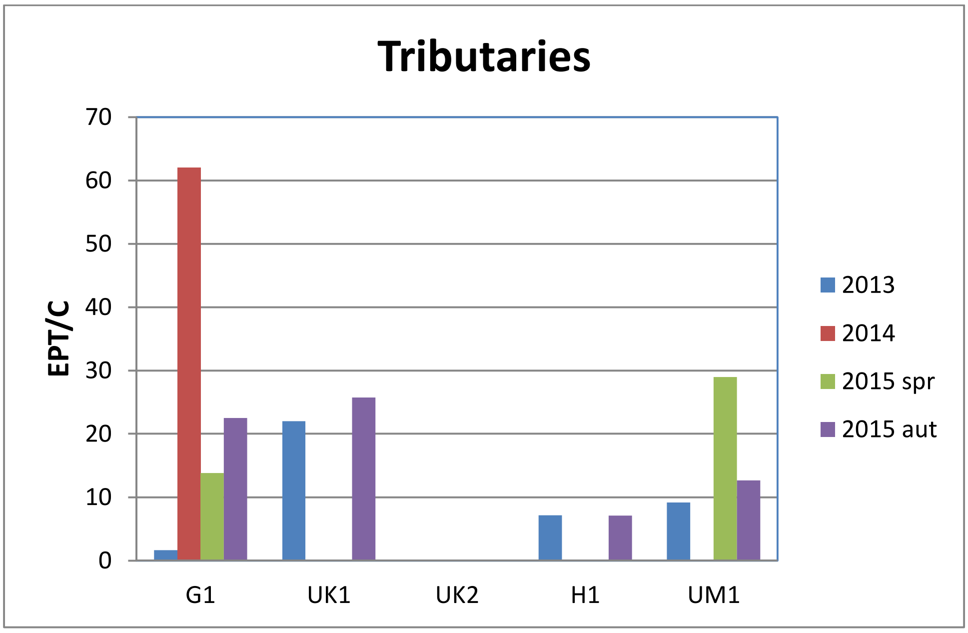
3.5.2.4 Tributaries – Ghorjamistsqali, Uchkotsqali and Heva Rivers

Figure 21 and Figure 25 show the results observed in some of the Adjaristsqali River tributaries:

- G1 - Ghorjamistsqali River
- UK1 and UK2 - Uchkotsqali River
- H1 - Heva River
- UM – Uchambistskali River (tributary of the Chirukhistsqali River)

None of these rivers are affected by the Project. Data collated at these sites contributes to the understanding of the macroinvertebrate communities' composition present in the Adjaristsqali River as a whole. The fact that these rivers will not be affected by the Project during construction or operation makes them good control sites and consequently important to monitor along with other sites that will be affected.

Figure 21: Macroinvertebrate total number of individuals

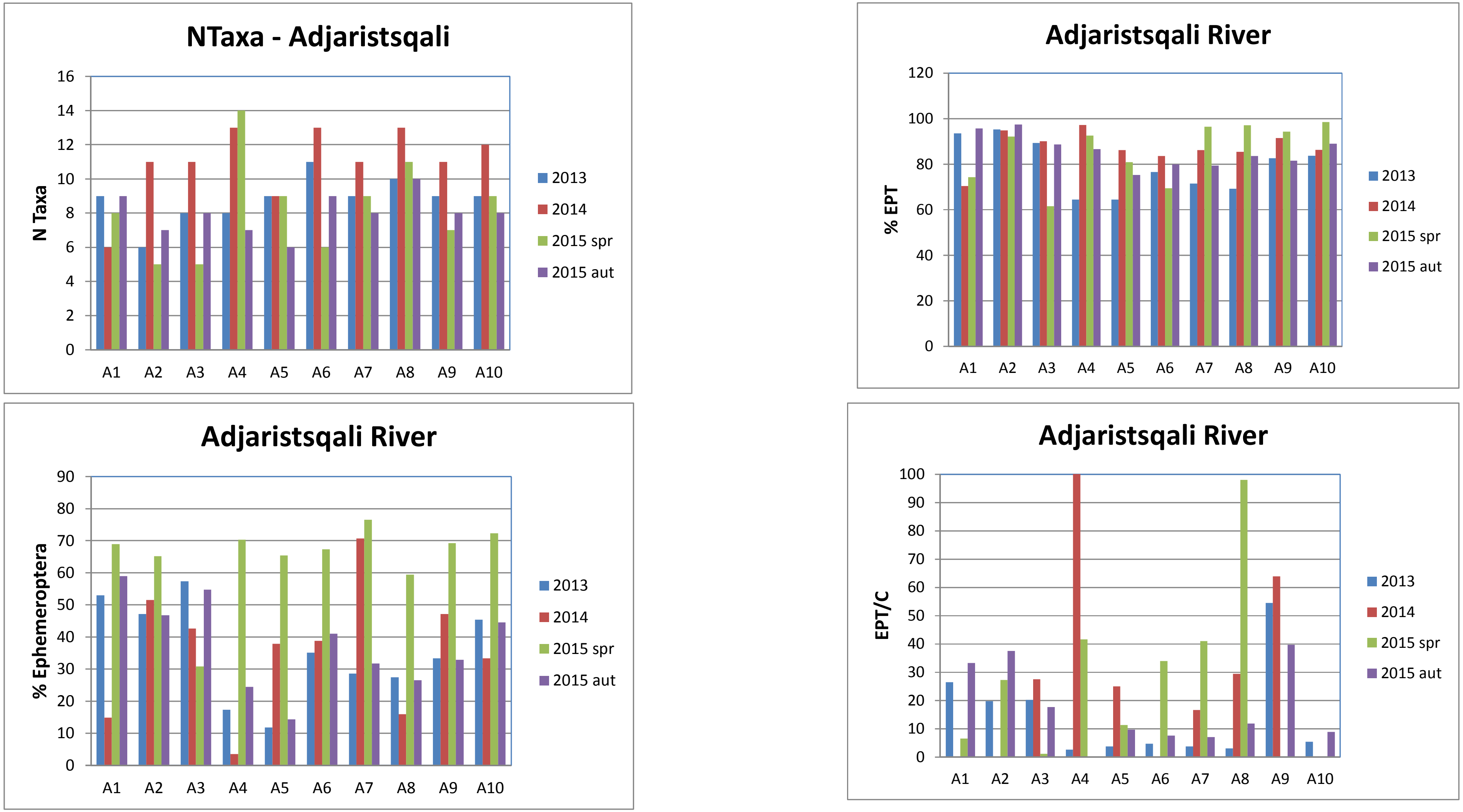


Macroinvertebrate abundance at sites at Uchkotsqali River (UK1) and the Heva River (H1) are up to 13 taxa; within the range recorded in Adjaristsqali River. However, abundance recorded in Ghorjamistsqali River was much lower than any other site.

The communities in the four rivers are dominated by the EPT group and there is no apparent difference in the proportion of this group between the different rivers. This is comparable to the Adjaristsqali, Skhalta and Chirukhistsqali rivers. The percentage of Ephemeroptera shows more variability throughout the sites and the sampling period but there is no obvious trend and the differences recorded might be owing to seasonality and normal variance between years. In terms of abundance the lowest number of individuals was recorded in the Ghorjamistsqali River.

The ratio EPT/C presents little variability between the three tributaries (Figure 25) and is comparable to the Adjaristsqali River sites A4 to A10.

Figure 22: Macroinvertebrate Indices in Adjaristsqali River



Note: EPT – Percentage of the composite of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera larvae. (caddisflies). EPT/C – The ratio between mayfly, stonefly, and caddisfly larvae abundance and Chironomidae (midges).

Figure 23: Macroinvertebrate Indices in Chirukhistsqali River

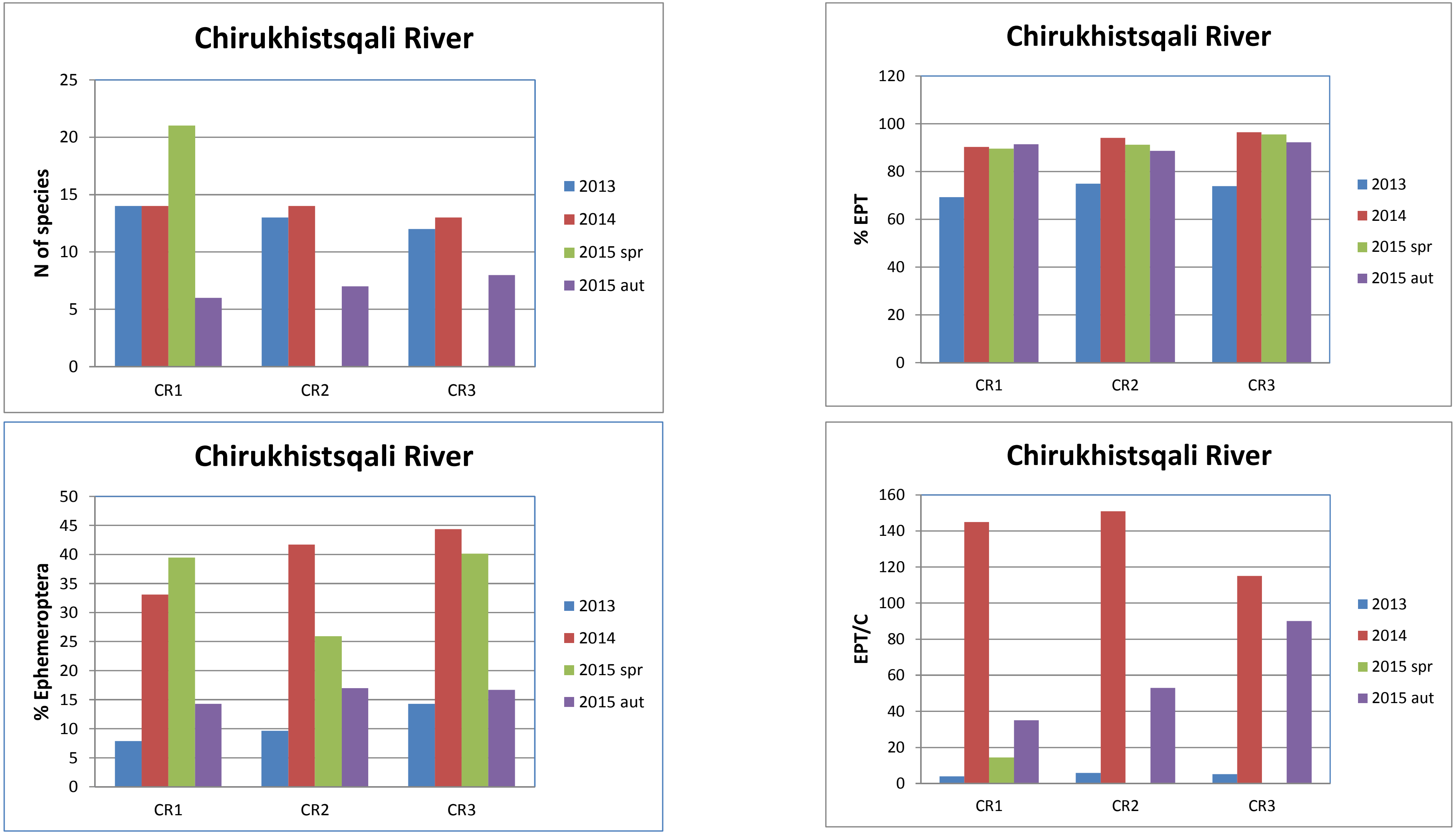


Figure 24: Macroinvertebrate Indices in Skhalta River

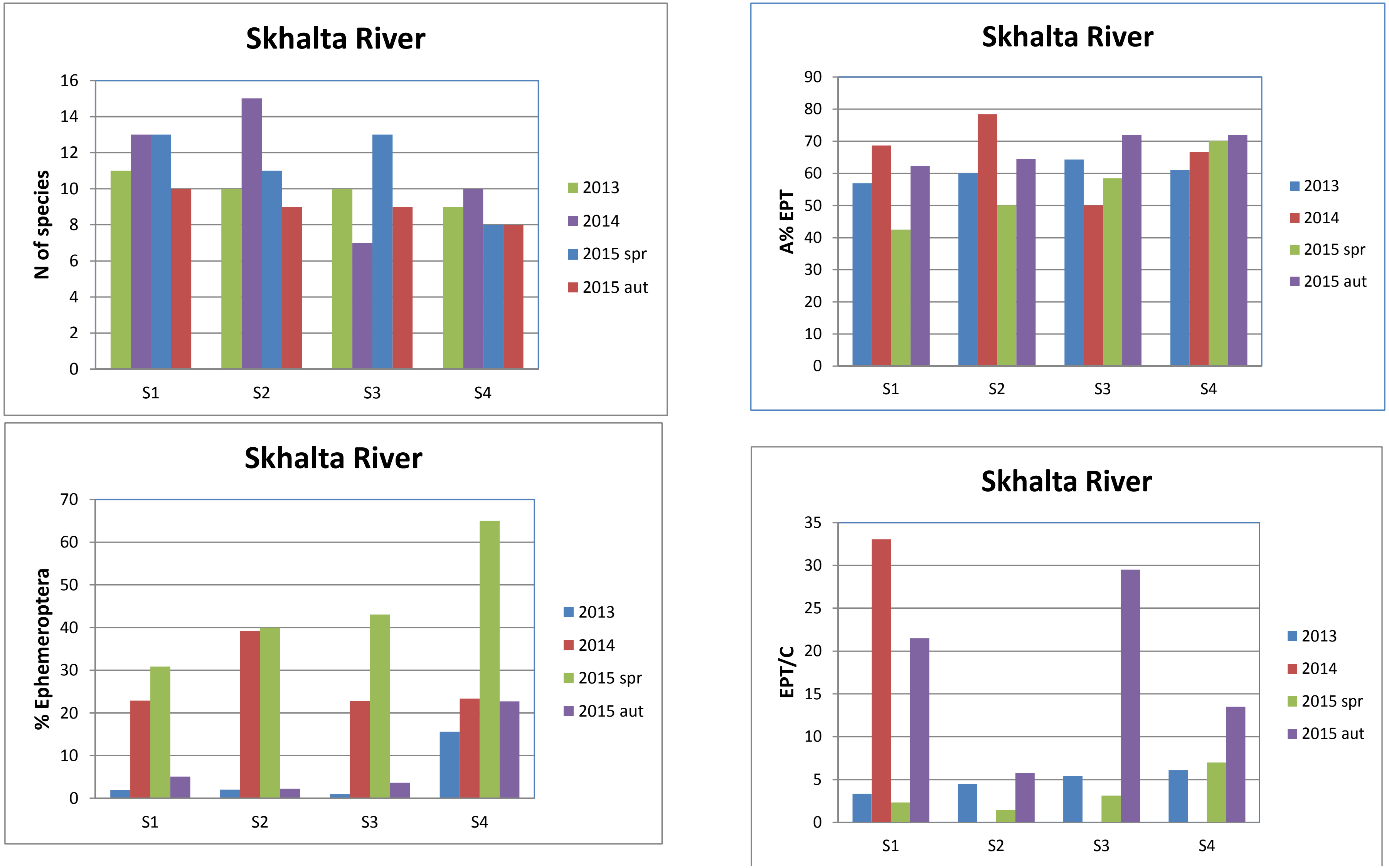
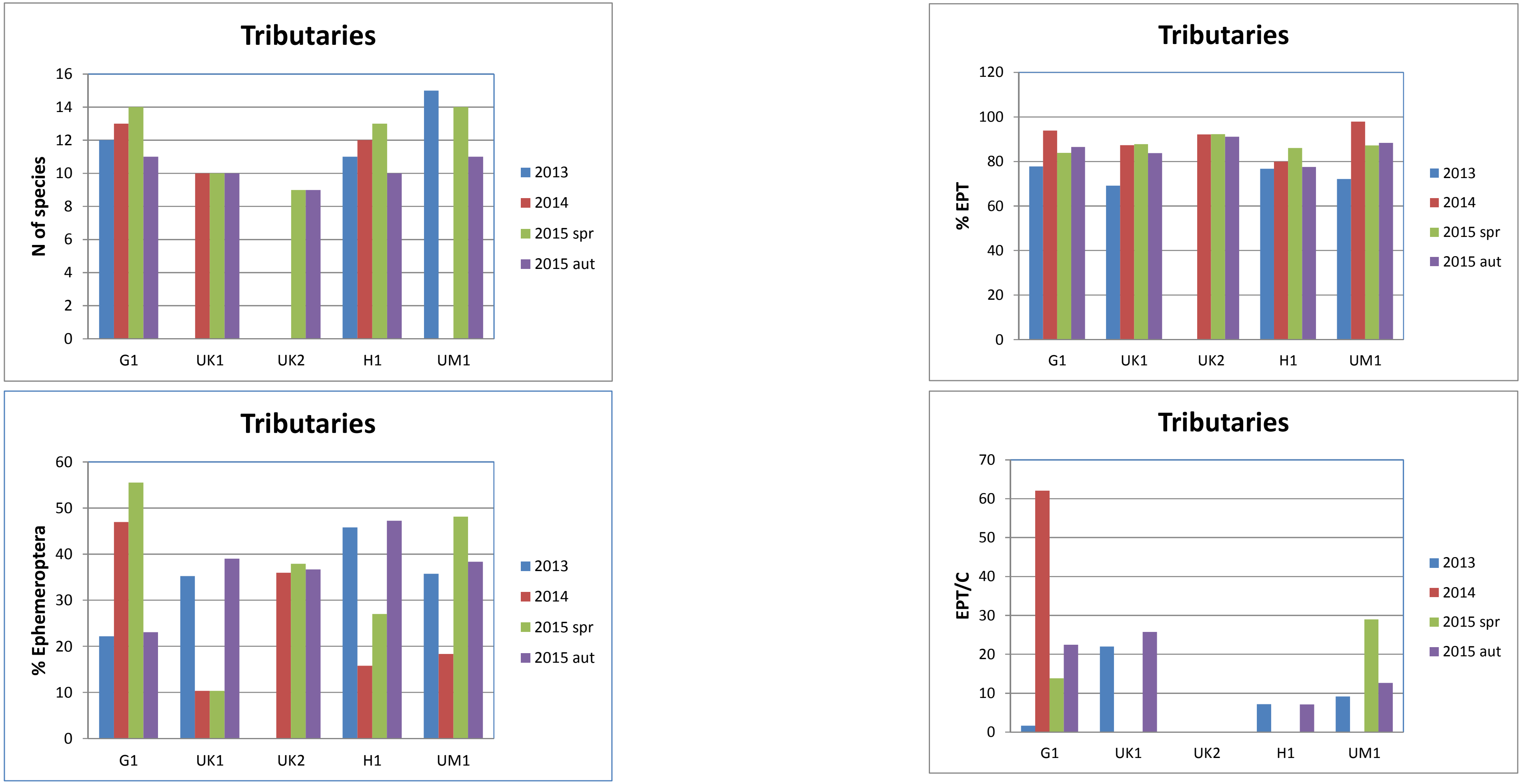


Figure 25: Macroinvertebrate Indices in tributaries



3.5.3 Summary

Overall the number of taxa (species present in the Adjara catchment is relatively small with a maximum of 15 species recorded. The relatively low number of taxa in the Adjara Rivers is likely to be explained by the physical characteristics of the rivers, particularly in the most upstream locations. Sites located closer to the source (such as A1, A2 and A3) could have lower species diversity as there is less opportunity for colonization by downstream drift. Headwaters can also be less productive owing to lower nutrient content, resulting in communities with low numbers of taxa and abundance.

The abundance of macroinvertebrates belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera should be noted in the Adjara rivers. It is evident the dominance of the EPT group in the number of species present as well as abundance. The percentage of this group in relation to the total abundance of macroinvertebrates at any sampling point is an indication of the water quality as the species belonging to these three orders are highly sensitive to pollution. Their presence indicates good water quality, while their absence suggests water may be polluted (presence of pollutants or high levels of sediment in suspension, for example). The EPT percentage should increase with increasing water quality.

The EPT index was always above 60 in all rivers (including the tributaries not influenced by the Project) with the exception of the Skhalta River. This could be just a reflection of the lower number of species recorded here. There is no clear difference in the EPT index in the 2015 samples (since the start of construction).

The percentage of the Ephemeroptera family alone was also calculated. A reduction in this value is observed in autumn 2015 samples both at the Skhalta and Chirukhistsqali Rivers. This follows considerably higher levels during spring and is also observed in tributaries (specifically in the Chirukhistsqali tributary) and could be explained by seasonal patterns and is unlikely to reflect changes owing to construction of the Project.

The abundance of EPT and Chironomidae indicates the balance of the community, since EPT are considered to be more sensitive and Chironomidae less sensitive to environmental stress (Plafkin et al., 1989, in Mandaville, 2002). A community considered to be in good biotic condition will display an even distribution among these four groups, while communities with disproportionately high numbers of Chironomidae may indicate environmental stress (Plafkin et al., 1989 in Mandaville, 2002).

Overall the results show a dominance of pollution sensitive species with only a small proportion of Chironomids present, particularly in the Skhalta River. The absence of Chironomids at some sites is also of note (particularly in the Skhalta River) which could be explained by the nature of the substrate with general lack of finer sediment, consistent with upland sites. As before there is no indication of a decrease in the conditions in 2015 compared with previous years.

There is a notable absence of Mollusca (snails and clams) in all samples. This may be due to sampling limitations.

3.6 Summary of findings

3.6.1 Catchment

Overall the review of baseline monitoring data suggests that although some differences were found between the different sub-catchments in terms of species distribution, these are not major and are mostly restricted to differences in the fish community between the main Adjaristsqali River and its tributaries.

Within the Skhalta and Chirukhistsqali rivers the mesohabitats distribution is widespread and there is no indication of particular sensitive habitats that are restricted to the reaches more influenced by the Project (ADj7(A), SKH1(A) and CH1(A)).

In the Adjaristsqali River mesohabitat F is dominant and its presence increases in both frequency and area as flows reduce. Under the same conditions, mesohabitats B2 and G2 reduce in frequency and area. All these mesohabitats are characterized by fast flow and shallow water depth, but with mesohabitat F occurring in locations with steeper gradients.

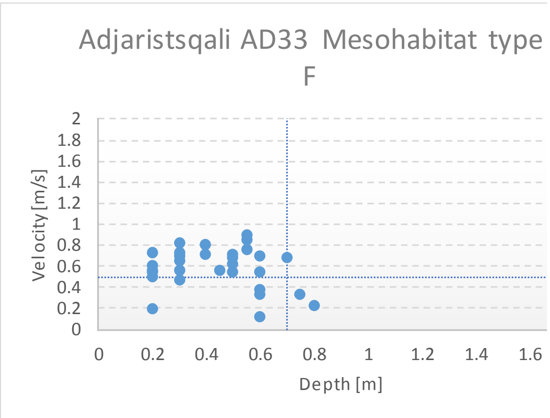
Looking at the microhabitat results analysis in more detail (Figure 26). it is clear that some of the areas identified as mesohabitats F in 2016 are characterised by slower velocities and lower water levels. However, the methodology does not allow the combination of steep gradient with slow velocities. Given that there is natural variability of flow levels within these areas, they remain designated as mesohabitat F as they are within the threshold for physical variables. Continued reduction in velocities in such areas of mesohabitat F may result in the disappearance of key sensitive habitats such as spawning habitats for fish (which were still recorded in 2016 despite lower flows).

In areas where the gradient is at the threshold of moderate and steep, it is expected that a reduction in flow velocity would result in a change from mesohabitats F and B2 to mesohabitats H and D. It is possible that these areas constitute a substantial proportion of this catchment, but the data is based on a visual assessment and is not sufficiently detailed to allow such analysis.

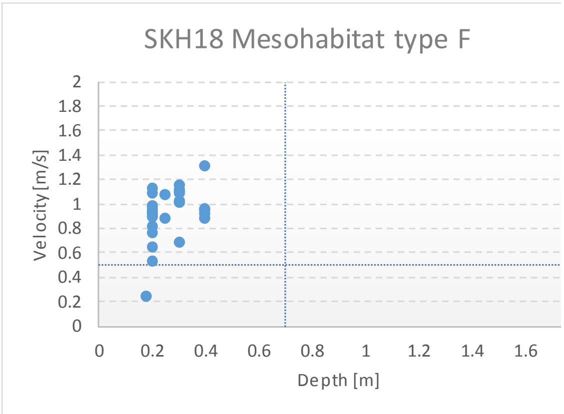
In smaller tributaries where mesohabitat F is also recorded and is dominant, water depth and flow velocities showed less variability compared with observations from the Adjaristsqali River. It is likely that in some areas of the Adjaristsqali River, as discharge levels reduce this variability in depth and flow will also reduce.

Figure 26: Mesohabitats F across the survey locations in 2013 and 2016.

2013

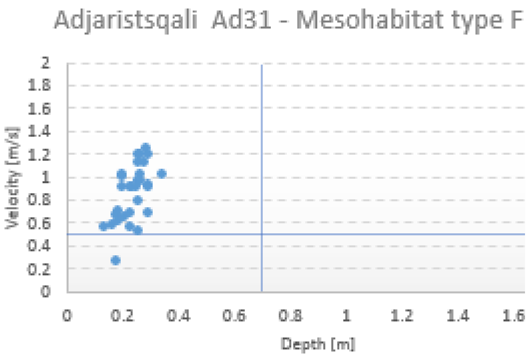


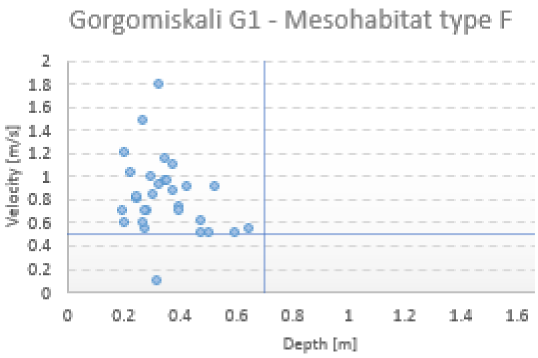
2013

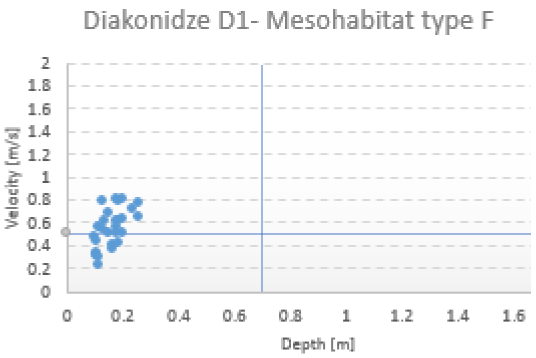


2016

2016







Spawning habitats are present in river reaches influenced by the scheme and could be lost through direct impacts and inundation. In the Adjaristsqali River for example, spawning habitat has been recorded for the Transcaucasian spirlin, common roach, chub, colchic kramulya, and colchic nase within the reach most influenced by Project (downstream of the dam) associated with mesohabitat F. However, equivalent spawning habitats are also present in reaches (upstream the dams and weir) and in tributaries not influenced by the Project. In the case of the Adjaristsqali River, it will be possible for species to spawn in reach Adj B for example if loss of spawning habitats in AdjJ(A) is significant. Consequently, it is unlikely that the Project will result in a significant reduction or loss of spawning habitat in the reaches influenced by the Project.

The fish communities are dominated by cyprinids and most fish species present are widely distributed in the catchment (Transcaucasian spirlin, Anatolian kramulya, colchic barbel, chub). A few species are endemic to the Kolkheti region; their distribution is consequently not restricted to Georgia or the Project area. None of the species recorded between 2012 and 2016 (spring) in the Project area are described as being Vulnerable or Endangered on the IUCN Red list but Black Sea trout is classified as Vulnerable on the Georgia Red List..

The reduction of flows downstream of the dams and weirs will result in a reduction of wetted perimeter as well as important changes in hydraulic characteristics (flow velocity and water level) as discussed above. As water level reduces the velocity will also reduce. These changes will not only result in loss of habitats but could also lead to a barrier effect if water level and velocity are not sufficient for individuals to move upstream. This in turn could prevent access to some tributaries for example. It is partially for this reason that in the reaches located immediately downstream of the Didachara and Skhalta Dams, impacts are considered Major due to changes in habitats prior to the adoption of mitigation.

In the Adjaristsqali and Skhalta Rivers the presence of a dam/weir will result in a physical barrier to upstream habitats. Although spawning habitats exist in other tributaries, a local reduction in fish numbers for some species (for example the Black Sea trout and colchic barbel) could result in residual impacts. The lack of access in these reaches could mean that populations upstream become isolated.

Fish passes have not been proposed at these two dams however, based on the fish data obtained from the survey effort to date, a monitoring and adaptive management approach is considered appropriate. The Black Sea trout distribution is mostly restricted to high altitude and upstream of these dams. Whilst in 2015 and 2106 a few exemplars of trout were recorded at the proposed dam location in the Skhalta River (suggesting that this species is present here) this is not a significant concern as spawning habitats are considered to be present at higher altitudes. Any residual effects will be monitored and adaptive management measures applied as appropriate.

The design of the Chirukhistsqali weir incorporates a fish pass and consequently impacts in the reach downstream of it are assessed as moderate. The fish pass design is based on accepted practice and guidance and following review of the data collected by the ichthyologists, the design is considered to be appropriate.

Migratory routes for trout and colchic barbel have been identified that will be prevented by the construction of the Didachara Dam. To mitigate this impact, it is important to ensure that ecological continuity to alternative spawning and feeding grounds in tributaries is maintained.

3.6.2 Findings downstream Didachara Dam

The section of the Adjaristsqali River downstream of Didachara Dam will be subject to a significant reduction in flow once the scheme is in operation. Low flows data relating to this stretch of river was obtained in 2016 and has informed a more detailed assessment of likely changes in mesohabitats. Comparison of the higher flows data obtained in 2012 and 2013, and the lower flows mesohabitat data obtained for this stretch of river in 2016 indicates the following:

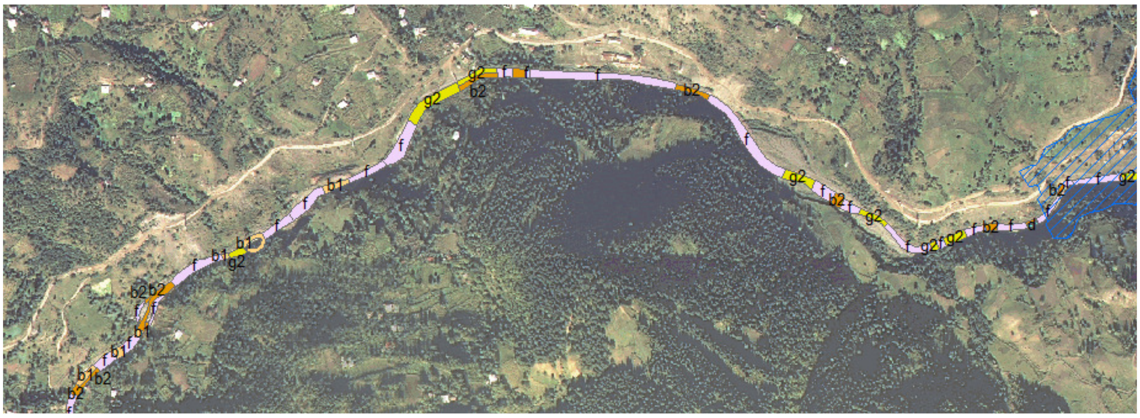
- Lower flows result in a reduction in the size of mesohabitat units and an overall reduction in diversity
- Whilst the mesohabitat types present at higher flows remain present, additional mesohabitat types associated with reduced flow velocities are introduced at the lower flow levels. This is indicated for example by the presence of a very small area of mesohabitat H during the 2016 surveys
- Of importance is the recording in 2016 of spawning habitat just downstream of the dam and associated with G2
- Migratory and feeding habitat in the reaches below Didachara Dam has been recorded and is associated with the mesohabitats present (F, G2 and B2)
- If discharge levels are reduced (resulting in lower flows), the proportion of those mesohabitats associated with these conditions will increase and those associated with higher flows will decrease. This will lead to a reduction in the overall variability of the mesohabitats present and, therefore, a reduction in the availability of different ecological niches for fish
- It is predicted that other mesohabitats associated with slower flows will occur once operational level flows are experienced. An increase in the area of mesohabitats associated with slower flows, such as mesohabitats H and possibly D (in lower gradient areas) is expected

- Downstream of the Skhalta confluence (Figure 5.3) 2016 surveys indicated a change from mesohabitats G2 and B1 (moderate gradient) to F (steep gradient) suggesting that the gradient here is on the threshold boundary. Several areas of mesohabitat E were recorded suggesting that even in situations when flow is reduced pools are retained and areas of deeper water still occur in downstream reaches. It is likely that this area is more resilient to a change in flow

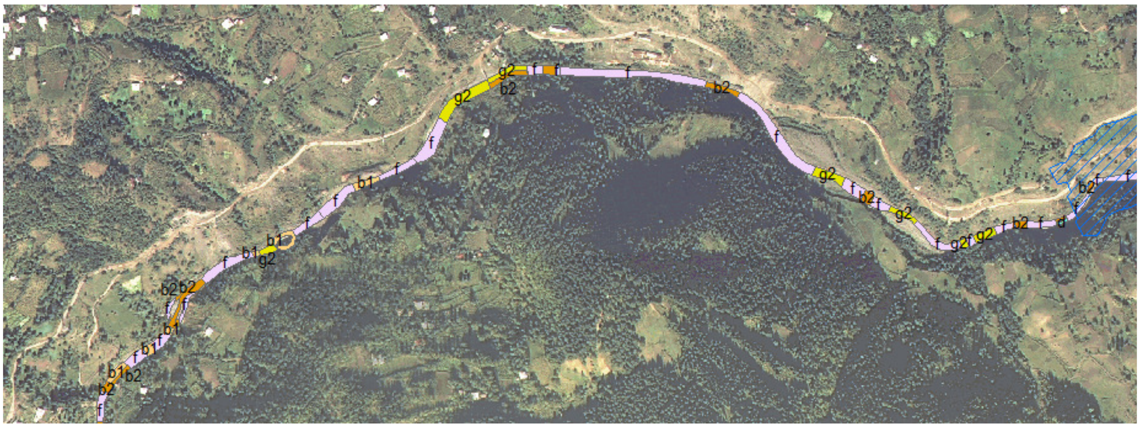
The mesohabitats identified in the section of the Adjaristsqali River immediately downstream of the Didachara Dam during each survey period are illustrated in Figure 27 for reference.

Figure 27: Mesohabitats in 2012, 2013 and 2106 Downstream of Didachara Dam

Mesohabitats downstream of Didachara Dam 2012



Mesohabitats downstream of Didachara Dam 2013



Mesohabitats downstream of Didachara Dam 2016

Note – sensitive habitats mapped as 1) spawning; 2) feeding; 3) growing 4) migratory routes

Figure 28: Mesohabitats in 2012, 2013 and 2016 downstream of confluence with Skhalta

Mesohabitats in 2012 downstream of confluence with Skhalta

Mesohabitats in 2013 downstream of confluence with Skhalta

Mesohabitats in 2016 downstream of confluence with Skhalta

Note – sensitive habitats mapped as 1) spawning; 2) feeding; 3) growing 4) migratory routes

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A. Appendix: Diversity Indices

Memo

Meso-habitat analysis

Measures of diversity and distribution

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PROJECT NO / FILE CODE	DATE	CLASSIFICATION
502000131-2-1060	2014-03-06	Unrestricted

This memo presents four indexes which are calculated from meso-habitat survey's results.
The following measures of diversity were calculated to analyse both composition and configuration of the meso-habitats:

1. Shannon's diversity index
2. Simpson's index of diversity
3. Li's and Reynolds' contagion index
4. O'Neill's dominance index

The two former are common measures to describe biodiversity in ecosystems. These are metrics which in the sense of meso-habitat analysis describe the composition (species richness and evenness) by the relative amount of area of different meso-habitat types. The two latter are configuration metrics applied in landscape ecology to measure the spatial distribution of patterns in landscapes. The contagion index describes how fragmented the distribution of meso-habitats is, while the dominance index expresses if one or more meso-habitat type dominate the patch landscape.

In the following formulas, we use:

- S : number of species (meso-habitat types)
- Ni : number of individuals (amount of area) of species (meso-habitat types) i
- N : total number of individuals (amount of area)
- $Pi = Ni/N$: fraction of individuals belonging to species (meso-habitat) type i

1. Shannon's diversity index

Formula	Min	Max	reference
$H = -\sum_{i=1}^{S} p_i \ln p_i$	0 Low richness and evenness	*ln* S High species richness and evenness	*Shannon and Weaver, 1962*

2. Simpson's diversity index

Formula	Min	Max	reference
D1= $\sum_{i=1}^{S} p_i^2$	0 Infinite diversity	1 No diversity	*Simpson, 1949*
D2= 1- $\sum_{i=1}^{S} p_i^2$	0 No diversity	1 Infinite diversity	
$\mathrm{D3} = \frac{1}{\sum_{i=1}^{S} p_i^2}$	1 No diversity	$+\infty$ Infinite diversity	

3. Li et Reynolds' contagion index

Formula	Min	Max	reference
$RC1 = 1 + \sum_{i=1}^{n}\sum_{j=1}^{n} P_{ij} \ln P_{ij} / n \ln n$	0 dissected (<0.33)	1 Clumped (> 0.66)	*Li & Reynolds*, 1993

- *n*: number of patch types (meso-habitat types)
- N_{ij} : number of adjacencies between patch type i and patches of types j.
- N_i : total number of adjacencies between patch type i and all patches of types. ($\sum_{j=1}^{n} N_{ij} = N_i$)
- $P_{ij} = P_{j/i} = \frac{N_{ij}}{N_i}$: conditional probability of patch type i being adjacent to patch type j

4. O'Neill's dominance index

O'Neill's index describes the dominance or not of one habitats on the others.

Formula	Min	Max	reference
$\mathrm{D} = \ln n + \sum_{i=1}^{n} P_i \, lnP_i$	0 No dominance	$\ln n$ High dominance	*O'Neill et al., 1988*
$D = \frac{\ln n + \sum_{i=1}^{n} P_i \, lnP_i}{\ln n}$	0 No dominance	1 High dominance	*Gasper & Menz, 1999*

- n: number of patch types (meso-habitat types)
- N_i : number of patches (amount of area) of type (meso-habitat type) i
- N: total number of patches (amount of area)
- $P_i = \frac{N_i}{N}$: Fraction of patches of type i

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B. Appendix: Habitat Mapping

Habitat mapping will be delivered as separate files due to file size constraints.

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