Environmental Protection of

International River Basins Project

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Annex 2.4

MANUAL FOR GROUNDWATER FIELD SURVEYS

In the countries of

Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine

Submitted by
Consortium led by Hulla & Co. Human Dynamics KG

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TABLE OF CONTENTS

ABBREVIATIONS

CWME	Country Water Management Expert
EC	electrical conductivity
EPIRBP	Environmental Protection of International River Basins Project (this Project)
EU	European Union
JFS	Joint Field Survey
KE	Key Expert
LDPE	low density polyethylene
LTC	level, temperature and conductivity (meter)
QA	Quality Assurance
QC	Quality Control
T	temperature
TDS	total dissloved solids
ToR	Terms of Reference
SC	specific conductance (electrical conductivity normalized to temperature of 25°C)
WFD	EU Water Framework Directive

INTRODUCTION

As specified in Task 2.4.1. of its Terms of Reference (ToR), Environmental Protection of River Basins Project envisions the development of manuals for joint groundwater field surveys for each basin/sub-basin. Groundwater JFS will be organised by KE5 and CWME. At least three local hydrogeologists will participate, as well as, in certain basins, chemists, who will be responsible for field measurement of groundwater chemical parameters, e.g. pH, temperature (T), eelctrical conductivity (EC), and total dissloved solids (TDS).

Field surveys will be carried out in spring–summer 2013 and summer 2014. Local experts will be trained to use modern monitoring equipment and WFD-compliant monitoring methodology (if the project is able to cover transportation costs). Thus, it is expected that in the period between summer 2013/2014 and after project completion, local experts will complete field studies on their own.

The purpose of groundwater JFS will be to specify groundwater characteristics in preliminary delineated groundwater bodies, focusing on parts for which information is missing (i.e. data gaps).

Field survey is impossible without field equipment. For training purposes, the project has rented modern groundwater monitoring equipment (including water level meters, temperature and conductivity meters, bailers, pH-, EC-, TDS-meters, etc.). Local experts will be trained to use this equipment during field surveys.

This manual will be tested during JFS in the Caucasus countries. It will be updated and supplemented with country/basin-specific features, and translated into national languages.

1. PREPARING FOR FIELDWORK

Careful planning and preparation for groundwater sampling trips save time and help reduce the number of problems, which commonly occur during fieldwork.

Well in advance of the field trip, it is important to inform well-owners of the team's planned activities and acquire permission to enter well fields for collecting samples.

Prior to the field trip, the team should study well locations (maps, plans), create sampling routes, study past analyses of water quality and prepare field data sheets for all wells to be sampled. As much paperwork as possible should be filled out prior to leaving for the field. **Official papers from the main Beneficiaries in national languages should be prepared to facilitate access to wells.** Sampling team leader and some of the team members should take along business cards.

The following information requires careful research in order to select wells to be sampled:

- hydrogeological characteristics of aquifers (groundwater bodies) to be sampled;
- well (spring) type and purpose of water use;
- prior sampling work in the area and collected water quality data;
- well depth and diameter;
- casing materials ;
- screened/perforated casing or other means by which water can enter the well;
- number of aquifers across which the well is screened;
- pump type, intake location, construction material, type and diameter of the casing;
- well yield;
- static and/or dynamic levels.

Correct sampling procedure starts with thorough preparation in the office and laboratory prior to sample collection. To assure a high quality sample, each sample container should be thoroughly cleaned and protected from any contamination during sample collection, preservation and transportation. The contract laboratory will provide sampling containers and required acids.

Logistics, including route details, mode of transport, accommodation, budget and movement of samples, should be planned in advance by KE5 and CWME, in consultation with participating personnel.

2. MATERIALS

The following materials should be prepared prior to the sampling trip:

- plastic sheets for protecting field equipment from pollution with soil – 2x2 m, 2 pieces
- plastic bucket for measuring well yield, purge volume of groundwater, and field parameters – 1 unit, 10–12 l in volume
- disposable rubber gloves for sampling – 20 pairs
- nylon rope for sampling bailer – 6-8 mm in diameter, 30 m long
- plastic tube for WaSP pump, for raising groundwater from the well – with 10 mm inner diameter, 30 m long
- battery for WaSP pump – 12V, ca. 40Ah
- coolers/thermal boxes for samples with cooling elements – 2 units
- concentrated nitric acid (HNO_3) for preserving groundwater samples for analysis of metals
- self-adhesive sample labels – 50 units
- field sheets – 25 units.

3. FIELD TRAINING USING MODERN MONITORING EQUIPMENT

The main purpose of training on groundwater monitoring is to provide practical demonstration and opportunity for hands-on installation and use of groundwater monitoring equipment. Training includes surveying, monitoring, sampling, as well as equipment programming and calibration. During survey work, employed procedures for taking field measurements and collecting, preserving and transporting samples will demonstrate how to use and apply modern field equipment in accordance to EU WFD requirements. Samplers will be trained to make sure that appropriate field sheets are completed and contain all relevant field observations and measurements, including information on sample preservation. Samples and completed field sheets will be submitted to the laboratory, in accordance with QA/QC requirements.

The training programme in 2013 will involve three groundwater experts from each participant country in the Project. It is expected that upon completion of training, local groundwater experts will be able to continue collecting groundwater monitoring data independently.

The following field equipment has been rented and will be used in the course of training:

- mechanical water level meter with 100 m long laser marked tape – for manual measuring of water level and well depth;
- automatic groundwater level, temperature and conductivity meter (LTC meter) – to be programmed and left in the well for an extended period for measuring level, temperature and conductivity;
- Automatic water level and temperature meter (levelogger) – to be programmed and left in the well for an extended period for measuring level and temperature;

- automatic atmospheric pressure meter (barologger) – for atmospheric pressure compensation of leveloggers;
- direct read cable for loggers – for connecting leveloggers with data loader;
- data loader – for reading data from leveloggers and programming loggers in the field;
- optical reader – for programming leveloggers and reading data in the office and in the field;
- stainless steel bailer – for groundwater sampling;
- WaSP pump – for purging wells before taking samples;
- GPS Garmin 62sc – for locating geographic coordinates of sampling points;
- pH and temperature meter – for measuring groundwater parameters at wells;
- electric conductivity/total dissolved solids (EC/TDS) meter – for measuring groundwater parameters at wells;
- digital camera – for taking photographic records.

Prior to fieldwork, all field equipment and instruments should be checked to ensure they have adequate power supply and operate according to specifications.

KE5 will explain the use, versatility, application, and pre-programming of leveloggers, which will be placed into monitoring wells to collect relevant data. Loggers record and store data from frequent measurement, including thousands of numbers on temperature, level and conductivity of water at the well. All data can be downloaded via cable directly from loggers onto a laptop or a small hand-held data collector. From here, data can be transferred by USB to a PC for statistical evaluation.

Figure 1 Automatic water level logger – installation (left);
data reading equipment – PC (top right); field data loader (bottom right)

Measurements taken during field operations include geographic coordinates, temperature (T), electrical conductivity (EC), pH, and total dissolved solids (TDS). In the case of monitoring wells, water levels and well depths should also be recorded. Observations related to weather and site conditions should be recorded as appropriate. Records should comply with the requirements of the appropriate field sheets.

4. GEOGRAPHIC COORDINATES OF MONITORING WELLS

The geographic coordinates (North and East) of each sampling point should be determined using Garmin GPSMAP 62sc units.

Figure 2 Garmin GPSMAP 62sc for locating geographic coordinates

5. MEASURING WATER LEVEL

Initial water level and well depth should be measured before placing the purge pump, using tape water level meter. These measurements will serve to determine the required depth of the purge pump intake (typically, mid-point of the saturated screen length). Information on well depth will serve to calculate the volume of stagnant groundwater, which needs to be evacuated before sample collection. Where data on well depth is available from construction details or from previous sampling, this data can be used; it should be checked after the completion of sampling.

Figure 3 Acoustic water level meter

6. WELL PURGING

Stagnant water – water, which has been sitting in the well casing – is different, both physically and chemically, from aquifer water. Hence, wells must first be purged before a representative water sample can be obtained. Well purging introduces fresh groundwater into the well this fresh water is representative of the aquifer. The amount of water, which should be pumped before collecting water samples, depends on well depth, hydraulic properties, sampling methodology and program requirements.

There are two ways to estimate the volume of purge water.

- Purge the well until pH, specific conductance (SC) and temperature (T) readings for the discharging water stabilize. Evacuate a minimum of 2-3 casing volumes of water.
- Use the formula $\mathbf{V = \pi * R^2 * L}$, where **V** – volume of purge water (*l*)
  π – constant = 3,1416
  R – radius of well casing (*dm*)
  L – height of water column in well (*dm*).

In low-transmissivity wells, less purging may be required to obtain fresh aquifer water.

In low-yield wells, high extent of drawdown may cause the purge pump to dry. Caution is advised.

7. WORKING WITH WASP SUBMERSIBLE PUMP

WaSP 12V submersible pump is used for purging monitoring wells prior to taking groundwater samples. The pump diameter is 46 mm. The pump can be used to purge monitoring well with diameter over 50 mm. The maximum pump capacity is 14 l/min.

Figure 4 Submersible pumps for purging monitoring wells

1. Prior to inserting pump into the well, connect the pump to the required length of ID 10 mm tubing. Low density polyethylene (LDPE) tube is recommended as it is softer and easier to connect to the pump.
2. Lower the pump into the well so that pump intake is submerged. Avoid placing pump too close to the bottom of the well to avoid ingress of silt or other sediments.
3. Connect the pump's negative alligator clamp securely to the negative terminal on your power supply, and then connect the positive pump clamp to the positive terminal.
4. The pump will start immediately.

The pump can run continuously when submerged. For best results it is recommended to use of a 12V marine battery or a vehicle battery with at least 40 amp-hour rating. If a vehicle battery is used, it is important that the vehicle be started and run for 2 minutes every 30 minutes in order to maintain the charge in the vehicle's battery. Failure to do this may result in damage to the battery and inability to start the vehicle. Running the vehicle while the pump is running will not damage the pump.

Do not run dry the pump! This will damage the motor.

Do not allow water to freeze inside the pump! Frozen water will expand and damage the unit.

5. When pumping is complete, remove the pump from the well. When removed, hold the pump in upright position to drain all water from the unit.
6. Decontaminate the WaSP pump after you are finished with collecting groundwater samples.
    a. Immerse the pump and discharge tubing in a bucket of warm water with non-phosphate detergent.
    b. Attach a short section of tubing to the pump outlet to recirculate the cleaning solution into the bucket.
    c. Attach the pump to your power supply and allow the cleaning solution to circulate through the pump. The required time to do so will vary depending on the concentration and type of contaminant the unit was exposed to.
    d. Repeat the procedure with clean water.

WaSP 12V submersible pumps can only partially be decontaminated. There is no decontamination procedure, which can ensure that all contaminants are completely removed from the pump. The best way to preclude cross-contamination between wells is to use a different pump for each well.

8. MEASURING FIELD QUALITY PARAMETERS

Each day, before commencing fieldwork, field meters should be calibrated for measurement of electrical conductivity (EC), pH, temperature (T), and total dissolved solids (TDS), using standard solutions provided in instrument field kits. The mechanisms and steps of calibration will be demonstrated, and trainees will undertake calibration.

Figure 5 Field pH/T and EC/TDS meters

Field quality parameters should be measured following the proper purging of wells and prior to collecting samples to be shipped to the lab. Field tests include measurements of pH, temperature, specific conductance and TDS at the sampling point.

All pertinent field data should be recorded in a field book, as well as in the Groundwater Sampling Field Data Sheet (Annex 1).

9. SAMPLING

The purpose for groundwater sampling is to obtain such results that most accurately reflect the water quality conditions within the aquifer. The procedures employed for sample preservation and storage seek to minimize reactions within the water sample after it has been collected and placed in a container.

Samples from the purged well or spring should be collected using stainless steel bailer for laboratory analysis for major ions, nitrogen compounds and dissolved metals. In the case of dissolved metals, nitric acid should be added to ensure that ions remain in solution and do not adsorb onto sample container walls.

The laboratory analytes are:

- Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, SO_4^{2-}, HCO_3^-, Cl^-, NO_2^-, NO_3^-, CO_3^{2-}, F^-;
- hardness, dry residue, total mineralisation, ionic balance, permanganate index;
- trace elements: arsenic (As), cadmium (Cd), lead (Pb), mercury (Hg).

Throughout the survey, emphasis should be placed on the procedures for observing, measuring, recording, the importance of sample labeling and filling out field sheets, and the correct procedures for sample transport within the required timeframes.

Figure 6 Stainless steel bailer for collecting groundwater samples

10. SAMPLE LABELLING

Samples should be labelled so that they be readily identifiable at all times. Container labeling should clearly identify the sample and distinguish it from other samples at the laboratory. Without appropriate labelling, all samples may look alike.

Labels should be durable. Most samples are preserved in ice. Labels need to resist moisture, and ink should also be non-water soluble. Careful packaging of samples is also important, as vibration of sample containers during transport may cause container labeling to rub off or become illegible.

Labelling on samples should contain as much information as practical. Labels may contain:

- date and time of sampling
- location and name of sampling site (including GPS coordinates if available)
- project number
- name of sample collector
- information about container pre-treatment and added sample preservatives
- observations on other factors, which may affect the analysis method or results.

Sample labels must specify a clear and unique *identifying code*, which can be used to cross-reference to the location of monitoring and time of sampling.

11. TRANSPORTING AND STORING SAMPLES

Samples should be transported to the laboratory every day. In practice, the remote location of sampling points from laboratories makes this difficult. Therefore, samples should be kept in coolers and transported to the lab every two days. Samples, which require low temperatures of storage, should be placed on ice immediately.

It is vital that all procedures are followed regarding sample transportation and storage. This will ensure that sample condition remains mostly unaltered and suitable for laboratory analysis. During transportation, contamination of samples can easily occur due to container cross-contamination, packaging material or chilling products. During storage, sample degradation can occur due to lack of appropriate preservation, inappropriate storage conditions, excessive storage time, and sample cross-contamination.

12. HEALTH AND SAFETY

Fieldwork should be conducted in such a way as to protect the health and safety of field personnel. Each team member has the authority and responsibility to stop operations should unsafe conditions present or develop. All groundwater monitoring personnel should perform their field activities in a safe manner and undertake actions to remove, reduce or control risk.

Filed personnel should carry a safety kit, as well as information on emergency procedure and location of nearest medical facility. Using the appropriate safety equipment will reduce risk in the process of sampling. Safety equipment can increase prevention or provide assistance in case of an incident.

A number of risks should be considered during fieldwork. The fieldwork team should study the potential risks and be prepared to control them, to ensure work safety in field conditions. During sampling, typical risks include:

- vehicle breakdown or accident, bogging in wet conditions;
- exposure to hazardous substances, such as decontamination chemicals, toxic products formed during sample preparation or stabilisation (e.g. acidification), toxic gases (e.g. hydrogen sulphide), bacteria in the wellhead or groundwater;
- risks, related to temperature exposure, e.g. sunburn and heatstroke;
- risks, related to working in, over, or close to water;
- poisonous animals (spiders, snakes) and plants.

When receiving containers and preservatives from the laboratory, they should be checked for leaks. Many preservatives can burn the eyes and skin, and they must be handled carefully. Sample container labels should include information on the type of preservative used, if any.

ANNEX 1. GROUNDWATER SAMPLING FIELD DATA SHEET

Groundwater sampling field data sheet						
Sampling point name and number						
Sampling date and time						
Groundwater body code/geological index						
Sampling point	Well		Spring			
River basin name	Prut, Ukraine					
Weather conditions	Sunny	Partly cloudy	Cloudy	Windy	Raining	Foggy
Sampling point coordinates						
N						
E						
Altitude						
Water quality parameters (field measurements) and groundwater level						
Temperature (^{o}C)						
pH						
Conductivity (µS/cm)						
TDS (mg/l)						
Well depth (m)						
Water level (m)						
Samples collected for	Main cations and anions		Trace elements			
Comments						
Sample collector name and signature						

Chain of Custody

1 Sample relinquished by:________________ Date:________

Received by:________________ Time:________

2 Sample relinquished by:________________ Date:________

Received by:________________ Time:________

3 Sample relinquished by:________________ Date:________

Received by:________________ Time:________