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Assessment of Water Supply System, Ambrolauri
Republic of Georgia

Technical Report Number 8

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Integrated Natural Resources Management in the Republic of Georgia Program

Technical Report Number 8

Assessment of Water Supply System, Ambrolauri

Republic of Georgia

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Table of Contents

List of Acronyms and Abbreviations

1. ^{o}C – Temperature degree by Celsius scale
2. CENN – Caucasus Environmental NGO Network
3. Cfu - Colony forming unit
4. D – Diameter
5. E. coli – Escherichia Coli
6. EU – European Union
7. FIU-Florida International University
8. GIS – Geographic Information Systems
9. GLOWS – Global Waters for Sustainability
10. GNEWRC - Georgian National Energy and Water Regulatory Commission
11. GWP – Georgian Water and Power
12. INRMW – Integrated Natural Resources Management in Watersheds
13. LLC – Limited Liability Company
14. L - liter
15. L/sc – Liter per second
16. m – meter
17. m^3 – cubic meter
18. mm - millimeter
19. m^2 – square meter
20. mg/l – milligram per liter
21. ml - milliliter
22. NGOs – Non-governmental Organizations
23. ROFIU-GE – Representative Office of Florida International University in Georgia
24. UNESCO –United Nations Educational, Scientific and Cultural Organization
25. UNESCO-IHE – Institute for Water Education
26. USAID – United States Agency for International Development
27. UWSCG – United Water Supply Company of Georgia
28. WHO – World Health Organization
29. WI – Winrock International
30. WSP – Water Safety Plan

1. Introduction

In September 2010, USAID-Caucasus launched a four-year program entitled: "Integrated Natural Resources Management in Watersheds of Georgia" (INRMW-Georgia), implemented within the framework of an umbrella program "Global Water for Sustainability" (GLOWS) by a consortium of international and national organizations under the leadership of Florida International University (FIU), in partnership with CARE International, Winrock International (WI), UNESCO-IHE, and the Caucasus Environmental NGO Network (CENN).

Within the INRMW framework, among various planned activities, it is envisaged to develop Water Safety Plans (WSPs) for six cities (Akhmeta, Telavi, Dedoplistskaro, Oni, Ambroaluri and Senaki) in the pilot watershed areas of the Rioni and Alazani-Iori river basins. To accomplish this task, a local WSP team was established with support of UNESCO-IHE. In accordance with the program work plan, the work was divided into two stages. During the first stage, WSPs were to be developed for four cities (Akhmeta, Telavi, Oni, and Ambroaluri) of the upper pilot watershed areas of the Alazani-Iori and Rioni Basins. During the second stage WSPs were to be developed for urban areas (Dedoplistskaro, Senaki) in the lower pilot watershed areas of Alazani-Iori and Rioni Basins. Assessments of water supply systems are baseline studies for WSPs that include a detailed description of centralized water supply systems, and identification of existing and potential hazards, hazardous events/situations/hazard sources and an assessment of their risks.

The present report is a detailed assessment of the water supply system for the city of Ambrolauri. It includes a description of the system, identification of existing hazards to drinking water quality, their sources and related hazardous events/situations together with water safety risk assessments. In addition, the report includes a list of recommended control measures to avoid and/or mitigate risks, together with management and monitoring measures, a description of the methodology used to gather data of the existing water supply system, an identification of hazards, an assessment of their risks and a determination of control measures. The report will serve as a basis for developing the WSP for the water supply system of the city of Ambrolauri in accordance with WHO guidelines.[1]

[1] World Health Organization (2005) Water Safety Plans: Managing Drinking-water Quality from Catchment to Consumer. WHO/SDE/WSH/05.06, http://www.who.int/water_sanitation_health/dwq/wsp170805.pdf

2. Methodology

Assessments of water supply systems in the targeted cities of pilot watershed areas are based on WHO guidelines that recommend investigation of existing systems from source to tap together with identification of hazards, their sources and/or hazardous events/situations imposing hazards to water safety, and assessment of their risks.

The analysis is based on information and data collected by the WSP team directly from the United Water Supply Company of Georgia as well as through site inspections of water supply systems from the catchment to the consumer and interviewing of local staff of the company based on sanitary observation questionnaires.

The WSP team visited each pilot city to collect information and elaborate flow diagrams which reflect all units of water supply systems from catchment to point of use. The following aspects were assessed:

- Land use in the catchment area;
- Abstraction method and location;
- Likely changes of water quality at the source;
- Detailed description of the water supply system;
    - Intake unit and treatment facilities and methods;
    - Water disinfection;
    - Water distribution system;
    - Storage (service reservoir, tankers);
    - Network;
- Water consumption and consumers;
- Drinking water quality monitoring procedures, databases and availability of trained staff.

In the next step the WSP team identified hazards, their sources and/or related hazardous events/situations and assessed risks. More specifically, the team identified all potential biological, physical and chemical hazards associated with each step/element of the drinking water supply system that can affect the drinking water safety followed by a basic risk assessment of these hazards. The final step for the drinking water supply system assessments was the determination of control measures for each hazard and hazardous event/situation, together with key capacity development (support) and monitoring measures and re-assessment of risks in terms of likelihood and impact taking into consideration effectiveness of each control measure[2]. Risks were prioritized in terms of their likely impact on the capacity of the system to deliver safe water.

[2] The means by which risks may be controlled

3. Institutional and Legal Frameworks for the Drinking Water Supply Sector

Currently, issues related to potable water are regulated by laws on Public Health, Water, and Mineral Resources, as well as by a number of regulations. In accordance with the water law, during the allocation of water resources, first priority is given to water allocation for drinking and bathing purposes. Furthermore, the law requires establishing water sanitary zones for water bodies used for drinking water purposes. Rules for sanitary zones are further defined by the order of the Minister of Health and Social Protection on Ambient Environmental Quality Standards (16 August 2001). The law on Mineral Resources of Georgia requires licensing of ground water abstractions for drinking water supply (for more details see relevant parts on surface waters and mineral resources)[3]. The law on Public Health divides responsibilities among various ministries with regard to water safety. The list of laws and regulations governing the potable water supply sector is given on the following page.

Drinking water quality standards and rules for drinking water quality monitoring are set out in the "Technical Regulation on Drinking Water" approved by the #349/N Decree, 17.07.2007 of the Minister of Health, Labor and Social Protection.[4] More specifically, the regulation defines rules of self-monitoring to be conducted by water suppliers. The "Technical Regulation on Drinking Water" is based on the Georgian Law on Public Health, WHO recommendations, EU directives, and regional characteristics including climate and relief conditions. The document regulates the quality of natural and treated tap water as well as the quality of bottled water. It does not cover the quality of small water supply systems with a capacity of 10m^3/day serving less than 50 persons as well as natural mineral waters, where the mineralization exceeds 1,500 mg/l. The regulation sets requirements against common parameters of smell, taste, color and turbidity as well as against organoleptic, microbiological, intra-microbiological, epidemiological, chemical composition, including inorganic and organic substances (common pesticides and individual organic pesticides) and radioactive safety of potable water (See annex 4). The quality of water in a natural water body intended for drinking water use should not exceed ambient water quality standards set out by the #297/N Decree of the Minister of Labor, Health and Social Affairs on "the Approval of Ambient Environment Quality Standards", issued on 16.08.2001.[5]

According to the "Technical Regulation of Drinking Water", rules for state compliance assurance monitoring and control of drinking water quality including components to be checked, frequency of sampling and analysis methods should be defined by the relevant law enforcement agency, currently by the Service of Food Safety, Plant Protection and Veterinary Service of the Ministry of Agriculture. In case the state laboratory of the Ministry of Agriculture does not have enough capacity to carry out drinking water quality testing, it may delegate its functions/outsource the assignment to an accredited independent laboratory. In cases where the required standards are not met under the Technical Regulation, the supplier of drinking water is liable to carry out appropriate measures, including reporting to relevant authorities, identification of pollution sources, restriction of water supply and implementation of corrective measures for the safety of the population[6].

[3] Technical Report 1. Rapid National Assessment, February 2011, http://www.globalwaters.net/wp-content/uploads/2012/12/Technical-Report-1-Repid-National-Assesemnet-of-Legal-Policy-and-Institutional-Settings.pdf
[3] https://matsne.gov.ge/index.php?option=com_ldmssearch&view=docView&id=52384&lang=ge;
[4]: i) http://www.momxmarebeli.ge/images/file_955911.pdf; ii) http://water.gov.ge/uploads/kanonmdebloba/standarti.pdf; iii) P. 105, Annex 4, Technical Report 1. Rapid National Assessment, February 2011, http://www.globalwaters.net/wp-content/uploads/2012/12/Technical-Report-1-Repid-National-Assesemnet-of-Legal-Policy-and-Institutional-Settings.pdf
[5] https://matsne.gov.ge/index.php?option=com_ldmssearch&view=docView&id=52384&lang=ge;
[6] For more details on water related issues please see INRMW technical report 1. Rapid National Assessment at http://www.globalwaters.net/projects/current-projects/inrmw/

The legal relations between the water supplier and the consumer are regulated by the "Rules on Drinking Water Supply and Consumption" adopted by the Georgian Energy and Water National Regulatory Commission, dated 26 November 2008.

Below is given the list of laws and regulations governing the drinking water supply sector:

- Water Law.[7]
- Law on Public Health. [8]
- #297/N Decree of the Minister of Labor, Health and Social Affairs, 16.08.2001 on "Approval of Ambient Environment Quality Standards".
- #349/N Decree of the Minister of Labor, Health and Social Affairs of Georgia, 17.07.07 on "Technical Regulation of Drinking Water".
- #59 Decree of the Minister of Environment, 07.05.1998 on the "Approval of the Provision on Water Protection Zone".[9]
- Law on Sanitary Protection Zones of Resorts and Resort Areas, 20.03.1998
- #16/N Decree of the Minister of Health, Labor and Social Protection, 22.01.2004 on the "Approval of the Guidelines for Hygienic Assessment of Materials, Chemicals, Equipment and Technologies Used in Centralized Water Supply Systems".
- #15/N Decree of the Minister of Health, Labor and Social Protection, 22.01.2004 on the "Approval of Sanitary Rules on Drinking Water Sampling".
- #17/N Decree of the Minister of Health, Labor and Social Protection, 22.01.2004 on the "Approval of Sanitary Rules on Water Treatment by UV Radiation.
- #250/N Decree of the Minister of Health, Labor and Social Protection, 15.09.2006 on the "Approval of Sanitary Rules on Chlorination of Centralized Urban and Rural Waters Supply Systems and Disinfection of Technical Facilities of these Systems".
- #32 Ordinance, 26.11.2008 of the GNEWRC on the "Approval of the Rules on Drinking Water Supply and Consumption".
- #18 Ordinance, 29.08.2008 of the GNEWRC on the "Approval of the Methodology for Setting Out Water Use Tarrifs".
- #14 Ordinance, 26.11.2008 of the GNEWRC on "Penalizing Illegal Users of Centralized Water Supply and Sanitation Systems".
- #17 Ordinance, 17.08.2010 of the GNEWRC on "Water Use Tariffs".
- # 10 Decree, 30.01.2009 of the Government of Georgia on "Approval of the Charter of the Ministry of Regional Development and Infrastructure".
- Regulations of the "United Water Supply Company of Georgia" LLC Approved by the Order No 02/01 dated 1st March 2010 Of The director of "United Water Supply Company of Georgia" LLC. [10]

The institutional framework for potable water supply management sector is as follows:

[7] http://nfa.gov.ge/files/kanonebi/wylis_shesaxeb.pdf
[8] http://www.nsc.gov.ge/files/files/legislations/kanonebi/sazogadoebrivi%20janmrteloba.pdf
[9] https://matsne.gov.ge/index.php?option=com_ldmssearch&view=docView&id=80770
[10] http://water.gov.ge/uploads/kanonmdebloba/debuleba5.pdf

- The Ministry of Labor, Health and Social Protection sets out ambient water quality standards in accordance with WHO guidelines.
- The Ministry of Agriculture carries out state control of drinking water quality.
- The Ministry of Environmental Protection develops and coordinates implementation of state water resources management policies and protection of water bodies from pollution and exhaustion. Currently, as a result of the parliamentary elections of October, 2012, reorganization of the Ministry is ongoing. More specifically, the agency of natural resources, together with environmental inspectorate will be moved to the Ministry of Environmental Protection from the Ministry of Energy.
- The Ministry of Regional Development and Infrastructure is responsible for state planning and coordination of development of water supply systems throughout Georgia. Provision of water supply to the Georgian population, except for the populations of Tbilisi, Mtskheta, Rustavi and the Autonomous Republic of Ajara is carried out by the State Company "The United Water Supply Company of Georgia", LLC, owned by the Regional Development Ministry. It has regional branches and subordinated to these branches are service centers in all relevant regions, including regions targeted by the INRMW program. More specifically, the Company has seven regional branches: i) Kakheti, ii) Shida Kartli and Mtskheta-Mtianeti, iii) Kvemo Kartli, iv) Samktskhe-Javakheti, v) Samegrelo, Zemo Svanety and Guria, vi) Imereti, Racha-Lechkhumi and Kvemo Svaneti and, vii) Kutaisi. These branches have their laboratories, which conduct monitoring activities for drinking water quality in the urban water supply system under their responsibility.
- The Georgian National Energy and Water Regulatory Commission (GNEWRC) sets out water supply and consumption rules, approves methodologies for setting up water use tariffs, sets water use tariffs, and approves rules on penalizing illegal water users, including those illegally discharging wastewaters in sanitation systems
- Georgian Water and Power (GWP) is a leading company in the water supply market of Georgia. The company provides water supply services to the population of Tbilisi and its neighborhoods, as well as to State organizations, industrial and commercial objects. The company also delivers wastewater services to the capital. GWP serves about 400 000 customers throughout the city, out of which about 2000 are budget organizations, 15 000 are commercial objects and the rest are residential customers.

4. Description of Water Supply System from Catchment to Consumer

The water supply system of the City of Ambrolauri operates under the Imereti, Ratcha-Lechkhumi and Kvemo Svaneti Regional Office of the United Water Supply Company of Georgia. The Service Centre of Ambrolauri consists of 15 employees, of which 11 are technical-engineering and operational staff. Please see Annex 7, Pic. 1.

The city is located in west Georgia, 550 m above sea level at the confluence of the Rioni and Krikhula rivers.

Four headworks: "Skhvava" (N43°13'49.174" E42°29'38.383"), "Krikhi" (N43°9'18.27" E42°29'44.227"), "Khoteura" (N43°10'38.036" E42°29'34.394") and "Ghurghuleti" (N 43°9'28.242" E42°29'40.729") are used for the abstraction of drinking water. From all four headworks the water is delivered to the city by gravity flow. Please see Annex 1 and 3.

4.1 Main Characteristics of the Water Source and its Catchments

Land use. The headworks are located in places that are not easily accessible and no agriculture or other anthropogenic activities are currently carried out at nearby territories. These areas are predominately represented by forest-covered mountains and rocky mountains. Only headworks „Skhvava" is located near a small settlement. Please see Annex 7. Pic. 2.

Water intake sources. All four water sources represent springs of ground water emerging mostly from karst aquifers.

In general, ground water in the upper pilot watershed area of the Rioni River Basin, where Ambrolauri municipality is located, belongs to the fracture and fractured-karst waters of Racha-Lechkhumi artesian basin contained in Meso-Cenozoic sediments forming a homogenous Syncline. Peripheral parts consist of Jurassic and lower Cretaceous sediments and central parts consist of sediments of upper Cretaceous and Cenozoic origin. Major aquifers occur in layers of Mid-Jurassic volcanic, Lower and Upper (Late) Cretaceous limestones, Neocene limestone and Quaternary alluvial-deluvial sediments. Lower Cretaceous aquifers contain karst and karst-porous groundwater, flowing on the surface as strong springs. Upper Cretaceous layers that are not widespread also consist of karst waters. Recharge areas are located in the upper parts of the Syncline and discharge areas – in the lower parts.[11]

More specifically, as it was mentioned above, Ambrolauri receives water from four headworks: Skhvava, Krikhi, Khoteura and Ghurghuleti. Skhvava and Khrikhi headworks are located in the watershed of the Khrikhula river, while Khoteura and Ghurguleti – in the watershed of Khoteura River.

[11] Detailed description of natural resources of Upper Rioni Pilot Watershed Area, including water, land and biological resources are included in the following reports: i) INRMW Technical Report 2. Rapid Assessment of the Rioni and Alazani-Iori River Basins of Georgia. http://www.globalwaters.net/wp-content/uploads/2012/12/Technical-Report-2-Rioni-Alazani-Iori.pdf ;ii) "ENVIRONMENTAL ASSESSMENT: INTEGRATED NATURAL RESOURCES MANAGEMENT IN WATERSHEDS OF GEORGIA (INRMW-GEORGIA), for Activity 4: Implementation of Resource Management Plans Implemented under: INRMW-Georgia Under DCN: 2010-GEO-015. DCN: 2012-GEO-064. http://www.globalwaters.net/wp-content/uploads/2012/12/INRMWPEAfinal.pdf and; iii) Technical Report 12. Detailed Assessment of the Natural Resources of the Upper Rioni Pilot Watershed Area , http://www.globalwaters.net/projects/current-projects/inrmw/

In these two catchments karst, fractured-karst, karst-stratal and karst-porous waters contained in the aquifer of Paleocene and Upper Cretaceous carbonate rocks (limestone, marl) as well as in the waterbearing complex of Cemonian, Apt-Alb stage Upper and Lower (Early) Cretaceous impermeable marl and clay deposits are found. Khoteura, Ghurghuleti and Krikhi headworks fall within the distriution area of the above first and the Skhvava headworks within the above second water bearing horizon.[12]

Abstraction method and location. The sources of the Skhvava headworks start from the rocky mountains of the gorge of the Krikhula River. Water is abstracted through a water collector located at 772 m above sea level. The size of the 1st sanitary zone of the headworks is 120 m² and is located 8 km from the city.

The Krikhi headworks is located at 624 m above sea level; water is abstracted by a spring water collection system. The area of the 1st sanitary zone is 100 m² and is located 3.5 km from the city.

The spring water collector of the Khoteura headworks is located at 688 m above sea level. The size of the 1st sanitary zone is 300 m² and is located 3.6 km from the city.

The spring water collector of the Ghurghuleti headworks is located at 678 m above sea level. The area of the 1st sanitary zone is 50 m² and is located 3.4 km from the city.

None of these four headworks and sanitary zones is fenced or guarded/supervised, which poses a threat to the water quality.

Water quality issues at sources. Routine deterioration of the water quality is predominately caused by heavy rains, which wash sediments out of karst sediments and increase the turbidity of ground water. During these events water quality does not meet national drinking water quality standards (physical parameters: color and turbidity). Technological treatment of the source water (clarification and filtration) is not provided at the headworks due to the absence of relevant technical facilities.

Another potential cause for deterioration of water quality (microbiological cause) might be unprotected Headworks. Domestic and wild animals can easily access the unprotected water catchment area, which could result in the animal fecal matter entering the water supply system and affecting the quality of the source water.

4.2 Description of Water Supply System

4.2.1 Water Abstraction and Treatment

The flow diagram of the water supply system of Ambrolauri is presented in Annex 3.

The Skhvava headworks consists of three water collector points with the following specifications (please see Annex 7. Pic. 2): N1 - collector well, 3 m x 2.5 m square and 1.4 m deep, with a concrete bottom; N2 - collector well, 4 m x 2.3 m square and 1.2 m deep, with an unlined bottom and; N3 – collector well, 4 m x 2.1 m square and 1 m deep, with an unlined bottom. Water discharge, in an ordinary case, is 40 L/sc at the intake point (70 L/sc is a maximum) (please see Annex 7. Pic. 2-5). The water intake facility was partially repaired in 2008 (part of the collecting pipes and valves of the collector wells were replaced). Other headworks are composed of only one collector well each.

The Krikhi headworks is an 8 m x 2.2 m square iron-reinforced concrete well with an unlined bottom, 1.7 m in depth. Average water discharge is 5-8 L/sc. The headworks was repaired in 2008.

[12] Technical Report 12. Detailed Assessment of the Natural Resources of the Upper Rioni Pilot Watershed Area

The Khoteura headworks is a 5 m x 4 m square iron-reinforced concrete well with an unlined bottom, 1.8 m in depth. Average water discharge is 28-35 L/sc. The headworks is protected by a dam from the riverside. The water intake was repaired in 2001. Please see

The Ghurghuleti headworks is a circular well (D=2. 3 m, H=1. 7 m in area), with an average water discharge of 5-6 L/sc. The water intake facility has not been repaired since its development. Currently, the technical condition of the headworks is not satisfactory; the intake construction used for water abstraction is out of date and is in poor condition.

In most cases headworks structures are damaged to different extents because no fundamental maintenance/rehabilitation has been carried out since the Soviet period. Water intake facilities are not fenced or guarded, no technological treatment or disinfection is provided at headworks, and water abstracted at the headworks goes directly to the main pipe of the water supply system.

4.2.2 Water Conveyance and Distribution

From the headworks water flows into the water mains with a total length of about 17.5 km. All headworks have their own water mains, except for Ghurghuleti headworks, where collector pipes transfer water from the headworks to the water main of the Khoteura headworks. Water mains were renovated in 2007, 2009 and 2011; 50 % of the iron and cast iron pipes were replaced by plastic (PVC) pipes. Currently, overall condition of the water mains is satisfactory. At 600 m above sea level there are three reservoirs (total capacity of 1000 m^3) (please see Annex 7. Pic. 7) with the following volumes: N1 – 500 m^3; N2 – 400 m^3 and N3 – 100 m^3. The reservoirs are located near the village Itsa. They are made of iron-concrete. N2 and N3 reservoirs are rectangular; N1 is circular. Chlorination with liquid chlorine takes place immediately prior to water entering the reservoirs[13]. In this area, there is a laboratory for monitoring of residual chlorine. Please see Annex 7. Pic. 8-9. Control of residual chlorine is carried out every day by an operator at fixed times. Results are recorded in a journal. From reservoirs, disinfected water is routed to the distribution network. The area of collectors is fenced and guarded. From the N2 reservoir the water is elevated 20 m with a 30 m^3/h capacity electrical pump[14] and flows 2 km to a fourth reservoir (N4 - 100 m^3 tank located at 620 m above sea level in 2 km far from N2 reservoir), which supplies one small section of the city. All four reservoirs are underground tanks and are in satisfactory condition. The reservoirs are fenced and managed by operators. Other than testing for residual chlorine, no water quality or quantity monitoring is carried out.

From the N2 and N3 water abstraction points of the Skhvava headworks, water flows out through 200 mm diameter pipes to join the water main (300 mm diameter and 7.5 km long pipe) transferring water from abstraction point N1 to 400 m^3 storage reservoirs, where water disinfection with liquid chlorine is carried out. The old section of the water main is iron pipe (4.9 km) and the new one – PVC (2.6 km) replaced in 2011. The entire water main is laid on the ground surface. 1.4 km of its iron section is corroded and leaking at a number of places. Please See Annex 7. Pic. 6.

From the Khoteura headworks, water flows through 220 mm diameter and 3.5 km long water main into 500 m^3 volume reservoir (N 1) near the village Itsa, where chlorination takes place. From this point water is provided to the distribution network. In 2007, a 1.4 km section of the water main was replaced by 200 mm PVC pipe. The remaining part of the pipe (1.6 km in length) is dilapidated (e.g. the pipe is corroded and leaking).

[13] During field assessment of the water safety, dry (lime) method of chlorination was used by the water company. However, recently this method of water desinfection was replaced with chorination by liquid chlorine.
[14] In accordance with UWSCG, pump was recently removed

From the Ghurghuleti headworks, water flows through a 110 mm diameter and 250 m long steel pipe and joins the 220 mm diameter water main of the „Khoteura headworks“ that was rehabilitated in 2007.

From the headworks Krikhi, water is provided to the city without reservoirs by 160 mm diameter and 3.5 km long main pipe made of plastic (PVC). In 2007, 1.5 km long section of the pipe was rehabilitated, the remaining 2 km section is in satisfactory condition.

The total length of the city's distribution network is about 23 km. During last years, part of the network was replaced by polyethylene pipes. The water pressure regime in the main pipes is balanced from the reservoirs. The pressure in the distribution network of about 3-4 bar is regulated by valves.

4.2.3 Water Use and Consumers

The water supply system of Ambrolauri city serves 702 customers, out of which 611 are households and 91 organizations. Most of the city has 24-h water supply.

According to resolution #17 (17 August 2010) of the Georgian National Energy and Water Supply Regulation Commission on Water Supply Tariffs, consumers with water meters pay 0.423 GEL per m^3 (including the price for sanitation service); the tariff for consumers without water meters is set at 2.03 GEL per capita (including the price for water sanitation service). Organizations (legal entities) pay 3.65 GEL per 1 m^3 of water (for the time being this rate includes the price for sanitation service). The process of installation of water meters has not yet started in Ambroaluri. Hence, the local population pays a flat tariff of 2.03 GEL per capita.

According to the Ambrolauri Service Center of Georgian United Water Company, the average maximum amount of drinking water consumption for households is 800 l per day (especially from late spring to early autumn), which is estimated without individual water meters. This amount is high and may be attributed to the 24-hour working regime of 4 storage/regulating reservoirs (with a total capacity of 1,100 m^3 and recharge rate of 2.7 hours), capacity of water supply springs and water losses in the network, which is approximately 10% according to the Service Center. Daily water consumption in the city of Ambrolauri is extremely high in comparison with the established rate by European countries, which varies from 120 to 150 l/day per resident.

5. Risk Assessment

Identification of hazards, their sources and potential hazardous events/situations as well as risk assessment of the Ambrolauri water supply system were conducted through field observation/inspection of the system using a special sanitary inspection questionnaire. This approach is based on WHO WSP guidelines (2005)[15], which recommend the identification of hazards and hazardous events by using sanitary observation questionnaires. This questionnaire should be elaborated for sanitary inspection of key points of the water supply system (headworks, water treatment plant, and main and distribution network, etc.) and water abstraction methods (e.g. drilled wells, pit wells, spring water collectors, etc.).

Stemming from the fact that almost all key components of water supply systems have the same problems and pose the same risks to water safety, sanitary inspection questionnaires were elaborated for entire water supply systems and not for particular elements. Furthermore, a risk prioritization matrix using hazard likelihood and impact criteria was developed and the risks were prioritized based on this matrix.

5.1 Compliance of Drinking Water Quality with National Standards

Monitoring parameters, sampling points and frequencies are defined by the Georgian Technical Regulation on Drinking Water, 2007. Please see Annex 4. Regular water quality monitoring of the Ambrolauri system currently focuses on the following basic set of parameters: *Microbial parameters* – *E. coli and total coliforms*; *Physical parameters* - taste, odor, color, turbidity, temperature; *Chemical parameters* – residual chlorine, pH, total hardness, nitrites, ammonium chlorides, sulfates, and iron.

The laboratory control of water is carried out by the Service Centers of UWSCG; water quality monitoring points are set up by the central office of UWSCG and are in compliance with the Georgian Technical Regulation on Drinking Water, 2007. For all water supply systems, control points should include:

i) Water intake (surface water filtrate).
ii) Water intake (ground water).
iii) Release points (treated water).
iv) Distribution network.

Water quality monitoring for the Ambrolauri Drinking Water Supply System is carried out by the laboratory of the Amrolauri Service Center of UWSCG (Please see Annex 7, Pic. 10 and 11). The Laboratory is in satisfactory condition, though the chemical analysis equipment is old (made in USSR). Samples from the different points of the distribution network are taken once a day and from the headworks once a month and analyzed for parameters listed above.

Assessment of drinking water quality for the Ambrolauri water supply system is based on 2011 water quality monitoring data (see annex 5). According to these data, 796 samples were collected, from which 754 were collected from the distribution network, 21 – from released (treated) water and 21 --

[15] World Health Organization (2005) Water Safety Plans: Managing Drinking-water Quality from Catchment to Consumer. WHO/SDE/WSH/05.06, http://www.who.int/water_sanitation_health/dwq/wsp170805.pdf

from the ground water sources[16]. Table 1 reflects Drinking water quality compliance with the national standards in 2011.

Table 1. Drinking water quality compliance with the National Standards for the Ambrolauri Drinking Water Suppy System, 2011[17]

Monitoring Point	Number of samples	Compliance with the National Standards %			
		Compliance		Non-compliance	
		Number of samples	%[18]	Number of samples	%
Ground water source (raw water)	21	19	90	2	10
Released (treated) potable water	21	17	81	4	19
Potable water in distribution system	754	725	96	29	4
In total	796	761	96	35	4

The table shows that although most components of the water supply system were in compliance with the National Standards, there were instances of non-compliance in 2011. The figures in the table show that 81% of samples from released (treated) potable water and 90% of samples from ground water sources (raw water) meet the National Standards. 754 samples were collected from the distribution network and among them, 29 (4%) samples did not meet requirements. This might be caused by the damaged distribution system, inadequate chlorination process and/or water interruptions.

In order to identify issues related to particular parameters, additional information was requested from the service center laboratory staff. Based on this information it was learned that non-compliance of water quality with the national standards was generally due to microbiological contamination – non-compliant concentrations of total coliform bacteria and E.coli. Physical parameters in general met the national standards, except in May and June, when water transparency was not in compliance with the standards. According to chemical parameters, water quality met national standards. However, concentration of residual chlorine was sometimes lower than the national standard (0.3 – 0.5 mg/l). It is unknown if chlorination was not conducted in these instances or if it was conducted insufficiently.

Concerning contagious diseases, for the city of Ambrolauri, statistics for 2011 show one case of acute viral hepatitis B and 14 cases of bacterial intestinal diseases. However, there is no evidence that these cases resulted from water contamination. For detailed information please refer to Annex 6.

5.2 Identification of Hazards, their Sources and Potential Hazardous Events/ Situations

For identification of hazards, their sources and potential hazardous events/situations and assessment of risks, visual observation of the water supply system was conducted by the WSP team jointly with the representatives of the local Service Center of United Water Supply Company of Georgia. In addition, a sanitary inspection questionnaire was developed, handed out and filled in by the technical personnel of the Ambrolauri Water Supply Service Center. It consisted of 10 questions with “Yes” or “No” answers. The sum of the “Yes” answers gave the scale/level of the risk divided into following classes: 9 -10 = Very High, 6-8 = High, 3 -5 = Medium, 2-0 = Very Low/no risk.

Stemming from the fact that the situation in all headworks is the same (with little differences), sanitary inspection questionnaire was elaborated for entire water supply systems and not for particular elements.

[16] From this monitoring data it is difficult to judge which parameters are not in compliance with the national standards
[17] Source: UWSCG
[18] Rounded off to the nearest whole number

Presented below is the completed questionnaire for Ambrolauri water supply system. The answers for all headworks were identical.

As defined in the WHO WSP Guidelines (2005):

- *A hazard is any biological, chemical, physical or radiological agent that has the potential to cause harm.*
- *A hazardous event is an incident or situation that can lead to the presence of a hazard (what can happen and how).*

Table 2. Questionnaire for sanitary observation

#	Question	Yes	No
1	Is the area around the catchment not protected?	X	
2	Do animals have access to the area around the catchment?	X	
3	Are there any solid or liquid waste collecting sites within 30 m of the catchment?		X
4	Is there any source of pollution within a 10 m radius of the catchment (e.g. animal breeding, cultivation, roads, industry etc.)?		X
5	Are coagulation and sedimentation tanks absent?	X	
6	Is the main pipeline corroded or damaged?	X	
7	Is water treatment plant absent?	X	
8	Is the chlorine tank improperly arranged?	X	
9	Has there been a discontinuity in water supply in last 10 days?		X
10	Does the community report any pipe breaks in the last week?	X	
In total		7	3

As shown from the aggregate responses to the questions of the Inspection Questionnaire, 7 positive responses out of 10 questions were received indicating that the system belongs to the **high risk category**.

Thus, the WSP team has identified the following hazardous events/situations/sources of water contamination:

1. Absence of a sanitary protection zone around the headworks, leaving these structures easily accessible to wild animals and livestock.
2. Damaged water abstraction facilities in the headworks.
3. Absence of any preliminary water treatment stage (sedimentation/coagulation reservoir, chlorination) at intakes.
4. Presence of large corroded and damaged sections in main pipes.
5. Improper design and out of date technologies for chlorination.
6. Frequent interruptions in water supply.
7. Frequent accidents in distribution systems.

All above listed hazardous events/situations/hazard sources may lead to any of three hazards: i) deterioration of physical properties of the drinking water, ii) microbial contamination of the drinking water and; iii) chemical contamination of the drinking water. Bacteriological hazards may cause the spread of water borne diseases, in particular during heavy rains, floods, increased air temperatures and droughts. Chemical contamination and deterioration of organoleptic (physical) properties (e.g.

odor, taste, color, transparency) of drinking water are also possible, though no significant chemical pollution source was found in the catchment of the water source.

5.3 Prioritization of Hazards

In accordance with WHO WSP guidelines (2005), hazards revealed for the whole water supply scheme were prioritized by application of a risk assessment matrix. Risks were quantified according to categories of hazards (e.g. microbial, chemical, etc.) for various hazardous events/situations/sources of hazards, as suggested in the WHO WSP guidelines.

By WHO WSP definition, risk is the likelihood (probablity) of identified hazards causing harm in exposed populations in a specified timeframe, including the magnitude of that harm and/or the consequences.

The risk of hazards was assessed by two factors: likelihood and potential impacts (results of water quality self-monitoring of the water supply system). The likelihood was expressed by anticipated occurrences of hazards identified through the sanitary observation of the system. Hazards threatening the water supply system were prioritized using the matrix in Table 3. The priority matrix is based on risk scores of the sanitary inspection questionnaire and water quality monitoring data received from UWSCG.

Table 3. Hazard prioritizing matrix for Ambrolauri water supply system

Deviations from drinking water quality standards, %	**Sanitary inspection score (SIS)**			
	0 – 2	3 – 5	6 – 8	9 – 10
71-100	0	0	0	0
31 – 70	0	0	0	0
11-30	0	0	0	0
1-10	0	0	4[19]	0
Risk level	low	medium	high	very high
Priority action level	none	low	**high**	urgent

Despite the fact that 761 (96%) water samples out of 796 meet the national standards and just 35 (4%) deviated from the standard according to the results (score 7) of the sanitary questionnaires, the entire system, including the distribution network, is assessed at *high risk*. The water supply points scored as "yes" on the sanitary inspection form represent the potential sources/factors of hazards for microbiological contamination of drinking water.

Thus, on the basis of the sanitary questionnaire and hazard prioritizing matrix for Ambrolauri water supply system, biological, chemical and physical contamination risk factors were identified that have a negative impact on the quality of drinking water and cause a hazard of exposure to water borne diseases or chemical contamination. In more detail, on the basis of visual inspection and the results of the sanitary observation questionnaire, the following components/steps of water supply system were identified as the most probable causes of contamination of potable water:

- Water disinfection;
- Headworks;
- Reservoirs;
- Main pipes and distribution network.

[19] The figure reflects (in total) deviation from standards, identified at all monitoring points

Apart from above, technical conditions and capacities of water testing laboratory and the quality of the water testing can be considered as factors that may indirectly impact the water quality. As it was described in the above paragraphs of this chapter, water testing equipment of the laboratory of the Ambrolauri Service Center is in good working condition and is operated and maintained by qualified chemists and operators. However, the equipment is old and accuracy/precision is thus more difficult to maintain. Furthermore, monitoring at headworks is carried out only once per month. This is judged to be insufficient given that the majority of headwork structures are damaged, water intake facilities are not fenced or guarded, no technological treatment or disinfection is provided and water abstracted at the headworks goes directly to the main pipe of water supply system. Regardless, the water quality testing component/step was not included in the identification of hazards and hazardous events/situations, because it is not a source for water contamination and represents the means for tracking the progress towards achieving operational limits/targets (in our case, national drinking water quality standards). Meanwhile, we have included measures related to the improvement of water quality testing as recommendations for inclusion the WSP.

To calculate a priority score (based on WHO guidelines) for each identified hazard we used semi-quantitative risk assessment and a prioritization matrix. The objective of this matrix is to rank hazardous events and identify the most significant hazards. Risk ratings, calculated based on the likelihood and severity of impact, were made based on matrices of tables 4 and 5.

Table 4. Definitions for likelihood and consequence/impact categories that could be used in hazard prioritization.

Rank	Level of likelihood/impact	Description of a level of likelihood/impact
	Likelihood	
A	Very high likelihood	Very frequent (e.g. to happen continuously or at least once a day)
B	High likelihood	Frequent (e.g. to happen at least once a week)
C	Moderate likelihood	Moderately frequent (e.g. to happen at least once a month)
D	Low likelihood	Rare (e.g. to happen at least once a year)
E	Very low likelihood/Unlikely	Very rare (e.g. to happen at least once every 5 years)
	Impact/consequence	
5	Catastrophic: Public health impact	Mortality expected from consuming water
4	Major: Regulatory impact	Morbidity expected from consuming water
3	Moderate: Aesthetic impact	Major aesthetic impact possibly resulting from the use of alternative but unsafe water sources
2	Minor: Compliance impact	Minor aesthetic impact causing dissatisfaction but not likely to lead to use of alternative less safe sources
1	Insignificant: No impact or not detectable	No detectable impact

Table 5: Qualitative risk analysis matrix – risk categories

	Consequences				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
A	H	H	E	E	E
B	M	H	H	E	E
C	L	M	H	E	E
D	L	L	M	H	E
E	L	L	M	H	H

Note: The number of categories should reflect the need of the assessment.

E – Extreme risk, immediate action required; H – High risk, management attention needed; M – Moderate risk, management responsibility must be specified; L – Low risk, manage by routine procedures.

Based on the above matrices each identified hazardous event/situation/hazard source was ranked against the level of hazard risk. The results are given in Table 6.

Table 6. Evaluation of hazard levels for Ambrolauri water supply system

Drinking water supply system component	Hazardous event/situation/hazard source	Hazard	Likelihood	Impact/severity	Qualitative risk
Water treatment	Inadequate disinfection *Insufficient amount of residual chlorine in water system*	*Microbial pathogens*	D *Recently manual chlorination by chlorinated lime was replaced with automatic chlorination by liquid chlorine that guarantees more effective water disinfection and minimum human error*	4	*H* *(High risk, management attention needed)*
Water treatment	Inadequate Disinfection *High amount of residual chlorine in water system*	*Chemical*	D *Recently manual chlorination by chlorinated lime was replaced with automatic chlorination by liquid chlorine that guarantees more effective water disinfection and minimum human error*	4	*H* *(High risk, management attention needed)*
Water treatment	Absence of disinfection *Possibility of water contamination at any stage of water supply*	*Microbial pathogens*	A *There is no chlorination of Krikhi source water*	4	*E* *(Extreme risk, immediate action required)*
Water treatment	*Increased water turbidity and changed color during heavy (seasonal) rains (especially at the Ghurghuleti intake facility)*	*Physical*	C *Water sources represent ground waters (karst-origin waters) which is easily impacted by heavy rains. Besides, technological treatment of water is not carried out*	3	*H* *(High risk, management attention needed)*
Headworks and water abstraction points	Domestic and wild animals can access the water catchment area, which could result in the *animal faecal matter entering the water supply system*	*Microbial pathogens*	D *The headworks is located in areas not easily accessible by humans and animals; the likelihood of contamination is not high*	4	*H* *(High risk, management attention needed)*
Headworks and water abstraction points	People may access the water catchment area and purposefully or unintentionally discharge chemicals into the wells *leading to chemical pollution of the source water;* Significant source of chemical pollution may exist in the catchment *and may pollute source water*	*Chemical*	*E* *Headworks is fenced but not guarded/ supervised 24 hours a day. However, the area is not easily accessible by humans; besides, there no single case of the source wate chemical contamination recorded; No serious source of chemical pollution was detected in the catchment; Therefore, the likelihood of source water chemical pollution is very low*	*5*	*H* *(High risk, management attention needed)*

Headworks and water abstraction points	Damaged headworks structures may result *in easy access of organic and chemical pollutants into source water*	*Microbial, physical chemical*	*D Headworks structures are damaged to different extents because no fundamental maintenance/rehabilitation has been carried out. The most damaged is the Ghurghuleti headworks. Regardless of the fact that in 2011 only 10% of samples from headworks didn't comply with national drinking water standards, these data are not sufficient enough to judge about the frequency of source water contamination due to insufficient number of samples taken and possible measurement errors of the laboratory. However, stemming from the fact that headworks are located in remote unpopulated areas with no/low human activities there, the likelihood of source water contamination is not high*	4	*H (High risk, management attention needed)*
Headworks and water abstraction points	*Increased water turbidity and changed color during heavy (seasonal) rains (especially at the Ghurghuleti intake facility)*	*Physical*	C *Water sources represent ground waters (karst-origin waters) which is easily impacted by heavy rains. Besides, technological treatment of water is not carried out*	3	*H (High risk, management attention needed)*
Reservoirs	Domestic and wild animals can access the reservoirs	*Microbial Physical*	E *The territory of reservoirs is fenced and protected, reservoirs are in a satisfactory condition and bird and other animal faecal are unlikely to enter the reservoir*	4	*H (High risk, management attention needed)*
Main pipes and distribution network	Damaged pipes and insufficient pressure and water interruption can *result in backflow from customer systems into the network*	*Microbial pathogens*	B *At some points of the pipes are damaged, backflow prevention devices are not installed in all service connections*	4	E *(Extreme risk, immediate action required)*

6.0 Determination and Validation of Control Measures

6.1 Determination of Control Measures

WSP control measures were determined based on information and data collected by the WSP team through interviewing of the staff of Ambrolauri Service Center, visual inspection of the system and analysis of existing drinking water quality data. At the assessment stage, control measures are suggested as recommendations to be included in the WSP as planned actions. In addition to measures to control risks, necessary monitoring and other management measures are suggested to be included in the WSP.

To mitigate hazards and ensure safe drinking water for the population of Ambrolauri the following control measures are recommended to be carried out:

1. Source and Source Protection

- Rehabilitation of an old intake point of the Ghurghuleti headworks.
- Rehabilitation of the Skhvava and Khoteura headworks.
- Fencing of water intake facility sanitary zone (where it is possible) and provision of 24-hour guard/supervisor at all headworks to avoid the potential hazard of surface contamination of source water in case of anthropogenic involvement at the intake point/territory.

2. Water Treatment

- Carrying out chlorination in compliance with corresponding norms.
- Ensuring chlorination of water from Krikhi headworks at the reservoirs.
- Modernization of chlorination procedure and technology.
- Installation of water technological treatment modules (sedimentation and clarification tanks) at headworks (where it is possible).

3. Reservoirs

- Cleaning of reservoir bottoms periodically.
- Modernization of reservoirs with technical equipment (water level meter, window for observation , etc.).

4. Water Mains and Distribution System

- Replacement/rehabilitation of damaged 1.4 km long section of D - 300 mm main steel pipeline connecting the Skhvava intake to the city.
- Rehabilitation of damaged 1.6 km long section of D - 220 mm main steel pipeline connecting the Khoteura intake with the city.
- Installation of water meters to detect drinking water leakages.
- Detailed inventory of the water supply system and development of GIS-based comprehensive database to include data on technical characteristics of the system, drawings, maps. etc.

Regarding water quality monitoring, the following measures are recommended to be carried out:

- Equipping the water testing laboratory with modern equipment and conducting training for laboratory staff.
- Elaboration of an accurate and detailed database of laboratory testing results (particularly microbe contamination parameters).
- Development of a plan for how to inform the population about incidents of water contamination and what protection measures should be taken from their side (boiling, etc.) to avoid waterborne diseases.
- Regular trainings for service personnel to introduce new approaches to improve potable water quality monitoring and water safety plans.

Summary information on identified hazards, hazardous events and control measures for Ambrolauri water supply systems is given in Table 7.

Table 7. Identified Hazards and control measures for Ambrolauri water supply system

#	Drinking water supply system component	Hazardous event/situation/hazard source	Hazard	Risk level	Control measures
1	**Water traeatment**	Inadequate disinfection *Insufficient or high amount of residual chlorine in water system*	Microbial pathogens Chemical	H *(High risk, management attention needed)*	***Short term strategy:*** • Carry out chlorination in compliance with corresponding norms • Check concentration of residual chlorine ***Long term strategy:*** • Modernize chlorination procedure and technology
		Absence of disinfection *Possibility of water contamination at any stage of water supply*	Microbial pathogens	E *(Extreme risk, immediate action required)*	***Short term strategy:*** • Ensure chlorination of water from Krikhi headworks, by connecting to the chlorination stage at the reservoirs ***Long term strategy:*** • Modernize chlorination procedure and technology
		Increased water turbidity and changed color during heavy (seasonal) rains (especially at the Ghurghuleti intake facility)	Physical	H *(High risk, management attention needed)*	***Short term strategy:*** • Interrupt water supply during high turbidity ***Long term strategy:*** • Arrange water technological treatment modules (sedimentation and clarification tanks) at headworks (where it is possible)
2	**Headworks and water abstraction points**	Domestic and wild animals can access the water catchment area, which could result in the *animal faecal matter entering the water supply system*	Microbial pathogens	H *(High risk, management attention needed)*	***Short term strategy*** • Appoint guard for supervision of water intakes • Fence water intake facility sanitary zone (where it is possible) ***Long term strategy*** • Rehabilitate and modernize damaged water intake units
		Damaged headworks structures may result *in easy access of organic and chemical pollutants into source water*	Microbial, physical *Chemical*	H (High risk, management attention needed)	***Short term strategy*** • Appoint guard for supervision of water intakes • Fence water intake facility sanitary zone (where it is possible) ***Long term strategy:*** • Rehabilitate and modernize damaged water intake units

		People may access the water catchment area and purposefully or unintentionally discharge chemicals into the wells *leading to chemical pollution of the source water;* Significant source of chemical pollution may exist in the catchment *and may pollute source water*	*Chemical*	*H (High risk, management attention needed)*	***Short term strategy*** • Appoint guard for supervision of water intakes • Fence water intake facility sanitary zone (where it is possible)
		Increased water turbidity and changed color during heavy (seasonal) rains (especially at the Ghurghuleti intake facility)	*Physical*	*H (High risk, management attention needed)*	***Short term strategy:*** • Interrupt water supply during high turbidity ***Long term strategy:*** • Arrange water technological treatment modules (sedimentation and clarification tanks) at headworks (where it is possible)
3	**Reservoirs**	Domestic and wild animals can access the reservoirs	*Microbial Physical*	*H (High risk, management attention needed)*	***Short term strategy:*** • Clean reservoir bottoms periodically ***Long term strategy:*** • Modernize reservoirs with technical equipment (water level meter, window for observation , etc.)
4	**Main pipes and distribution network**	Damaged pipes and insufficient pressure and water interruption can *result in backflow from customer systems into the network*	*Microbial pathogens*	E *(Extreme risk, immediate action required)*	***Short term strategy:*** • Ensure corresponding water pressure in the pipes by installing additional valves ***Long term strategy:*** • Assess hotspots and carry out full rehabilitation of the main pipes and network • Install water meters

6.2 Risk Reassessment and Validation of Control Measures

After detailed description and identification of hazards for Ambrolauri water supply system, the next steps consist of risk reassessment and validation with technical personnel and the head of the Ambrolauri service center. For this purpose under the INRMW program a meeting was organized with the management team of Ambrolauri water supply service center. In this meeting consultants from UNESCO-IHE and a team working on water safety plans participated. The team presented actual and potential hazards to the Ambrolauri water supply system, risks which can provoke deterioration of drinking water quality and also control measures related to these risks (Table 7).

In general, hazards, their sources, related hazardous events and control measures presented by the working group were approved and judged acceptable for the Ambrolauri Water Supply Service Center with certain comments, particularly:

- Increasing of frequency of monitoring residual chlorine levels;
- Priority should be given to installation of the settling tank/basin, which would help prevent the threat of turbid water entering the system and reaching consumers;
- Washing valves should be installed at the respective points in the distribution network, which would help to periodically wash out residual material from the distribution network;
- Earthquakes should be taken into consideration during the rehabilitation of the water supply units as one of the potential hazards for damage of the water supply system;
- For timely protection against turbid waters, automatic shutters should be installed on reservoirs.

For effective implementation of the control measures, the following supporting programmes should be implemented:

- Laboratory capacity building for improving water quality monitoring;
- Defining the actual water demand and losses (elaboration of water balance);
- Developing a hydraulic model;
- Elaboration of long term development plans for the water supply system.

A consolidated list of hazards, related hazardous events/hazard sources and suggested control measures, monitoring and supporting programs which include above mentioned remarks, is presented in table 8 below.

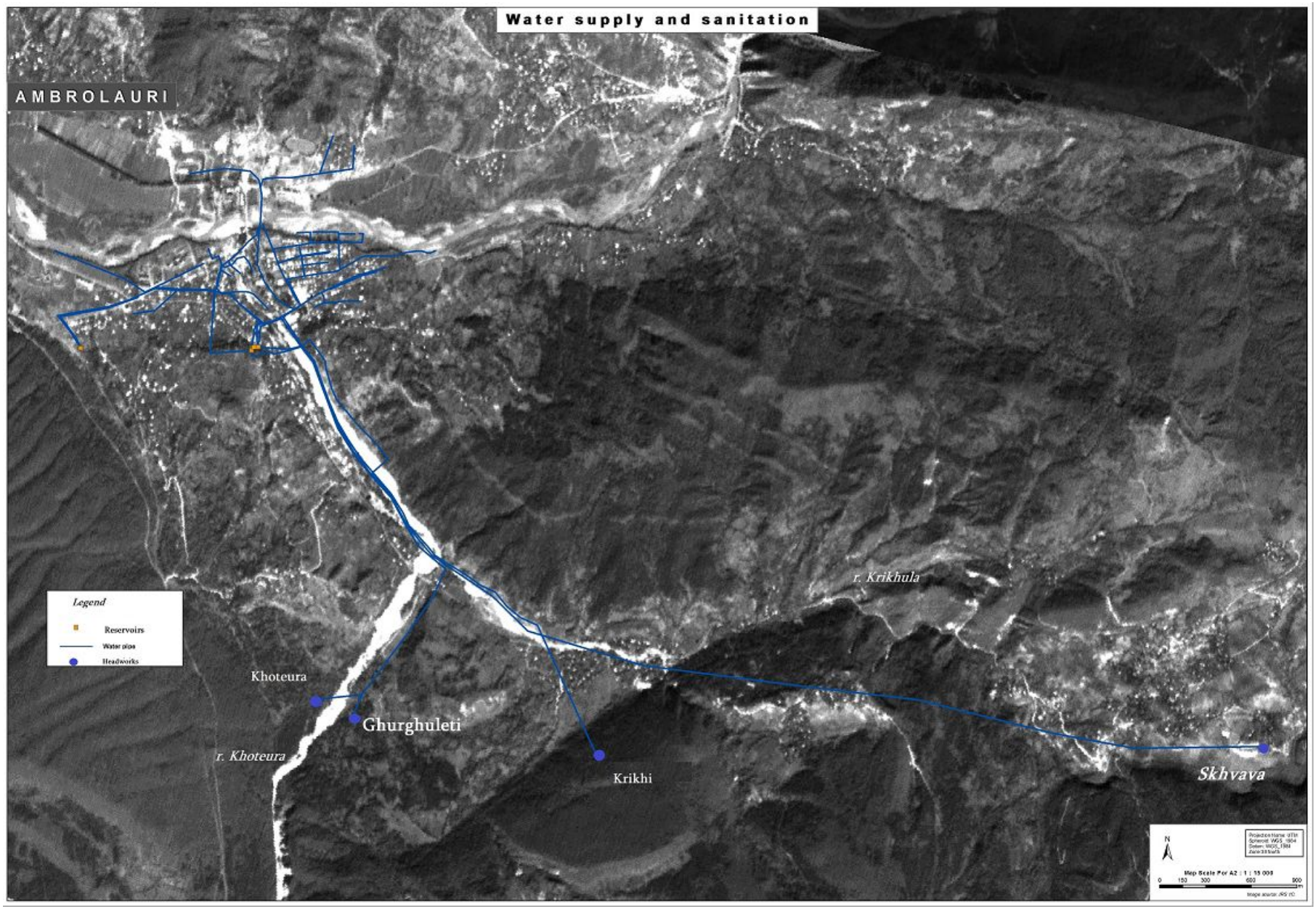
Table 8. Hazardous Events, Hazards, Control and Monitoring Measures and Supporting Programs Identified for Ambrolauri Water Supply System

#	Drinking water supply system component	Hazardous event/situation/hazard source	Hazard	Risk level	Control and monitoring measures		Supporting programs
					Developed by water safety team	Additional measures after validation workshop	
1	**Water treatment**	Inadequate disinfection *Insufficient or high amount of residual chlorine in water system*	Microbial pathogens Chemical	H *(High risk, management attention needed)*	***Short term strategy:*** • Carry out chlorination in compliance with corresponding norms ***Long term strategy:*** • Modernize chlorination procedure and technology	• Increase frequency of water quality monitoring regarding residual chlorine	• Strengthening of the technical capacity of service centre laboratories • Training of laboratory staff on water monitoring implementation • Results of laboratory testing (particularly microbial contamination parameters) require more detailed description and quantitative reflection. • Identification real water supply-demand and water losses (development of real water balance); • Setting up of hydraulic model of water supply system • Development of action plan for public information and recommendation in case of drinking water pollution and emergency situation • Elaboration of long term development plan for water supply
		Absence of disinfection *Possibility of water contamination at any stage of water supply*	Microbial pathogens	E *(Extreme risk, immediate action required)*	***Short term strategy:*** • Ensure chlorination of water from Krikhi headworks, by connecting to the chlorination stage at the reservoirs ***Long term strategy:*** • Modernize chlorination procedure and technology	• Increase frequency of water quality monitoring	
		Increased water turbidity and changed color during heavy (seasonal) rains (especially at the Ghurghuleti intake facility)	Physical	H *(High risk, management attention needed)*	***Short term strategy:*** • Interrupt water supply during high turbidity ***Long term strategy:*** • Arrange water technological treatment modules (sedimentation and clarification tanks) at headworks (where it is possible)	• Increase frequency of water quality monitoring	
	Headworks and water abstraction points	Domestic and wild animals can access the water catchment area, which could result in the *animal faecal matter entering the water supply system*	Microbial pathogens	H *(High risk, management attention needed)*	***Short term strategy*** • Appoint guard for supervision of water intakes • Fence water intake facility sanitary zone (where it is possible) ***Long term strategy*** • Rehabilitate and modernize damaged water intake units	• Increase frequency of water quality monitoring • Take into consideration of earthquakes as one of the potential hazards for damage of water supply system	

		Damaged headworks structures may result *in easy access of organic and chemical pollutants into source water*	Microbial, physical chemical	H *(High risk, management attention needed)*	***Short term strategy*** • Appoint guard for supervision of water intakes • Fence water intake facility sanitary zone (where it is possible) ***Long term strategy:*** • Rehabilitate and modernize damaged water intake units	• Increase frequency of water quality monitoring • Take into consideration of earthquakes as one of the potential hazards for damage of water supply system	system • Periodical update of water safety plan and service training of staff
		People may access the water catchment area and purposefully or unintentionally discharge chemicals into the wells *leading to chemical pollution of the source water;* Significant source of chemical pollution may exist in the catchment *and may pollute source water*	Chemical	*H (High risk, management attention needed)*	***Short term strategy*** • Appoint guard for supervision of water intakes • Fence water intake facility sanitary zone (where it is possible)	• Increase frequency of water quality monitoring	
		Increased water turbidity and changed color during heavy (seasonal) rains (especially at the Ghurghuleti intake facility)	Physical	H *(High risk, management attention needed)*	***Short term strategy:*** • Interrupt water supply during high turbidity ***Long term strategy:*** • Arrange water technological treatment modules (sedimentation and clarification tanks) at headworks (where it is possible)	• Increase frequency of water quality monitoring	
3	**Reservoirs**	Domestic and wild animals can access the reservoirs;	Microbial	H *(High risk, management attention needed)*	***Short term strategy:*** • Clean reservoir bottoms periodically ***Long term strategy:*** • Modernize reservoirs with technical equipment (water level meter, window for observation, etc.)	• Increase frequency of water quality monitoring • Equip reservoirs with automatic valve (self-closing gate valve) for immediate interruption of turbid water	
4	**Main pipes and distribution network**	Damaged pipes and insufficient pressure and water interruption can *result in backflow from customer systems into the network*	Microbial pathogens	E *(Extreme risk, immediate action required)*	***Short term strategy:*** • Ensure corresponding water pressure in the pipes by installing additional valves ***Long term strategy:*** • Assess hotspots and carry out full rehabilitation of the main pipes and network • Install water meters	• Increase frequency of water monitoring in the network • Install washing valves at the respective points of the distribution network • Take into consideration of earthquakes as one of the potential hazards for damage of water supply system	

Annexes

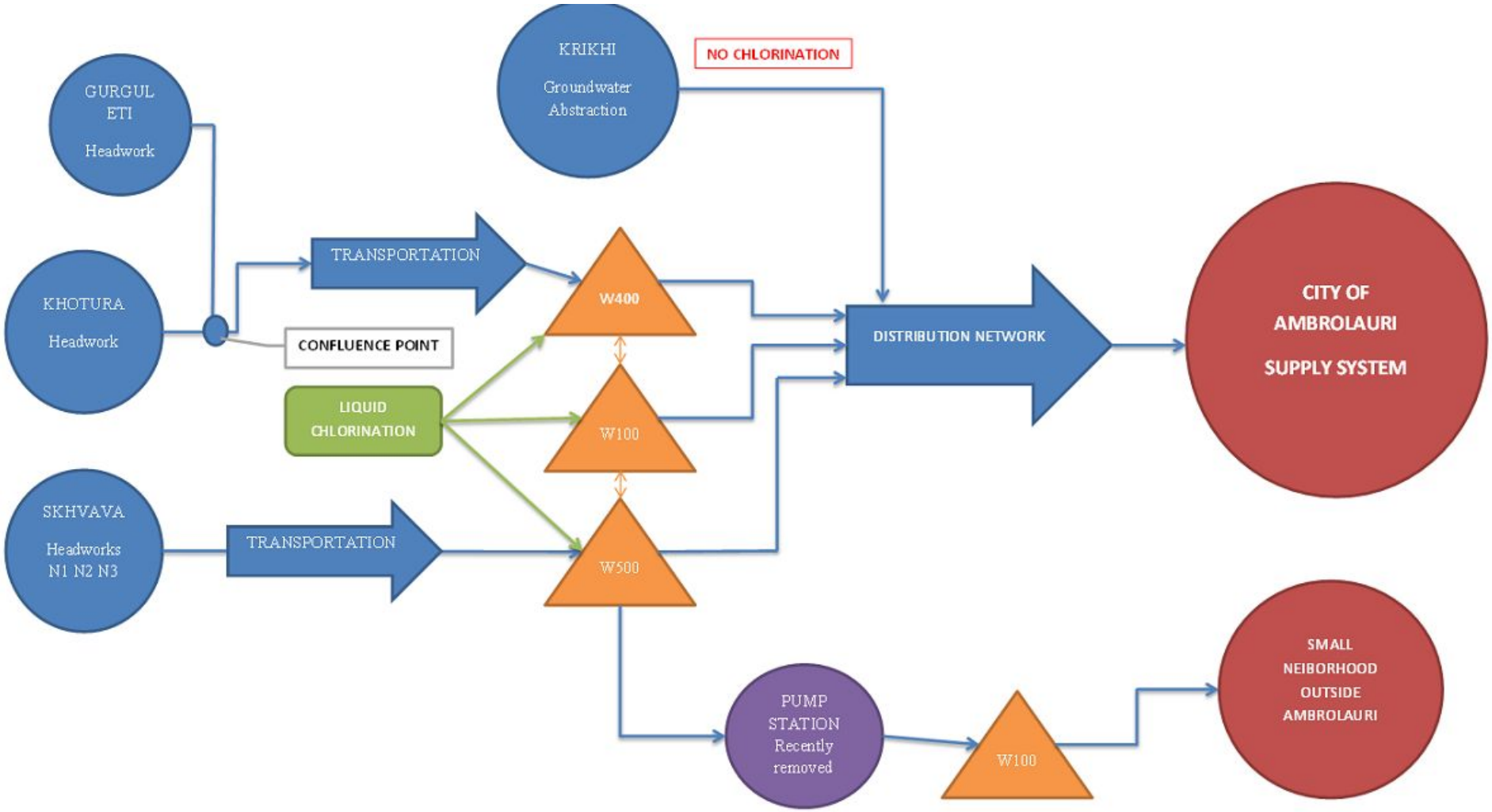
Annex 1. Map of the Ambrolauri Water Supply System



Annex 2. Basic Data on Ambrolauri Water Supply System

Number of consumers served by the company	Number of households and organizations served	Consumers with water meters	Water source name, type and discharge	Number and volume of water collector reservoirs	Water treatment method	Total metric length of the system
2500	611 households and 91 organizations	**0**	Skhvava Intake facility karst waters – 70 l/sc Khoteura Intake facility karst waters – 28 l/sc Ghurghuleti Intake facility karst waters – 5 l/sc Krikhi Intake facility karst waters – 8 l/sc	500 m^3 - 1 piece; 400 m^3 - 1 piece; 100 m^3 - 2 pieces	Chlorination (chlorine lime)	Main pipe 17.5 km distribution network – 23 km

Annex 3. Ambrolauri Water Supply System Flow Diagram



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Explanations:

Operation stage (water abstraction, purification, consumption)

Accumulation stage (reservoirs and tanks)

Transportation stage

N1, N2, N3 – Abstraction points

Uninterrupted process

interrupted process

Annex 4. Sanitary Requirements for Drinking Water Quality (Defined by the Technical Regulation of Drinking Water. *Decree #349/N Ministry of Labor, Health and Social Affairs of Georgia 17.07.07)*

Index	Measuring unit	Standard not more than
Smell	Numbers	2
Taste	Numbers	2
Coloration	Degree	15
Turbidity	Turbidity unit (by formazin or Mg/l by kaolin)	3.5 2
Sulphate (SO42-)	mg/l	250
Chloride (Cl-)	mg/l	250
Oil products, total	mg/l	0.1
Surfactant substance anion active	mg/l	0.5
Rigidity	mg. eq/l	7-10
Calcium (Ca)	mg/l	140
Magnesium (Mg)	mg/l	85
Sodium (Na)	mg/l	200
Zinc (Zn 2+)	mg/l	3.0
Iron (Fe, total)	mg/l	0.3
Mezophilic aerobes and facultative anaerobes	Colony forming unit/ml 37 0C 22 0C	 20 100
Total coliformic bacteria	Amount of bacteria in 300 ml	not allowed
E.coli	Amount of bacteria in 300 ml	not allowed
Pathogenic microorganisms, including Salmonella	In 100 ml	not allowed
Coliform	Negative colony forming unit in 100 ml	not allowed
Pseudomonas aerugiosa (only for pre-aliquoted)	in 250 ml	not allowed

Annex 5. Number of Completed Analysis by Months, 2011

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NAMES OF INDEPENDENT WATER SUPPLY SYSMENS: 1. Krikhi, 2. Ghurghuleti 3. Skhvava 4. Khoteura													
Number of Portable Water Quality Inspections at Control Units													
TOTAL INSPECTIONS	Headwork At Water Headwork (raw water)			At Ground Water Headwork (raw water)			Released (treated) potable water			Potable Water in Distribution System			Period of Time
	TOTAL	inter alia		TOTAL	inter alia		TOTAL	inter alia		TOTAL	inter alia		
		With normal range	Divergence from a norm (+)		With normal range	Divergence from a norm (+)		With normal range	Divergence from a norm (+)		With normal range	Divergence from a norm (+)	
796				**21**	**19**	**2**	**21**	**17**	**4**	**754**	**725**	**29**	**TOTAL**
55				4	4	_	4	3	1	47	47	_	**January**
53				4	4	_	4	3	1	45	45	_	**February**
61				4	2	2	4	2	2	53	51	2	**March**
63				1	1	_	1	1	_	61	59	2	**April**
64				1	1	–	1	1	_	62	59	3	**May**
68				1	1	_	1	1	_	66	63	3	**June**
71				1	1	_	1	1	_	69	66	3	**July**
77				1	1	_	1	1	_	75	69	6	**August**
74				1	1	–	1	1	_	72	70	2	**September**
68				1	1	_	1	1	_	66	63	3	**October**
68				1	1	_	1	1	_	66	64	2	**November**
74				1	1	_	1	1	_	72	69	3	**December**

Annex 6. 2011 Registered Cases of Contagious Diseases for the City of Ambrolauri

Source: Statistical Yearbook, medical statistics, 2011

#	Cases of Contagious Diseases, 2011	
	Ambrolauri	
1	Viral hepatitis A	0
2	Acute viral hepatitis B	0
3	Chronic viral hepatitis B	1
4	Typhus	0
5	Para typhus A, B, C	0
6	Salmonellosis	0
7	shigellosis (shigella infection)	0
8	Other bacterial intestinal diseases	0
8.1	including: escherichiosis	0
9	Yersiniosis	0
10	Amebiasis	0
11	Diarrhea	14
12	Brucellosis	0
13	Malaria	0

Pic.1. Service Center of Ambrolauri

Pic 2. The Headworks of Skhvava

Pic. 3 & 4. Intake Units N2 and N3 of Skhvava headworks

Pic. 5. Primitive Spring Water Collector

Pic. 6. Water Main Coming from Skhvava Headworks

Pic 7. Reservoirs

Pic 8. Chlorination Process

Pic 9. Residual Chlorine Testing Laboratory Nearby Reservoirs

Pic 10. and Pic. 11. Laboratory of Ambrolauri Service Center

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