MEGHRIGET RIVER: *RIVER BASIN CONCEPT PLAN*

Presented to:
International Conference on River Basin Management and Cooperation in the Euro-Mediterranean Region

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1. Introduction

This document is a draft river basin management concept plan for the Meghriget river basin of southern Armenia. It has been formulated as an illustration of how to use the planning guidelines for river basin planning, prepared by PA Consulting and its subcontractors for USAID and the Armenia Water Resources Management Agency in 2008. This draft concept plan is an intermediate product, which needs further consultation and development before it can be considered a river basin management plan.[1]

The river basin planning guidelines propose a ten-step planning process, of which step six (6) is formulation of a concept plan, represented by this document. Formulation of the River Basin Management Concept Plan is a summary of results from the prior steps two through five of the river basin management planning process proposed in the guidelines. The Concept Plan includes the delineation and classification of waters, the ecological status of waters, the environmental objectives for each water body, the pressure/impact analysis, and the preliminary program of measures, with some prioritization of alternatives. Step one, the basin characterization, was completed for the Meghriget basin in summer, 2008, and is used here as an input.

This concept plan takes a long-term perspective on river basin management improvements--the time frame for the proposed work should be approximately ten years. It is critical that the concept plan be widely discussed and accepted by key stakeholders, including local governments, major water user groups, and civil society leaders, if it is to be detailed and then implemented. At this stage this consultation and discussion of the draft concept plan has not yet taken place. However, the work included in the concept plan includes several stakeholder forums held in Kapan in 2007 and 2008 to allow the stakeholders to identify key water resource issues in the Meghriget, a extensive field trip by PA consultants and staff throughout the Meghriget in May, 2007, and repeated detailed discussions with the Southern BMO personnel, in Kapan and Yerevan, who are intimately familiar with the water resource issues in the Meghriget basin.

In order to proceed with any activity related to this draft plan, further in-depth consultations with stakeholders in the Meghriget should take place. Key potential implementers should, after discussion, commit to the river basin concept plan in writing.

1.1 Background on Meghriget River Basin

The Meghriget River basin is considered, for the purposes of this concept plan, to be all of the watersheds which drain out of Syunik Marz directly into the Araks River within the boundaries of Armenia (see Annex: Map 1, 2). This includes the Meghriget River and all its tributaries, as well as the Karchevan, Shemeglukh, Karavget, Malev, Astazurget, Shvanidzor, Shavzir, Nuvadi, Kaisbajur and Tondirget drainages. The total area is 664 km^2, of which 336 km^2 is the Meghriget River watershed itself, and the remainder is the parallel smaller watersheds.

A full characterization of the Meghriget River Basin was completed and published as: **Synthesis Report of Meghriget River Basin Characterization** by PA Consulting in Yerevan, in August, 2008. The Characterization report includes a full description of the climate, hydrology and water quality, biology, geography, socio-economic situation, water use, water balance, flood characteristics, and major water resource issues of the basin. A short summary of that data follows.

1.2 Summary of Characterization of Meghriget River Basin

<u>Climate:</u> The Meghriget is a semi-arid part of Armenia, with temperatures and precipitation sharply varying by altitude. The annual precipitation is 275 mm/yr at low elevations (below 500

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[1] **This report was authored by a PA Consulting technical team of Will McDowell, Gevorg Nazaryan and Robert Cardinalli under the USAID Armenia funded water program.**

m) and as much as 1000 mm/yr above 3000 meters, where much of the annual precipitation falls as snow.

<u>Topography and Geology:</u> The basin has steep topography, with elevations from 450 meters above sea level to 3700 meters above sea level. Most of the basin is made up of Tertiary granitic and other intrusive rocks, but a small area in the northeast has sedimentary geology.

<u>Hydrology and Water Quality:</u> The Meghriget River is the major perennial drainage of this area. It discharges 2.94 m3/sec annual average from an upper watershed of 274 km2 (0.0036 m3/sec/km2), while the other drainages discharge 0.001 to 0.002 m3/sec/km2. Most of the flow occurs in spring snowmelt from April to June, with low flows in the Meghriget from August through February, and no permanent flow during this period from most of the other drainages, except in their uppermost reaches. No large aquifers exist, although springs flow into the upper Meghriget river. Water quality tends to be good, except at certain very localized sites affected by runoff from mining operations, intensive crop or livestock operations, or urban runoff.

<u>Land Use and Land Ownership:</u> The majority of land in the basin is pasture, desert, bush, or forest (both juniper forests and broadleaf forests exist). Cultivated land, mostly in orchards, small grains and potatoes, is very limited—less than 4% of total land area. Most cropland and orchard is irrigated. The Meghri State Forestry and local villages control the majority of the land ownership. One small protected area exists and one more is proposed for steep forested lands.

<u>Demography:</u> There are approximately 11,909 people in the basin, with the majority located in the towns of Meghri and Agarak, while about 2,300 people are scattered in a dozen rural villages. The total basin population density is 19 persons/km2, but in actuality it averages much lower in rural areas. Emigration to towns and cities, and loss of population, is an issue.

<u>Economy:</u> Mining, agriculture and commerce are the three principal economic sectors employing the people. A large copper-molybdenum mine in Agarak is the largest employer, by far, in the whole river basin. Meghri is known in Armenia for production and processing of pomegranates, figs, grapes and other warm-climate fruits. Cattle, sheep, and pigs are common in rural villages, but total numbers are quite small.

<u>Water Use and Water Balance:</u> About 11 separate potable water systems exist. Ten rustic gravity irrigation schemes irrigate 350 hectares, while 9 irrigation pumping systems (using Araks river water) and one system of deep wells (also near Araks River) irrigate nearly 400 additional hectares. A small hydropower generating facility near Meghri uses Meghriget River water, and several other hydropower facilities are being contemplated, including a large bi-national run-of-river system on the Araks River with Iran. A total of eight (8) water permits are administered by WRMA-Southern BMO, including two for urban water/wastewater, one for irrigation, four industrial and one hydropower. A Meghriget River annual water balance indicated 624mm of precipitation, 279 mm of runoff, 318 mm of evapotranspiration and 26mm of deep percolation. Economic water balance indicates that water is most in demand, and most scarce in August-September, when surface water shortages are often reported in the Meghriget.

<u>Issues:</u> The primary water resource issues identified in the characterization include:
*Seasonal water shortages for irrigation and drinking water
*Lack of water treatment and dilapidated infrastructure for drinking water supply
*Pollution of water by industry and agriculture.
*Lack of water quality data
*Aquatic animals and plants vanished/vanishing
*Low level of ecological education in the population
*Poor location of solid waste/industrial waste facilities.

2. Classification of Surface Water and Ground Water Bodies

After Characterization, classification is the second step in the river basin planning process. The primary purpose of classification is to assign each surface water body (stream, lake, canal, or reservoir) and ground water body (aquifer) to a category or type which has its own set of distinct, and ecologically appropriate environmental objectives.

Classes of water bodies are usually defined by ecological characteristics which determine what type of chemical water quality and aquatic life is found there under natural conditions—altitude, geology, etc. River basin planning is simpler if the number of water body categories is few, therefore classification systems should be as simple as possible. Large water bodies are delineated, or separated, according to objective criteria so that each part (e.g. tributary) of a larger system falls within the appropriate category.

Classification systems encompass natural water bodies, and man-made water bodies. The European Water Framework Directive recognizes that certain types of man-made waters, known as **highly-modified water bodies** (canals, some reservoirs) cannot be expected to reach the same high environmental objectives as natural waters. Armenia’s approach reflects the European approach in this and several other aspects. However, Armenia’s Water Code also requires that water bodies be “classified” or described, according to a large set of criteria. This descriptive classification is complementary and parallel to the system described here.

The 12 types of rivers and streams are classified according to the following system:

Table 1: Streams & Rivers Classification System for River Basin Planning

	Varying size of river basin		
	Small River Basin	Average River Basin	Large River Basin
Varying geology, altitude<800m	**1.** 10-100 km^2 Local importance Altitude< 800m Geology - siliceous	**2.** 100 -1000km^2 National importance Altitude<800m Geology - siliceous	**3.** 1000-10000km^2 International Importance Altitude<800m Geology - siliceous
	4. 10-100km^2 Local importance Altitude<800մ Geology - calcareous	**5.** 100 -1000km^2 National importance Altitude<800m Geology - calcareous	**6.** 1000-10000km^2 International importance Altitude<800m Geology - calcareous
Varying geology, stable altitude>800m	**7.** 10-100km^2 Local importance Altitude>800m Geology - siliceous	**8.** 100 -1000km^2 National importance Altitude>800m Geology - siliceous	**9.** 1000-10000km^2 International importance Altitude>800m Geology - siliceous
	10. 10-100km^2 Local importance Altitude>800m Geology - calcareous	**11.** 100 -1000km^2 National importance Altitude>800m Geology - calcareous	**12.** 1000-10000km^2 International importance Altitude>800m Geology - calcareous

2.1 Surface Water Classification in Meghriget Basin

There are 13 distinct surface water bodies delineated for the Meghriget Basin. These surface water bodies are displayed in the following table:

Table 2: Classification of Surface Water Bodies in Meghriget Basin

Name of Drainage	Size (km^2)	Maximum altitude (m)	Minimum altitude (m)	Type of Surface Water	Actual hydrologic regime*:
Meghriget River (total):	336	3760	513	Several (see below)	perennial
Tashtun tributary:	67	3300	1600	1	perennial
Kaler tributary:	32	3100	1600	1	perennial
Avriget tributary:	44	3760	1600	1	perennial
Middle Meghriget:	178	1600	800	2	perennial
Lower Meghriget:	14	800	513	2	perennial
Karchevan	19	2647	535	7	intermittent
Shemeglukh	13	2089	506	7	ephemeral
Karavget	23	2416	488	7	ephemeral
Malev	51	2982	474	7	intermittent
Astazurget	35	2150	451	7	intermittent
Shavriz-Suriget	31	2345	442	7	ephemeral
Nuvadi-Karisbajur	52	2366	412	7	ephemeral
Tondirget	12	2232	416	7	ephemeral
Other areas (direct to Araks):	92			7	ephemeral
TOTAL:	664				

*perennial=flows all year; intermittent=flows part of year; ephemeral= flows rarely

The physical-geographical characteristics for Meghriget, such as diversity of relief forms and existence of tributaries with significant flows, as well as impact of industries and Meghri city, provide the basis for delineating Meghriget into the following discrete surface water sections:

Section 1 - Upper flow of Meghriget River including Tashtun tributary up to the confluence of tributaries Ayriget (Arevik) and Kaler with Meghriget River. This section of Meghriget River has highly incised topography, high peaks, deep canyons and forest-covered hills with steep slopes. The minimum absolute altitude of the delineated section is 1600 m. The territory is sparsely populated, with Tashtun village the principal population.

Section 2 - Tributary Kaler, which confluences with Meghriget at the absolute altitude of 1600 m. The topography of the tributary's basin is lower compared to the previous basin, and the topography is milder. The territory is sparsely populated—no villages are located here.

Section 3 - Tributary Arevik (Ayriget), which also forms a confluence with Meghriget near the mouth of river Kaler. The topography of tributary's basin is also lower compared to the previous one, although this is also a high-mountain environment. The territory is sparsely populated—Lichq village is here.

Section 4 - Middle section and part of the lower section of Meghriget River, up to Meghri city. This large section is characterized by relatively less steep but still incised topography. The altitude boundaries of the section vary between 800-1600 m along the river, but include higher elevations in upper tributaries to the Meghriget. The main criterion for delineation is the upper end of Meghri town. There is a hydrologic monitoring post, and EIMC water quality monitoring station here.

Section 5 - The last section is lower part of Meghriget River, from Meghri city up to the river mouth at Araks River. The altitude of the section does not exceed 800 m above the sea level. This delineated section has valley topography and a hydrologic/ water quality monitoring post.

The Karchevan River is a small river to the west of Meghri, but it shows high impact from development due to the presence of a large copper-molydenum mine and ore processing facility, the town of Agarak, and a substantial amount of agriculture in the lower reaches. Karchevan water is also supplemented by inter-basin transfer from Bughakar (middle Meghriget tributary).

The small tributaries of Araks River to the east of Meghri (Shemeglukh, Karavget, Malev, Astazurget, Shavzir, Suriget, Nuvadi-Karisbajur, and Tondoirget) are medium to low-altitude intermittent and ephemeral drainages. Most have maximum altitudes at or below 2000 m above sea level, and receive limited snowfall. These tributaries are minor and very water scarce. There are no major settlements or other major pollution sources, although the traditional villages of Aldara, Shavanidzor, and Nuvadi are located here. The agriculture in these villages is dependent on high-lift pumping from the Araks River, not local water supply. There is no need to delineate the small tributaries of Araks into discrete sections and each of them can be considered one water body.

2.2 Ground Water Classification in Meghriget

The delineation and classification of ground water bodies contributes to river basin planning through definition of the location, quality and quantity of underground water resources (aquifers) in each basin, monitoring and forecast of water supply and demand, as well as protection of water bodies from contamination and of managing their water use. The proposed method is in line with the overall strategy of implementation of EU Water Framework Directive and Armenia's water code. Delineation and classification of ground water bodies is an intermediate step between characterization of ground waters, and evaluation of their status.

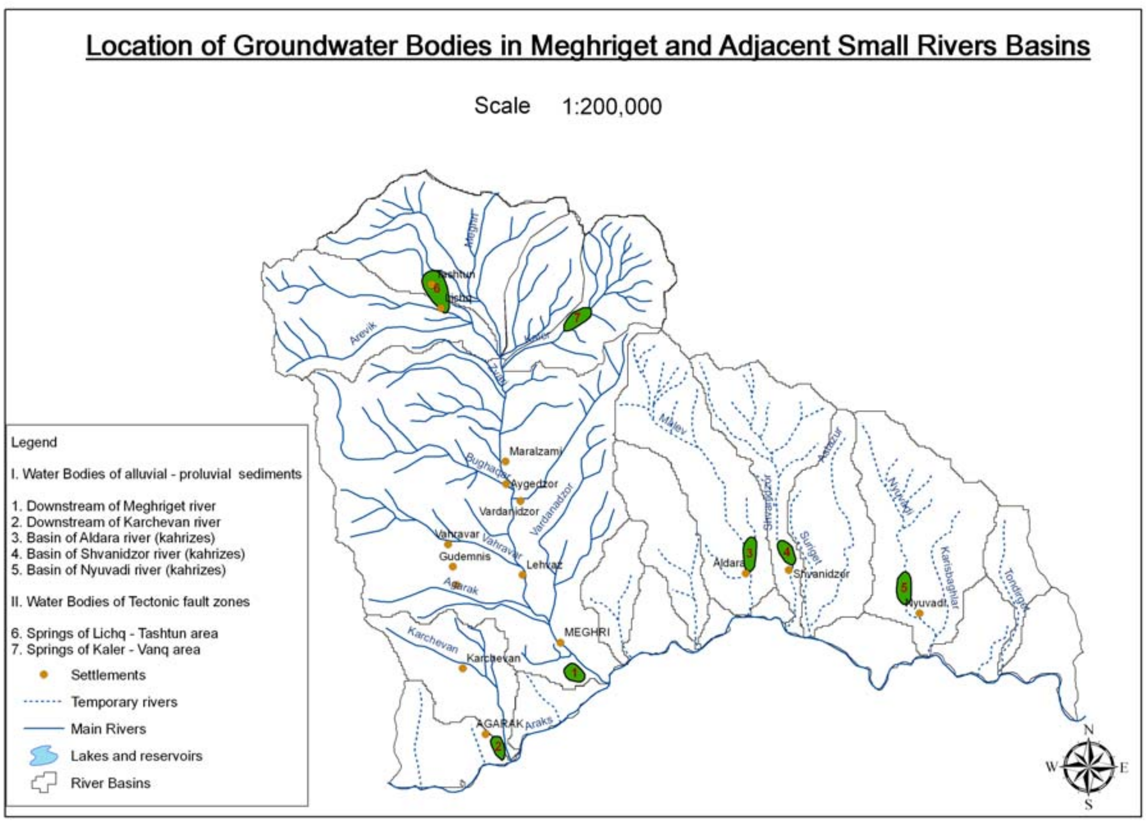
According to the above mentioned EU document "The ground water body must be a coherent sub-unit of the river basin to which the environmental objectives apply. Hence the main objective of delineating these ground water bodies is to allow their quantitative and chemical status to be evaluated, and compared to environmental objectives." The environmental objectives which will be developed (in a later section) are to prevent the pollution of ground water bodies and to maintain a balance between recharge and water abstraction (pumping).

Table 3 –Classification of underground waters of the Republic of Armenia

Geological conditions of rocks	Water bearing property of rocks	Location depth of water bodies from the Earth's surface, m	Nature of water pressure	Vunlerability of water bodies to pollution
Alluvial, colluvial, fluvial	Low water bearing	< 10	Non-pressure	Highly vulnerable
	Water bearing			
		10-100	Non-pressure Non-pressure	Slightly vulnerable
		>100	Pressure	Not vulnerable
Volcanic	Local water bearing	10-100	Non-pressure	Slightly vulnerable
	Local water bearing	>100	Pressure Non-pressure	Not vulnerable
Other rocks	Local water bearing Low water bearing	< 10	Non-pressure	Highly vulnerable
	Water bearing	10-100	Non-pressure	Slightly vulnerable

The above-mentioned geological types together with natural-climatic conditions form the below mentioned water bodies, which are not hydraulically connected (fig. 1).

Figure 1: Ground Water Bodies of Meghriget Basin

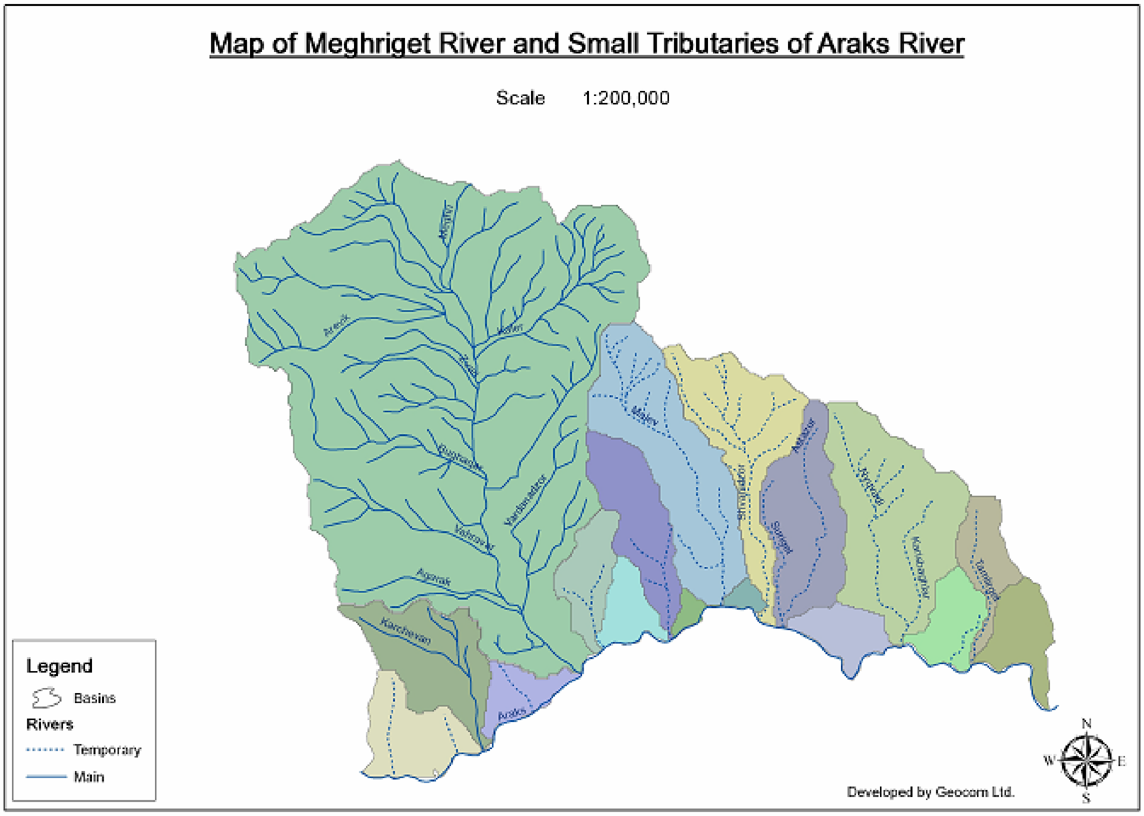


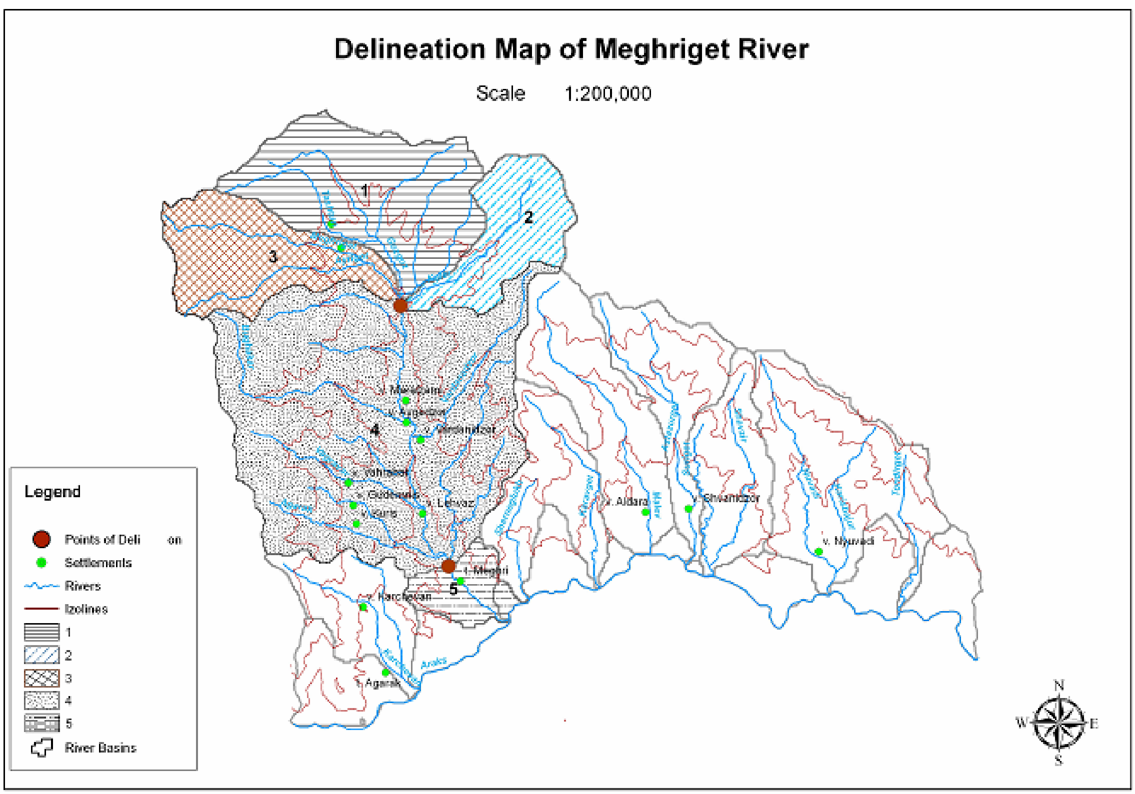
The following ground water bodies are related to alluvial-colluvial origins (non-pressure):
*lower section of Meghriget River (№1),
*lower section of Karchevan River (№2),
*Alvanq (Aldara) (№3), Shvanidzor (№4) and
*Nrnadzor (Nyuvadi) (№5).

The following water bodies are related to volcanic fault zones (local water bearing, non-pressure):
*Tashtun-Lichq (№6) and
*Kaler-Vanq (№7).

Waters collected in those bodies (№№6,7) are discharged into the surface in the form of springs. Springs of the section Tashtun-Lichq are entirely used. In the section Kaler-Vanq there are unused springs with 1 l/sec and more discharge.

Figure 2: Map of Meghriget Basin and Delineated Surface Waters in Meghriget





3. Assessing Water Body Status and Setting Environmental Objectives

Assessing water body status and setting environmental objectives is the third step in the river basin planning process. Assessing status is measuring the quality and quantity of water in a stream, lake or aquifer against water quality standards and minimum flow standards. The concept of “good ecological status” for surface waters from the EU Water Framework Directive is used here, with some simplification, because Armenia does not have biological standards for freshwaters. The concept of “good status for ground water,” meaning balance of between recharge and abstraction (pumping), and prevention of ground water pollution, is also used here.

Environmental objectives are the desired future conditions of water quality and water quantity expected for each distinct water body. These objectives (also called “targets”) are set in order to measure the progress of improvement in water resources during a river basin planning period, usually a number of years. Environmental objectives are quantitative and can be measured by monitoring. They often reflect water quality “standards” but are more specific than standards, and can vary from one class, or category, of water to another.

Modern river basin plans, such as those required by the European Water Framework Directive, require water bodies to meet biological, chemical/physical and hydrologic objectives, which in combination, reflect a desired “good water status.” In this document the focus is primarily on chemical/physical and hydrologic objectives, because Armenia has limited data available on biological conditions. In the future, with more research on Armenia’s aquatic biology, biological objectives can and should be incorporated into this system.

The first section reviews the chemical status of Meghriget basin waters, and the second section reviews the flow status. Then these analyses are applied to the process of setting environmental objectives.

3.1 Assessing Surface Water Quality Status of Waters in Meghriget basin

The methodology proposed in Guideline 3.1 is to use the Canadian Water Quality Index to evaluate the water quality status of each surface water body. The Canadian Index is simply a way to summarize complex data from numerous parameters and for a long time series of data.

There are several ways to apply this index. The nine primary indicators are chosen because they represent the most common kinds of pollution of surface waters in most regions of the world: dissolved oxygen, pH, suspended solids (TSS), dissolved solids (TDS), BOD5, nitrate, nitrite, ammonia (NH3), and phosphorus. There is also an evaluation done of the 31 basic parameters used by EIMC, which includes numerous metals and some other contaminants.

The scale applied to the water quality index is as follows:

Table 4: Stream Status is Assigned based on Canadian Water Quality Index (WQCI):

Class	Quality	Color Class	WQCI value
I	Excellent		95-100
II	Good		80-94
III	Moderate		65-79
IV	Poor		45-64
V	Very poor		0-44

In this case, we choose to use nine (9) primary indicators of water quality, and apply it to all the data from 2005 to 2008 for Meghriget river at the three sampling points which have long-term data sets. There are also three different sets of standards for Armenia: drinking water supply, recreation and fisheries, with fisheries usually being the most stringent. The results are shown in Table 5.

Table 5: Canadian Water Quality Index Results for Meghriget, using Nine Primary Parameters

Observation point, 2005-2008 data (sample point code)	Recreational-household water use		Drinking water use		FIsheries water use	
	WQCI value	Quality	WQCI value	Quality	WQCI value	Quality
Meghriget, above the junction with Gotzgotz River (89-0)	87	Good	87	Good	67	Moderate
Meghriget, above Meghri (89)	90	Good	89	Good	69	Moderate
Meghriget, Meghri River mouth (90)	92	Good	87	Good	69	Moderate

Using 31 indicators, including many of the metals, the results are as follows:

Table 6: Canadian Water Quality Index Results for Meghriget, using 31 Parameters

Observation point, 2005-2008 data (sample point code)	Recreational-household water use		Drinking water use		FIsheries water use	
	WQCI value	Quality	WQCI value	Quality	WQCI value	Quality
Meghriget, above the junction with Gotzgotz River (89-0)	85	Good	78	Moderate	70	Moderate
Meghriget, above Meghri (89)	81	Good	75	Moderate	68	Moderate
Meghriget, Meghri River mouth (90)	85	Good	78	Moderate	71	Moderate

The results illustrate several interesting points. First the Armenia fisheries standards are more demanding and require the rivers to obtain higher water quality to meet the “good status” level. Second, the fisheries water quality problems in all reaches are somewhat related to these nine primary parameters. But the drinking water and recreational water quality is already at good status when we only consider the small group of nine parameters. When we consider the larger group of parameters, including metals, then drinking water and recreational water status actually decline. This is because they are not much affected by the common nine pollutants, but some of the less common pollutants, for example metals which are present, cause these sites to fail to meet “good status” in water quality for drinking water, and only to pass marginally as “good status” for recreational waters.

Unfortunately, we do not have sufficient data for other sites in the Meghriget basin to rate their status. A very limited amount of data, and field observations, in Karchevan indicate that the lower part of that watershed has some serious water quality issues, such as extremely high turbidity and total suspended solids, which likely would make that water body “poor status” at best for fisheries, drinking water or recreation.

3.2 Setting Ecological Flow and Assessing Flow Status of Waters in Meghriget basin

To maintain a healthy aquatic ecosystem, a stream must maintain adequate flows in all seasons of the year. Most aquatic fauna and flora (fish and other species) are adapted to expect a certain characteristic pattern of flows at distinct times of year. Major alterations to these flows, especially the excessive loss of flows during the dry season, are a major stress on aquatic life. To determine if these factors affect the Meghriget River requires good data sources.

Table 7 – Monthly distribution of the flow in hydrological observation points Meghriget-Meghri and Meghriget-Lichq

Monthly Flow, %											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Meghriget-Lichq %											
1.9	1.6	2.0	6.3	18.2	29.0	20.8	8.8	4.2	2.8	2.2	2.2
Meghriget-Meghri %											
2.8	2.5	5.0	12.5	24.2	20.2	14.0	6.2	3.6	3.1	2.8	3.1

Using the table above and taking into consideration that the minimum flow in Armenian rivers is mostly observed in the month February, we conclude that the ecological flow in February is: for Meghriget-Lichq - 0.13 m^3/sec, or 8.1% of the flow, and for Meghriget-Meghri - 0.88 m^3/sec, or 35.2% of the flow. Thus, for the remaining 11 months the values of the ecological flow will be as presented in the table below:

Table 8 – Calculated ecological flow in sections Meghriget-Meghri and Meghriget-Lichq

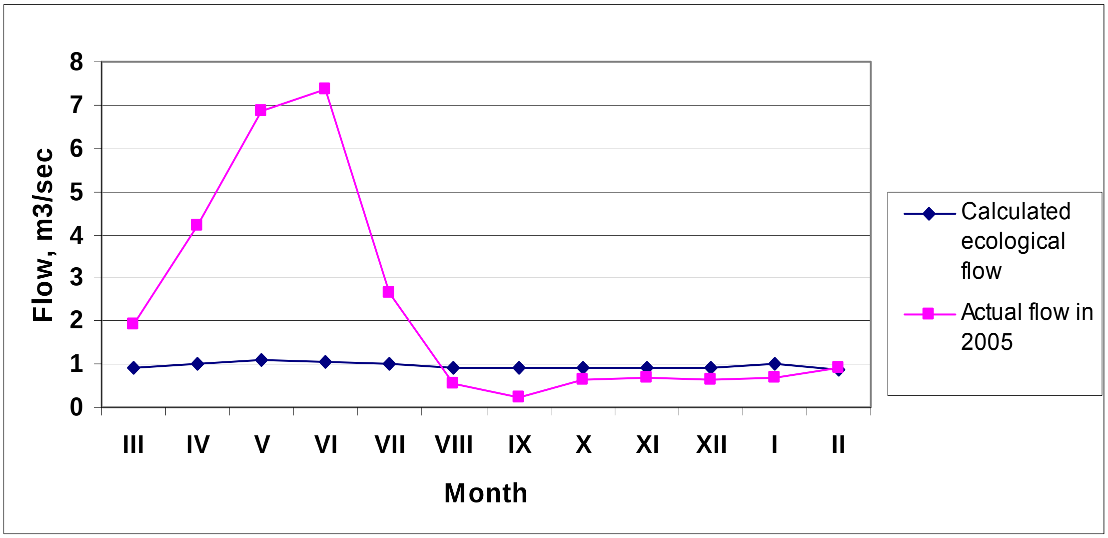
Monthly Ecological Flow, m^3/sec.											
Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Meghriget-Lichq (upstream) m3/sec											
0.13	0.13	0.14	0.15	0.16	0.16	0.15	0.14	0.14	0.14	0.14	0.14
Meghriget-Meghri (downstream) m3/sec											
1.00	0.88	0.92	1.01	1.09	1.06	1.00	0.93	0.91	0.91	0.90	0.91

Using the values from the monthly ecological flow calculation, the actual flows for 2005 at Meghri are compared to ecological flow in Table 9, and a fall in months of August, September, October, November, December and January is seen (recent data from Lichq not available). The shortfall is most acute in September, when the irrigation demands are at a maximum, and river flow is declining rapidly due to lack of any further snowmelt. Shortages in other months are rather minor compared to this major issue in August-September. Local authorities in Meghri confirmed that there is a shortage of irrigation water in late summer, but ecological needs are not explicitly recognized.

Table 9– Comparison of the calculated ecological flow and actual flow in 2005 in Meghriget-Meghri section

	Jan	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Calculated ecological flow	1	0,88	0.92	1.01	1.09	1.06	1	0.93	0.91	0.91	0.9	0.91
Actual flow in 2005	0.67	0.91	1.92	4.22	6.85	7.37	2.63	0.55	0.24	0.64	0.67	0.66

FIGURE 4: Hydrographs of Actual Flow and Minimum Ecological Flow-Meghri



3.3 Assessing Ground Water Status

In Meghriget Basin, wells are not common. The largest tube wells are in Agarak, and provide water to the industrial metals processing plant. These wells withdraw water from an alluvial aquifer very close to the Araks River. There is no available data on water quality for this ground water source, nor quantitative pumping data. We cannot assess the status of this or the other small ground water sources without data.

3.4 Application of Environmental Objectives to Meghriget basin

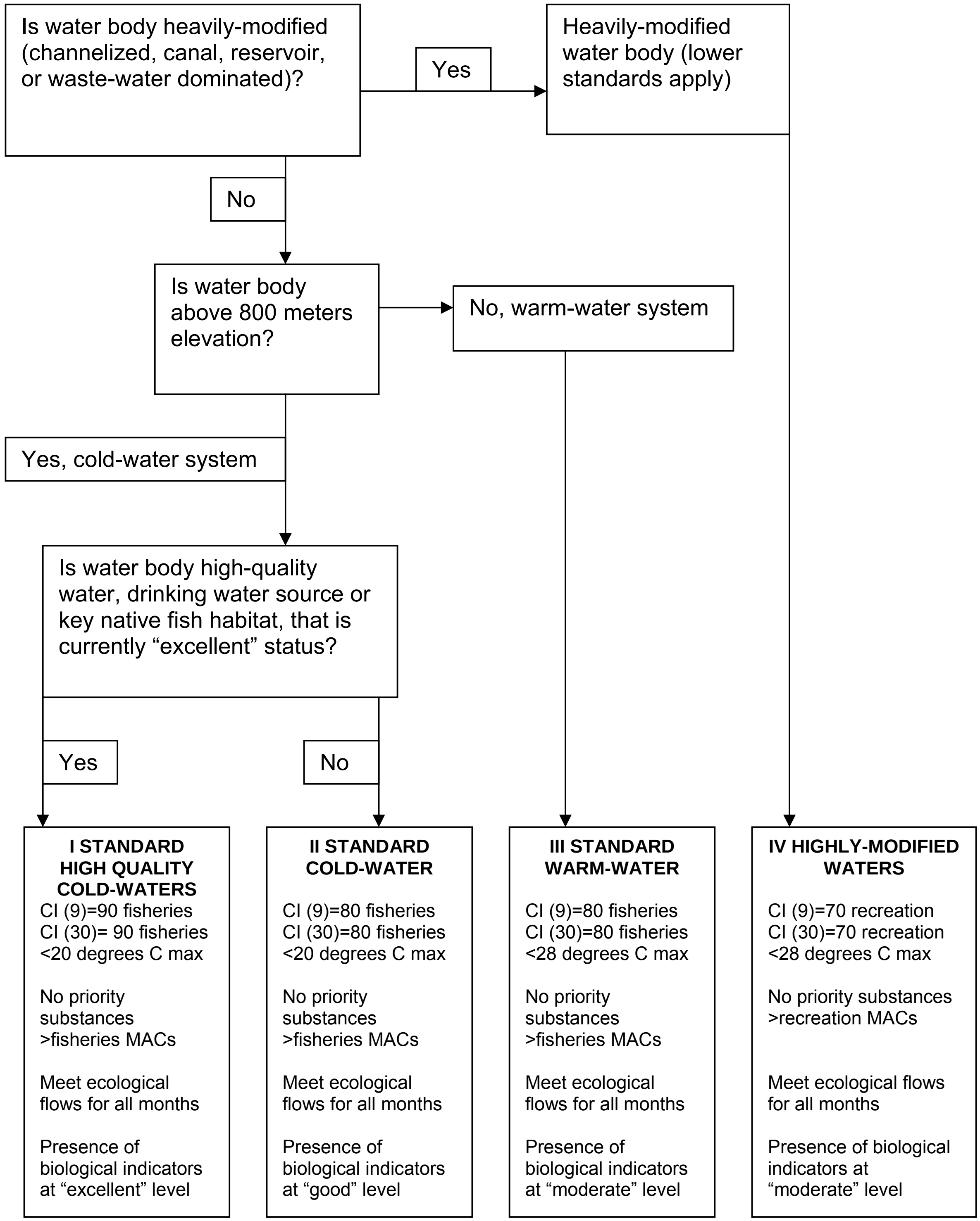
Environmental objectives must be assigned based on an understanding of the type of water body under consideration. These types are explained below, then illustrated with a flow chart:
Objectives Type I: High-quality cold-water streams: These are the streams above 800 meters elevation which already are or demonstrate the potential to be extremely high-quality sources of water and/or prime habitats for native cold-water fish, including spawning habitats for fish such as trout. Many mountain streams in remote areas of Armenia, including protected areas, probably meet this qualification, and the purpose of this system is to protect these extremely high-quality water resources by setting the environmental objectives very high. This will prevent the degradation of these waters. It will also probably prevent some types of development which would inevitably degrade these waters. So it is important to apply this designation carefully.

Objectives Type II: Cold-water streams: These are all streams with normal water temperatures below 20 degrees C throughout the year, usually above 800 meters elevation, which do not demonstrate the “high-quality” characteristics of Type I, although they may have native cold-water fish present. These streams are found in more developed parts of the country, where agriculture and light industry are expected to have some minor effects on water quality. Some of these streams are modified by hydropower or irrigation dams, but they remain substantionally natural. This is the most common type of stream in Armenia.

Objectives Type III: Warm-water streams: These are all streams with normal water temperatures in summer reaching more than 20 degrees C. in natural conditions. Most of these streams are found below 800 meters elevation, and are characterized by a warm-water fish fauna (carp, catfish).

Objectives Type IV: Highly-modified water bodies: These are streams or canals which are found in highly urbanized or industrialized areas and have been modified so that they have relatively few characteristics of a natural stream: major alteration of channel form (e.g. permanent bank protection), concurrent water temperature alterations due to domination by drainage from urban streets or industrial parks, non-natural substrates, etc. These streams may have a remnant fish population, but can never re-establish a normal ecology. These streams are found only in a few urban areas of Armenia, and should never occur in rural environments.

FLOW CHART FOR OBJECTIVES TO APPLY FOR STREAMS IN ARMENIA:



Examples of Objectives Type I streams in Southern Basin Management Organization area (Syunik Marz) include the streams in Shikahogh National Reserve, and the upper watershed streams of the Meghriget River basin, which flow from watersheds dominated by alpine areas and natural forest, and have essentially unaltered natural ecosystems. These include the Tashtun, Avriget, and Kaler tributaries to Meghriget.

Examples of Objectives Type II streams in Meghriget include the majority of streams in the river basin, such as middle and lower Meghriget, Karchevan, Malev, Astazurget. These streams are found in watersheds with both natural forests, pastures used by livestock, and agricultural operations.

Obviously, many of the **intermittent streams** (those that dry up every year in dry season) will not meet the environmental objectives throughout their length, but the objectives should be applied to those areas that demonstrate perennial flow in the upper part of each subbasin (e.g. upper Malev, upper Astazurget). The lower Meghriget is below 800 meters, and might be considered a warm-water stream, but actual data suggest the streams' water temperature stays below 20 degrees C. throughout the summer due to the influence of high-elevation snowmelt—therefore it is considered a cold-water stream.

Examples of Objective Type III streams (warm-water) do not exist within the Meghriget river basin, but are illustrated by the Araks River on the southern boundary, which is a good example of a warm-water stream (note the type of fish found in Araks are primarily warm-water species). Warm-water streams are common in Aragat valley.

Examples of Objective Type IV streams (highly-modified) do not exist in the Meghriget basin. In fact, they may not exist anywhere in the Syunik Marz, with the possible exception of urban stream channels in Goris or possibly, Kapan.

There are various types of data which can be used to make an assessment of the status of the streams:
*Water quality data (chemical and physical parameters from laboratory analysis)
*Stream flow data (minimum environmental flow analysis)
*Biological indicators (still to be developed, but native fish are likely to be used)
*Other observations by BMO or EIMC staff experienced in water quality evaluation: this can be observations of physical or biological issues made in field: e.g., high levels of algae, fish kills, extremely high turbidity, etc.

Water quality data is summarized and assessed using the Canadian Water Quality Index (see Table 1). The above flow chart shows that we have four (4) types of environmental objectives: one for high-quality cold water ecosystems, one for cold-water ecosystems, one for warm-water ecosystems and one for highly-modified water bodies. According to the Guideline 2.2 we already know that there are 12 distinct classes of surface water bodies (see Table 4 in Guideline 4). In the future, there may be justification for having a distinct set of environmental objectives for each type of stream, especially when biological indicators are fully developed. But for now, there are only four general types of environmental objectives.

In the Section below we show the result of applying this system to the Meghriget basin.

3.5 Environmental Objectives for Classified Water Bodies for the Meghriget basin

The input data are the classified water bodies with their characteristics and evaluation values for classified bodies. As a result of application of environmental objectives to classified and evaluated sections of Meghriget River itself the following tables are obtained (Table 10).

Table 10: Current Status and Specific Environmental objectives for Meghriget River

Delineated reaches of the Meghriget River	Classes	Current Status	Environmental Objectives
Meghriget, above the junction with Gotzgotz River (EIMC sampling point 89-0)	**(7)** 10-100km^2 Local importance Altitude>800m Geology – siliceous	**Moderate** CI (9)=67 fisheries CI (31)=70 fisheries Temperatures good Probably meets ecological flows (data lacking) Bio-Indicators not chosen yet	**Good (II)** **CI (9)=80 fisheries** **CI (30)=80 fisheries** **<20 degrees C max** **No priority substances >fisheries MACs** **Meet ecological flows for all months** **Presence of biological indicators at "good" level**
Meghriget, above Meghri (EIMC sampling point 89)	**(2)** 10-100km^2 Local importance Altitude>800m Geology – siliceous	**Moderate** CI (9)=69 fisheries CI (31)=68 fisheries Temperatures good Mercury (Hg) present but sufficient data lacking Does not meet ecological flow objectives Aug-Sept Bio-Indicators not chosen yet	**Good (II)** **CI (9)=80 fisheries** **CI (30)=80 fisheries** **<20 degrees C max** **No priority substances >fisheries MACs** **Meet ecological flows for all months** **Presence of biological indicators at "good" level**

Meghriget, Meghri River mouth (EIMC sampling point 90)	**(2)** 10-100 km^2 Local importance Altitude< 800m Geology – siliceous	**Moderate** CI (9)=69 fisheries CI (31)=71 fisheries Temperatures good Does not meet ecological flow objectives Aug-Sept. Bio-Indicators not chosen yet	**Good (IV)** **CI (9)=70 recreation** **CI (30)=70 recreation** **<28 degrees C max** **No priority substances >recreation MACs** **Meet ecological flows for all months** **Presence of biological indicators at "moderate" level**

Table 11: Type of Environmental Objectives and Status Assigned to all Streams/Rivers (surface water bodies) in Meghriget Basin

Name of Drainage	**Size (km^2)**	**Type of Surface Water**	**Type of Objectives*:**	**Status:**	**Quality of Data (good, fair, poor)**:**
Meghriget River (total):	336	Several (see below)			
Tashtun tributary:		1	I	**Moderate**	poor-fair
Kaler tributary:		1	I	Unknown	poor
Avriget tributary:		1	I	**Moderate**	Poor-fair
Middle Meghriget:		2	II	**Moderate**	**good**
Lower Meghriget:		2	II	**Moderate**	**good**
Karchevan	19	7	II	**Poor**	fair
Shemeglukh	13	7	II	unknown	poor
Karavget	23	7	II	unknown	poor
Malev	51	7	II	unknown	fair
Astazurget	35	7	II	unknown	fair
Shavriz-Suriget	31	7	II	unknown	poor
Nuvadi-Karisbajur	52	7	II	unknown	poor
Tondirget	12	7	II	unknown	poor
Other areas (direct to Araks):	92	7			
TOTAL:	664				

*Objectives: I=high-quality cold waters, II=cold waters, III=warm-water, IV=highly-modified water bodies

**Quality of data: Good data=multi-year data sets; Fair data=a few laboratory analyses, complemented by local information; Poor=little if any objective data

3.6 How water quality status was assigned to streams

Meghriget river reaches have good water quality data and flow data. The moderate status was given because they score below 70 on the Canadian water quality index, and these reaches do not meet their environmental flow minimums many years during August and September. Therefore they do not meet "good status" for water quality or for water quantity.

Meghriget upper tributaries (Tashtun, Avriget , Kaler) are potentially high-quality waters. They have very poor data however. Some data from EIMC point 89-0 (see Table 4) which took measurements at a point below the confluence of the Tashtun and Avriget (but above the Kaler) show that the Canadian Water Quality Index for that site is also "good" quality. This is apparently due to excessive nutrients in the spring.

The Karchevan tributary to Araks has little available data (some may exist), but a sample in 2007 obtained by American University of Armenia showed extremely high turbidity and some other exceedances. Visual observation and photos on numerous occasions have indicated that the lower Karchevan has a severe turbidity problem which is chronic, and probably a major limitation on aquatic life. Therefore, the status was assigned "poor" based on "fair" quality data: some laboratory data plus numerous observations by qualified observers.

The remaining streams in the Meghriget basin have no data. Also, these streams have no known problems, according to BMO personnel and residents of the area. It is likely that their status is moderate to good in the upper reaches where water flow is perennial. In the lower reaches where these rivers are normally dry, there is no way to assign a "status."

Status and Objective for Ground Water Bodies

The ground water bodies of the Meghriget Basin have no data available to evaluate status. Ground waters Nos. 2, 3, 4, 5 are all used as drinking water supplies, so it is assumed that microbiological tests are done periodically by Ministry of Health, but this data was not acquired. Chemical status of these ground waters is unknown, but assumed to be moderate to good, based on the nutrient and toxics status of the nearby surface waters (which are either fed by these ground water systems—No. 6 and 7; or receive recharge from these surface waters—all others).

Sampling to determine the status of these ground waters is recommended.

Table 12: Status and Objectives for Ground Waters in Meghriget Basin

Ground Water Body	Type:	Status:	Objectives:
lower Meghriget River (№1)	Alluvial, colluvial, non-pressure, depth unknown	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)
lower section of Karchevan (No 2)	Alluvial, colluvial, non-pressure, depth unknown	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)
Alvanq (Aldara) (№3),	Alluvial, colluvial, non-pressure, <10 meters	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)

Shvanidzor (№4)	Alluvial, colluvial, non-pressure, <10 meters	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)
Nyuvadi (№5).	Alluvial, colluvial, non-pressure, <10 meters	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)
Tashtun-Lichq (№6)	Volcanic fault zone, non-pressure, depth unknown (discharge as springs)	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)
Kaler-Vanq (№7).	Volcanic fault zone non-pressure, depth unknown (discharge as springs)	unknown	Balance recharge and discharge; No presence of contaminants (toxic, organic or microbiological)

4. Pressures/Impact Analysis and Identification of Measures

Introduction:
This analysis is an attempt to identify and describe surface water resource problems and their potential solutions in a logical way. It guides the river basin manager in analyzing how distinct land use and development pressures affect surface water resources, and helps to assure that solutions for surface water resource problems actually address the root problems.

The analysis of pressures and impacts on surface waters is a key step in the river basin planning process, which starts with the diagnosis of river basin issues, and concludes with the development of a prioritized program of measures to address specific components of those issues. It can be visualized as an analysis of the "components of each water resource problem." The approach used for the pressures/impacts analysis is taken from the European Water Framework Directive, and is called Driver-Pressure-State-Impact-Reponse (DPSIR).

The Driver-Pressure-State-Impact-Response (DPSIR) model used for pressures and impacts analysis is based on the following definitions:

1. Driver - Anthropogenic activities which affect water resources (e.g. population growth, agriculture, transportation, industry)
2. Pressure - Direct effects of drivers (e.g. discharge of pollutants, abstraction of water)
3. State - Physical, chemical or biological condition measured in water resource (e.g. level of contamination, change in temperature, level of bacteria)
4. Impact - Effect on aquatic ecosystem (e.g. reduction in fish, eutrophication -algae bloom, etc.) or in human health
5. Response - Proposed actions (measures) to reduce impacts by altering drivers or pressures

Impacts are the important factor of concern. But impacts can be difficult and expensive to measure. Often the "state" is used as an indicator of probable impact. "State" tends to correspond to particular sets of parameters directly measured by the monitoring team, usually EIMC in Armenia.

The relationship between "state" variables and actual impacts is usually the subject of studies in aquatic ecology or in human public health and epidemiology. Relationships between "state" and "impact" determined by valid scientific studies are generally thought to apply equally well to Armenia and to other similar climates to where the study was carried out (e.g., European studies of relationship between nutrients and eutrophication are probably valid in Armenia, unless shown otherwise).

Before applying the pressures/impacts analysis, it is necessary to qualify the **susceptibility of the water body to pollution or abstraction,** depending on its type and size, and dimensions of pressure (a small stream with large pollution loads is very susceptible, while a large river with small pollution loads is less susceptible to pressures). Urban areas close to water body make it highly susceptible, but if urban areas in sub-basin are distant from the actual water body, it is less susceptible. Wetlands act as buffer zones between urbanization and water bodies.

Pathways are the physical means by which pressures are translated into impacts (runoff, direct discharge, withdrawal by pumping systems, etc.)

4.1 Application of Pressure/ Impacts Analysis to Surface Water in Meghriget Basin

The application of the pressures and impacts analysis to the Meghriget River Basin in Southern Armenia is based primarily on information included in the River Basin Characterization Synthesis Report for Meghriget, complemented by field visits, interviews with stakeholders and with the Southern Basin Management Organization (BMO). Delineation of water bodies was done by GEOCOM, a consulting firm. Driving forces are primarily large and small-scale mining, and irrigation.

Table 13: Pressure/Impact Analysis Results
WATER BODY: Lower Meghriget River, Meghri to mouth BASIN: Meghriget

Pressures:	**Pathways:**	**Suscept-ibility:**	**State (supporting data):**	**Impacts:**
Abstraction of irrigation water upstream and in Meghri	Diversion dams	Seasonally High (Aug-Sept)	Flows reduced in late summer—no quantitative data	May affect fish habitat, water temperature
Municipal wastewater	Direct discharge (point-source) from sewer (no treatment plant)	Medium	Nutrients: High nitrate and sometimes high ammonia concentrations; ammonia above standard ; Population 4800 persons on town sewer	Ammonia can be toxic to aquatic life; potential negative effects on dissolved oxygen in summer/fall
Solid waste & stormwater in Meghri town	Leaching and direct runoff from roadsides	Medium	Suspended Sediments elevated, nutrients, BOD, slightly elevated (TSS >100 in June, 2005 when levels upstream of town not elevated)	High suspended solids; likely nutrients and BOD elevated; negative effects on benthic life
Metals mines, natural sources upstream	Unknown; leaching	Medium	Cu, Mo, Zn at very low levels from upstream areas	May have minor impact on aquatic life
Small-scale industry (food processing, vehicle maintenance) in Meghri	Direct discharge (not confirmed)	Medium	Nutrients: High nitrate levels, BOD likely elevated, but data doesn't reflect a problem; and O2 not high	Likely nutrients and BOD: none confirmed
Channel constriction	Highway and roads in town along river	Low—not a broad valley	Observations without data	Increase velocity and erosiveness of flow

Table 14: Pressure/ Impact Analysis Results II
WATER BODY: Middle Meghriget River, (this is from confluence of Kaler, Ayriget and Tashtun to upstream end of Meghri town) BASIN: Meghriget

Pressures:	Pathways:	Suscept-ibility:	State (supporting data):	Impacts:
Mining wastewater (Lichvaz area or other)	Direct discharge of tailings, leaching from adits or old mine wastes	High	Levels of mercury and Cu elevated above upstream background (note Cu in Meghri 10x higher than in Lichq)	Not known, may affect aquatic life; human risk unknown
Abstraction of irrigation water	Diversion dams	Seasonally High (Aug-Sept)	Flows reduced in late summer—as low as 0.2 m3/sec	May affect fish habitat, water temperature
Agriculture-crops and livestock manure	Runoff	Medium	Nutrient (NO3) levels high	Minimal - O_2 high due to re-aeration of fast-flowing stream
Village domestic wastewater	Direct discharge, runoff, leaching	Low	Nutrient (NO3) levels high	Minimal---population low
Road, pipeline infrastructure & construction & maintenance	Runoff and erosion	Low	Increased turbidity from suspended sediment in stream likely.	Minimal

Table 15: Pressure/ Impact Analysis III
WATER BODY: Tashtun/Lichq Tributaries to Meghriget BASIN: Meghriget

Pressures:	Pathways:	Suscept-ibility:	State (supporting data):	Impacts:
Agriculture-crops and livestock manure	Runoff	Low	Nutrient (NO3) levels high	Minimal---O2 high due to reaeration of fast-flowing stream
Village domestic wastewater	Direct discharge, runoff, leaching	Low	Nutrient (NO3) levels high	Minimal---population low
Abstraction of irrigation water	Small diversion dams	Low	None	Minimal

Table 16: Pressure/ Impact Analysis IV
WATER BODIES: Kaler/ Ayriget Tributaries to Meghriget BASIN: Meghriget

Pressures:	Pathways:	Suscept-ibility:	State (supporting data):	Impacts:
Agriculture-crops and livestock manure	Runoff	Low	None	Minimal---O_2 high due to reaeration of fast-flowing stream
Abstraction of irrigation water	Small diversion dams	Low	None	Minimal

Table 17: Pressure/ Impact Analysis V
WATER BODIES: Karavget-Sherneglukh/Malev/Astazurget/Shavriz-Suriget/Nuvadi/Tondirget BASIN: Meghriget (tribs to Araks)

Pressures:	Pathways:	Suscept-ibility:	State (supporting data):	Impacts:
Agriculture-crops and livestock manure	Runoff	Low	None	Minimal – O_2 high due to reaeration of fast-flowing stream
Abstraction of irrigation water	(Pumped Water from Araks)	Low-surface water ephemeral	None	Minimal

Table 18: Pressure/ Impact Analysis VI
WATER BODY: Karchevan BASIN: Meghriget (Agarak area-drains to Araks)

Pressures:	Pathways:	Suscept-ibility:	State (supporting data):	Impacts:
Mining waste	Direct discharge of mill waste, erosion of tailings in floodplain	High	Extremely high suspended solids, turbidity. Levels of Mo and Cu elevated above upstream background	Likely damage to aquatic life; human risk unknown
Agriculture-crops and livestock manure	Runoff	Medium	Nutrient (NO_3) levels high	Not known
Stormwater and solid waste from Agarak town	Direct discharge, runoff, leaching	Medium	Nutrient (NO_3) levels high; BOD likely an issue	Not known
Abstraction of irrigation water	Diversion	Seasonal: Medium	No data. Stream dries up in winter	Not known

4.2 Pressure/ Impact Analysis of Ground Water in Meghriget Basin

The application of the pressures and impacts analysis for ground water to the Meghriget River Basin in Southern Armenia is based primarily on information included in the River Basin Characterization Synthesis Report for Meghriget, complemented by field visits, interviews with stakeholders and with the Southern Basin Management Organization (BMO). Driving forces are primarily large and small-scale mining, and irrigation. Unfortunately no actual ground water quality or pumping data is available, so all conclusions in this section are conjecture.

From the Guideline 2.3 – Classification of underground water resources, it became clear that the most vulnerable underground water sources in the Meghriget river basin are the aquifers of alluvial-colluvial origins: lower section of Meghriget River (№1), lower section of Karchevan River (№2), Alvanq (Aldara) kyahrizes (№3), Shvanidzor kyahrizes (№4) and Nrnadzor (Nyuvadi) kyahrizes (№5). For those underground water bodies the main pressures and impacts could be identified as following (kyahriz is a traditional shallow horizontal well):

Table 19: Pressure/ Impact Analysis 19
GROUND WATER BODIES: № 1, 2, 3, 4 and 5 BASIN: Meghriget

Pressures:	**Pathways:**	**Suscept-ibility:**	**State (supporting data):**	**Impacts:**
Mining waste-Karchevan and Meghriget	Recharge to alluvial aquifer by contaminated surface water	High	High suspended solids in Karchevan river, levels of Mo and Cu elevated in Karchevan and somewhat in Meghriget.	Human risk unknown
Metals mines, natural sources upstream	Unknown; leaching	Medium	Cu, Mo, Zn at very low levels in surface water of Meghriget	Not known
Solid waste & storm water in Meghri town	Recharge of direct runoff from roadsides	Medium	Suspended Sediments elevated, nutrients, elevated in lower Meghriget	Likely nutrients (NO3) elevated
Agriculture-crops/livestock	Recharge from runoff	Medium	Nutrient (NO_3) levels high	Not known
Storm water and solid waste from Agarak town	Recharge from runoff-Karchevan	Medium	Nutrient (NO_3) levels high; BOD likely an issue	Not known
Abstraction of irrigation water-Agarak	Pumping	Seasonal : Medium	No data. Stream dries up in winter	Not known

4.3 Identification of Proposed Measures

Once the pressures/ impacts analysis is finished, the identification of measures can proceed. The measures should be developed using a participatory process as outlined in the guideline 5.2 section. Key stakeholders, particularly local government (Marz authorities in territorial administration, agriculture, health), private industry, water user groups, and environmental groups working with the BMO, should propose a variety of measures for each specific impact, usually using a “brainstorming” type of approach. At this stage the measures are conceptual, that is they do not need a cost, or to be dimensioned; the concept is sufficient.

Measures should be identified by specific water body. In some cases very similar measures are needed in various water bodies. During the meetings to develop the mix of measures, one of the key tasks is to decide which measures should be applied at a broader geographic scale than a single water body.

The following are examples of measures suggested for Meghriget river basin. Although not generated by the requisite participatory process, they provide useful examples.

Table 20: Proposed Measures I

Water Body: Lower Meghriget (below Meghri) Basin: Meghriget River

Pressure:	Impact:	Proposed Measures:	Responsible Authority:
Abstraction of irrigation water	Reducing flow below ecological minimum, affecting fish habitat and increasing water temperature	1) Adjust water use permits for Aug-Sept. period using ecological flow guidance. 2) Improve water conveyance structures and reduce withdrawals in Aug-Sept. 3) Study irrigation storage options for upper river	1) BMO 2) Water user associations 3) Marz authorities
Municipal wastewater discharge	Ammonia toxicity to aquatic life, depressing O2 in late summer	1) Study options for simple treatment (sludge settling and simple oxidation pond) 2) Review options for re-use as irrigation water	1) Marz authorities 2) Marz authorities
Agriculture-crops and livestock	Nutrient levels high, especially in spring	1) Review livestock and crop-management practices for runoff risks—especially manure management in spring; note problem areas for educational efforts	1) Marz agriculture dept.
Solid waste and stormwater in Meghri town	High suspended solids, nutrients, bacteria and BOD washed into river, may be health hazard and negative effects on benthic life	1) Develop solid waste management program for Meghri 2) Do annual clean-up/ education program 3) Study stormwater management options	1) Municipal authorities 2) Municipal authorities 3) Marz authorities
Small-scale industries (food-processing and vehicle maintenance)	Likely increase in nutrients/BOD; possible oil and grease	1) Review the WU Permits for nutrients/BOD 2) On-site inspection of vehicle maintenance facilities to assure safe disposal of lubricants (oil/grease)	1) BMO 2) BMO
Channel constriction in town	Possible flood hazard in Meghri town due to loss of channel capacity	1) Study flood peaks impact on channels in Meghri town (combine with stormwater study)	1) Marz authorities

Table 21: Proposed Measures II

Water Body: Middle Meghriget Basin: Meghriget River

Pressure:	Impact:	Proposed Measures:	Responsible Authority:
Mining wastewater	Mercury and Cu (both toxic to aquatic life) may affect aquatic life, possible risk to human health	1) Do quarterly monitoring of Hg and Cu above Meghri, various sites. 2) Review discharge permits for mining operations; inspect sites	1) EIMC 2) BMO

Pressure:	Impact:	Proposed Measures:	Responsible Authority:
Abstraction of irrigation water	Reducing flow below ecological minimum, affecting fish habitat and increasing water temperature	1) Adjust water use permits for Aug-Sept. period using ecological flow guidance. 2) Improve water conveyance structures and reduce withdrawals in Aug-Sept. 3) Study irrigation storage options for upper river	1) BMO 2) Water user associations 3) Marz authorities
Agriculture-crops and livestock	Nutrient levels high	1) Review livestock and crop-management practices for runoff risks—especially manure management; note problem areas for educational efforts	1) Marz agriculture dept.

NOTE: Other water bodies in the Meghriget Basin, other than Karchevan (see below) do not have specific measures designed for them, because the pressures and impacts are not so severe, and the susceptibility of the water bodies are estimated to be LOW.

Table 22: Proposed Measures III

Water Body: Karchevan Basin: Meghriget River

Pressure:	Impact:	Proposed Measures:	Responsible Authority:
Mining waste discharged	Mo, Cu and suspended solids elevated, likely damage to aquatic life, risk to human health unknown	1) Do quarterly monitoring of Hg Mo, and Cu below Agarak 2) Review discharge permits for mining operations; inspect sites, develop clean-up plan with company 3) Get clean production audit, and develop option for reducing wastes	1)EIMC 2) BMO 3) Agarak mining company
Mining waste deposited in floodplain areas	Mo, Cu and suspended solids elevated	1) Develop clean-up plan for wastes in floodplain of Karchevan	1) BMO with Agarak mining
Abstraction of irrigation water	Reducing flow below ecological minimum, affecting fish habitat and increasing water temperature	1) Adjust water use permits for Aug-Sept. period using ecological flow guidance. 2) Improve water conveyance structures and reduce withdrawals in Aug-Sept. 3) Study irrigation storage options for upper river	1) BMO 2) Water user associations 3) Marz authorities
Agriculture-crops and livestock	Nutrient levels high	1) Review livestock and crop-management practices for runoff risks; note problem areas for educational efforts	1) Marz agriculture dept.
Solid waste and stormwater in Meghri town	High suspended solids, nutrients, bacteria and BOD washed into river, may be health hazard and negative effects on benthic life	1) Develop solid waste management program for Meghri 2) Do annual clean-up/ education program 3) Study stormwater management options	1) Municipal authorities 2) Municipal authorities 3) Marz authorities

5. Final Step: Review of Measures

Review of the program of measures is the fifth step in a river basin plan. The measures proposed in the preceding steps are potential activities which can help resolve water resource problems in the basin. This step involves evaluating those measures to determine which are potentially most effective, most efficient, most environmentally sound, and in sum, highest priority.

One of the key tools for evaluating the potential measures is economic analysis. Another important aspect of the review is participatory evaluation of measures. Stakeholders who understand the water resource problems in their own area, and the resources locally available for solving those problems, must be involved in selecting the most appropriate solutions. Broad participation in decision-making is a key to success at this stage of river basin planning.

The following tables present the proposed program of measures for the Meghriget River Basin Concept Plan. Each measure refers to a water resource issue being addressed in a particular water body. For each measure there is a proposed responsible lead agency, a short set of activities, and some qualitative criteria for each activity. The criteria are:
are *Environmental Review required? Environmental assessment is required by Armenian Law (known as "Environmental Expertise") for all major projects, especially infrastructure. For each project, the requirment is listed as "yes/no."

*Economic Benefit? This is a rough estimate of whether the activity will generate a positive number of of jobs, and/or extra income for existing workers and employers.

*Capital Cost? This is a rough qualitative estimate of the size of capital investment required. There is no scale, but each symbol "+" can be thought of as an order of magnitude.

The purpose of these three categories is to initiate the discussion of activities in the Concept Plan. Activities which require no environmental impact assessment, generate positive income/employment, and have no capital cost may be the most feasible, and easiest to initiate. On the other hand, projects requiring environmental study and a high capital cost, probably are difficult to realize, no matter how good the economic benefits.

A typical example of a project which is difficult to initiate would be an irrigation storage dam, due to its high capital costs, complex environmental problems of all dams (almost regardless of siting), and problematic cost/benefit ratios of many projects.

The purpose of this list of activities is to initiate discussion with the stakeholders. For this reason it is qualitative and the comparison criteria are meant simply to aid the internal discussion of options with stakeholders. Some of these options may be discarded before the final river basin plan is adopted. New options may be generated. And the highest rated options must be more thoroughly investigated before the river basin plan is finalized. But this exercise gives the framework for the set of activities which will become the core of the river basin plan.

Table 23: Program of Measures for Meghriget River Basin
(Lower Meghriget Section—Meghri town and below):

Economic benefit*		Capital Cost:
+++ very positive	---very negative	+++very high
++ positive	-- negative	++ high
+ minor positive	- minor negative	+ moderate

Issue:	Proposed Measure:	Responsible Agency:	Environmental Review Required:	Economic Benefit	Capital Cost:
1. Over-abstraction for irrigation	1) Adjust water use permits for Aug-Sept. period using ecological flow guidance.	1) WRMA-BMO	No	--	0
	2) Improve water conveyance structures and reduce withdrawals in Aug-Sept.	2) Water user associations	Yes	+	++
	3) Study irrigation storage options for upper river (Lichq reservoir)	3) Marz authorities	Yes	++	+++
2. Municipal wastewater discharge	1) Study options for simple treatment (sludge settling and simple oxidation pond)	1) Marz authorities	Yes	-	+++
	2) Review options for re-use as irrigation water	2) Marz authorities	Yes	+	+
3. Agriculture-crops and livestock	Review livestock and crop-management practices for runoff risks—especially manure management in spring; design best management practice & educational efforts	Marz agricultural staff with BMO support	No	+	0
4. Solid waste and stormwater in Meghri town	1) Develop solid waste management program for Meghri	Municipal authorities	Yes	-	++
	2) Do annual clean-up/ education program	Municipal authorities	No	?	0
	3) Study stormwater management options	Marz authorities	Yes	+	+
5. Small-scale industries)	1) Review the WU Permits for nutrients/BOD	WRMA-BMO	No	?	?
	2) On-site inspection of vehicle maintenance facilities to assure safe disposal of lubricants (oil/grease)	2) WMRA-BMO	No	?	?
6. Channel constriction/ flood risk	Study flood peaks impact on channels in Meghri town (combine with stormwater study)	Marz authorities	Yes	+	++

* Economic benefit means probable increase in employment and/or incomes

(Middle Meghriget River Section and Tashtun, Avriget, Kaler water bodies):

Issue:	Proposed Measure:	Responsible Agency:	Environmental Review Required:	Economic Benefit	Capital Cost:
1. Over-abstraction for irrigation	1) Adjust water use permits for Aug-Sept. period using ecological flow guidance.	1) WRMA-BMO	No	--	0
	2) Improve water conveyance structures and reduce withdrawals in Aug-Sept.	2) Water user associations	Yes	+	++
	3) Study irrigation storage options for upper river	3) Marz authorities	Yes	++	+++
2. Mining wastewater	1) Do quarterly monitoring of Hg and Cu above Meghri town, at various sites.	EIMC	No	?	0
	2) Review discharge permits for mining operations; inspect sites of all mines, active and inactive	WRMA-BMO	No	?	0
3. Agriculture-crops and livestock	Review livestock and crop-management practices for runoff risks—especially manure management in spring; design best management practice & educational efforts	Marz agricultural staffs with BMO help.	No	+	0

Program of Measures for Meghriget River Basin (Karchevan River)

Issue:	Proposed Measure:	Responsible Agency:	Environmental Review Required:	Economic Benefit	Capital Cost:
1. Mining and mill wastewater discharge	1) Do quarterly monitoring of Hg and Cu above Agarak-and at Meghri highway bridge over Karchevan	EIMC	No	?	0
	2) Review discharge permits for mining and milling operations; inspect sites of all mines, and mills, active and inactive	WRMA-BMO	No	?	0
2. Mining waste in floodplain	Develop clean-up plan and schedule for wastes in floodplain of Karchevan	WRMA-BMO with mining corporation.	Yes	-	+
3. Agriculture-crops and livestock	Review livestock and crop-management practices for runoff risks—especially manure management in spring; design best management practice & educational efforts	Marz agricultural authorities with BMO help	No	+	0
4. Over-abstraction for irrigation	1) Adjust water use permits for Aug-Sept. period using ecological flow guidance.	WRMA-BMO	No	--	0
	2) Improve water conveyance structures and reduce withdrawals in Aug-Sept.	Irrigators groups	Yes	+	++
5. Solid waste and stormwater in Agarak town	1) Develop solid waste management program for Agarak	Municipal authorities	Yes	--	++
	2) Do annual clean-up/ education program	Municipal authorities	No	?	0
	3) Study stormwater management options	Marz authorities	Yes	+	+