INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary:
OPTIMAL TERRITORIAL AREA AUTHORITY N. 3 MARCHE CENTRO – MACERATA (FB2)

Contact person of the Final Beneficiary: NARDI DANIELE

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.

PART B – PILOT DATA

1. Describe which parameters do you want to monitor:
   - Natural flow rate (Springs);
   - Groundwater level and seasonal variation (Wells/Wells Fields);
   - Rainfall (catchment input);
   - Basic indicator and quality parameters (temperature, alkalinity, conductivity, nitrates);
2. Describe which performance index do you want to calculate: NONE
3. Do you have data already relevant to the project? YES☒ NO☐
   PRELIMINARY PROJECT AND RELATED BUDGET, ATTACHED
4. Do you need equipment or investment? YES☒ NO☐
   FLOW METERS (N. 45), WATER LEVEL SENSORS (N. 14), PROBES (N. 20) PROVIDING INDICATOR PARAMETERS, NITRATE PHOTOMERIC SENSORS (N. 9), RAIN GAUGES (N. 5), PIEZOMETERS (N. 10), TRANSMISSION/ACQUISITION DATA SOFTWARE AND INVESTMENT NEEDED TO INSTALL THE EQUIPMENT ABOVE (MANHOLES, WEIRS, ETC.)
5. Is the project already start? YES☒ NO☐
   PROJECT APPROVAL BY THE BOARD (Del. n. 2, as of 29.01.2014); SINGLE TENDER PROCEDURE FOR THE HYDROGEOLOGICAL STUDY FINALIZED WITH CONTRACTING UNIVERSITY OF CAMERINO, SCHOOL OF SCIENCE AND TECHNOLOGY – GEOLOGY DEPARTMENT.
   PURCHASE OF EQUIPMENT WILL LIKELY START WITHIN END OF MARCH, 2014
6. Indicate the time line chart.
   PURCHASE/INSTALLATION OF ALL THE EQUIPMENT FORESEEN WITHIN JUNE, 2014

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources: 20
2. Population served by your system: 350.000 APPROXIMATELY
3. Service area (Km^2): 2.500 km^2.
4. Total number of connections/customers: 160.000
5. Total number of retail connections: 125.000 (HOUSEHOLDS)
6. Amount of water produced (monthly and yearly average): 37 Mil. m^3/year
7. Average annual water volume delivered to customers: 26 Mil. m^3/year
   a. supply capacity;
   b. percent imported water supply;
   c. percent surface water supply;
   d. percent potable groundwater supply.
8. Service area elevation range.
9. Total number of pressure zones in service area.
10. Approximate elevation range in each pressure zone.
11. Average number of customer connections per pressure zone.
12. Average static pressure delivered to pressure zone (Bar).

Is your project about water losses? YES☐ NO☒

If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

2. Are all water service connections metered? YES☐ NO☒
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

a. water volume (m^3) input to distribution (produced and purchase)
b. billed authorized consumption volume
c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
d. total authorized consumption volume (sum of **b** and **c**)
e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%)
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other____________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program ________
☐Water line replacement ________
☐Reduce tank overflows ________
☐Leak detection/elimination ________
☐Theft Prevention ________
☐Meter service connections ________
☐Meter Sources ________
☐Line Looping ________
☐Flushing Program ________
☐Other ________

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 caracters).

The Pilot case to be implemented in ATO 3 concerns the installation of a metering and real-time monitoring system, which would provide useful data for a better planning of WSSs interconnection, definition of proper Drinking Water Protected Areas (DWPAs), management of emergency situations, sharing data with different level Authorities and Civil Protection Department. Foreseen investment concerns building of manholes for the installation of meters on the existing pipes, construction of weirs on the discharge channels, in order to assess their flow rate through water level sensors, drilling of wells to be equipped with piezometers, other construction works connected to the equipment installation.

Thanks to the implementation of this Pilot case and foreseen investment 20 out of the over 300 WR in use in ATO 3 will be equipped in order to provide real-time data concerning water input in the network and water discharge. Installed piezometers and rain gauges, together with hydrologic studies, will also provide better knowledge about aquifer recharge rate and catchment real dimension.

Real-time monitoring of the sources will ensure enhanced WR management and control by the Utilities or Municipalities. Collected data will provide improved planning of investment needed, especially concerning WSSs interconnection and DWPAs measures.

Sharing adopted methodologies and approaches, as well as decision-making framework, will help Utilities, Municipalities or Public Authorities facing similar situations in the Adriatic Region, providing an experimented solution, also useful in order to set a protocol for the management of cross-border WSSs. Thanks to the dissemination of general results similar systems will be adopted, DWPAs measures activated and monitored, network interconnections correctly planned, emergency situations avoided.

INTERNAL USE NOT TO BE DISTRIBUITED

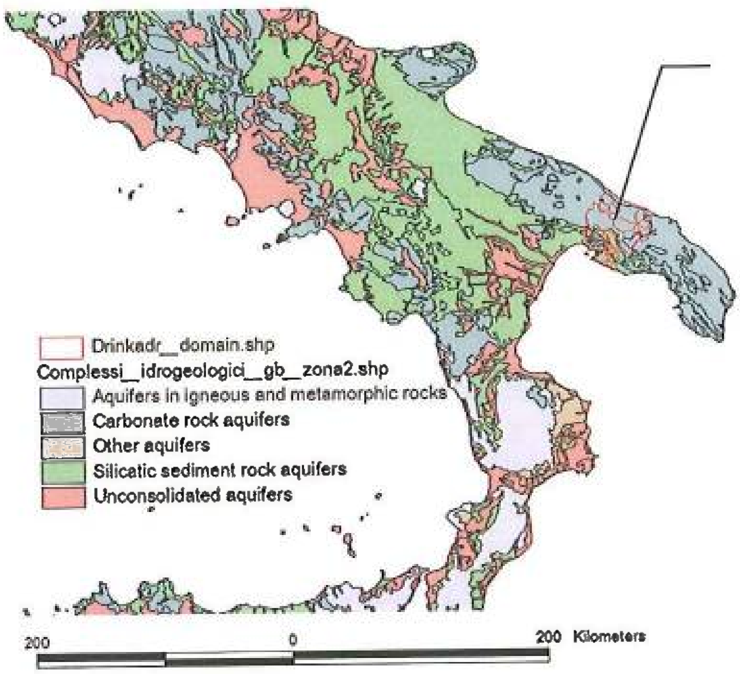
WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: National Research Council, Water Research Institute (FB3)
Contact person of the Final Beneficiary: Costantino Masciopinto, via F. De Blasio, 5, 70132 Bari

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.



PART B – PILOT DATA

1. Describe which parameters do you want to monitor.

- Microbiological parameter: total bacteria count (37 and 20°), E. coli, spores of sulphite-reducing clostridia, Salmonella, somatic coliphages, viruses (selected samples), giardia and crypto (selected samples), Antibiotic resistance gene (ARG)
- Chemical constituents: dissolved organic carbon (DOC), pH, T, specific conductance
- Hydrological data: water depth in wells

2. Describe which performance index do you want to calculate.
   Groundwater scarcity, resources availability, climate change impacts
   Check of water quality for drinking purposes
3. Do you have data already relevant to the project? YES X NO☐
   If Yes, describe
   Microbiological and chemical constituents of groundwater

4. Do you need equipment or investment? YES☐ NO X
   If Yes, describe

5. Is the project already start? YES X NO☐
   If Yes, indicate the starting date
   November 1, 2014
   IF No, indicate when it will likely start

6. Indicate the time line chart.

The activity will be carried out by following DRINKADRIA time sheet

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

THE DATA COLLECTION IS IN PROGRESS

Indicate, if available:

1. Number of supply sources.
2. Population served by your system.
3. Service area (Km^2).
   AREA: 1991 KM^2; MAX. LENGTH: 53 KM; MAX. WIDTH: 50 KM (THE AREA COVERS 24 MUNICIPALITIES OF THE APULIA REGION AND 3 PROVINCES)
4. Total number of connections/customers.
5. Total number of retail connections.
6. Amount of water produced (monthly and yearly average).

The drinking water consumption supplied by the regional water company AQP is estimate in 66 Mm3/year. This water is mostly supplied by large artificial reservoirs placed outside the Apulia region with a minor component coming from 2 karst spring located in Campania region.

The water consumption for touristic use is 1.4 Mm3/year and is mostly supplied by the same water system described above.

Concerning the irrigation use, the pilot area is mostly occupied by agricultural land (olive, vine grape, fruit trees, wheat and vegetables) with irrigated crops covering about 220 km2: The total irrigation demand is estimated in 78 Mm3/year (about 3,500 m3/ha). Irrigation demand is completely based on groundwater with both private and collective pumping facilities. Groundwater pumping is mostly concentrated along the coastal areas covering an ideal strep having width between 10 and 15 km from the sea.

Concerning the industrial water use supplied by groundwater, the estimated annual water withdrawal is 4.2 Mm3.

7. Average annual water volume delivered to customers: not yet available
   a. supply capacity;
   b. percent imported water supply;
   c. percent surface water supply;
   d. percent potable groundwater supply.
8. Service area elevation range: NOT YET AVAILABLE
   Min.: 0 m above sea level
   Max.: 510 m above sea level
   Average: 170 m above sea level
9. Total number of pressure zones in service area.
10. Approximate elevation range in each pressure zone.
11. Average number of customer connections per pressure zone.
12. Average static pressure delivered to pressure zone (Bar).

Is your project about water losses? YES☐ NO X

If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

2. Are all water service connections metered? YES☐ NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

a. water volume (m^3) input to distribution (produced and purchase): NOT YET AVAILABLE
b. billed authorized consumption volume: NOT YET AVAILABLE
c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
d. total authorized consumption volume (sum of **b** and **c**)
e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%)
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other ____________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program	______	☐Meter service connections	______
☐Water line replacement	______	☐Meter Sources	______
☐Reduce tank overflows	______	☐Line Looping	______
☐Leak detection/elimination	______	☐Flushing Program	______
☐Theft Prevention	______	☐Other	______

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters).

- Estimation of climate change impacts on groundwater
- Evaluation of quality status of surface and ground waters according to EU Directives;
- Models and methodology to remove seawater intrusion from the coastal aquifer;
- Methods to improve the management of groundwater supply;
- Groundwater modeling to demonstrate improved groundwater quality

DRINK ADRIA

Programme co-funded by the EUROPEAN UNION

DRAFT

Ostuni Pilot area at the Apulia Region – Southern Italy

Italian National Research Council, CNR-IRSA

DRINKADRIA Actions: 4.2-4.3, Starting 11/2013, ending 01/2015

4.2- Present and future risks on water resources availability with emphasis on drinking water supply

4.3- Present and future risks water safety and risks imposed to water resources used for drinking water supply

REPORT (May, 2014)

CONTENT

1. INTRODUCTION

Apulia is one of the driest regions of Italy with an average annual rainfall of less than 600 mm (1950–2000). Its most southern part, known as Salento peninsula, forms the heel on the "boot" of Italy. Here the economy depends largely on farming, leading to a mainly agricultural land use with a large share of irrigated cropping due to the low precipitation. The total water consumption in Apulia (see Table 1) is estimated to about 2400 Mm^3/y where of 58% (1400 Mm^3/y) are consumed by agriculture, 18% (430 Mm^3/y) by industry and 24% by urban users (580 Mm^3/y). As the Salento peninsula does not have any relevant surface water sources, groundwater has been traditionally the main water source. Due to the chronic water scarcity, the Apulian Aqueduct has been built already in 1906 [1] to provide additional water to the South from freshwater sources in the North of Apulia. Nowadays it provides about 440 Mm^3/y for drinking. The remaining annual water demand of 1960 Mm^3/y is largely covered by groundwater. However, natural recharge does not refill the aquifers sufficiently, and overexploitation with consequent sea water intrusion into the water table is a severe problem at many locations. The number of the often private (and illegally drilled) wells amounts to around 140,000.

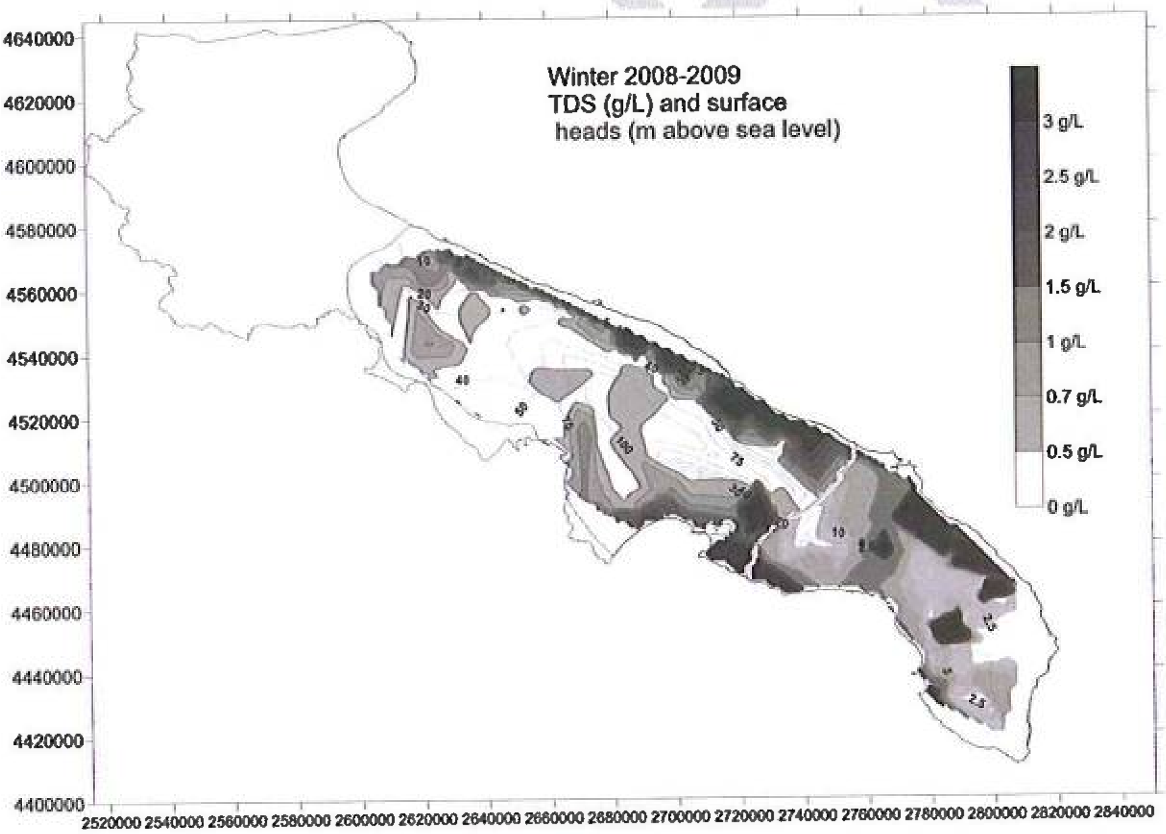


Figure 4.2.1. Salinity levels of the groundwater in the Salento peninsula given as TDS concentration in g/L (TIZIANO project, http://tiziano.regione.puglia.it/)

According to international and national studies and publications [2] the Mediterranean region is expected to undergo particularly negative climate change impacts over the next decades, which, combined with the effects of anthropogenic stress on natural resources, make this region one of the most vulnerable areas in Europe. The anticipated negative impacts are mainly related to possible extraordinary heat spells (especially in summer), increased frequency of extreme weather events (heat waves, droughts and severe rainfalls) and reduced annual precipitation and river flow.

Main problems in the Ostuni and Salento peninsula are related to the increase of water table depth and to the groundwater salinization due to over abstractions and sea water intrusion, as it is shown in Figure 4.2.1. At several places of the Salento coastal area the electrical conductivity of the groundwater already exceeds 15000 µS/cm (i.e. about 7 g/L of salinity). The groundwater flows under low pressure inside karstic fissures and it is affected by withdrawals for drinking and irrigation uses, as better explained below. Artificial recharge has been considered at Ostuni as a pilot study to counteract saltwater intrusion and overexploitation of the aquifer. In Salento natural recharge of coastal rock aquifer occurs via existing vertical fracture and sinkholes replenished by small ditches (i.e. lame). Near Ostuni the volume from run-off, which is approximately 0.6 Mm^3/y and secondary effluents from wastewater treatment plants (WWTP) located nearby (see http://primac.ba.cnr.it/) could be thus used for injection of reclaimed water via already existing boreholes. Actually an average flow of 76 L/s is instead outflowed along the coast by the Lama d'Antelmi channel, by providing health problems for tourists and for swimming.

The abstracted water is mainly used for irrigation but to some degree is also used for human purposes. The Salento karstic aquifer supplies 80% of the population (about 800,000 inhabitants) with 126 million m^3/y of water for drinking purpose, and some concern has arisen regarding the groundwater quality. Public health concerns are particularly associated with ingestion of water contaminated with human or animal faeces, which can be a source of pathogenic bacteria, viruses, protozoa and helminths. The fate of these pathogens, associated with that of faecal contamination indicators has been investigated by IRSA for establishing minimum setback distance between effluent recharge and withdrawal that can occur in safe conditions, within the Reclaim Water EU project (http://www.ist-world.org/ProjectDetails.aspx?ProjectId=cdf4c9803a364e4b81cf8997d41e74b7 Accessed May 23, 2014).

1.1 OSTUNI Pilot AREA

The Apulia region with more than 4 million inhabitants has been exposed to a sequence of prolonged droughts in the past decades, which caused a general decrease in water supply and an increase of demand for irrigation. Moreover, in the past decade the region has been recognized as being among those at the highest risk of desertification in Europe, due to the observed climatic trends and intensified agricultural practices.

The Pilot Area is 1991 km^2, with a maximum length of 53 km, maximum width of 50 km. The area covers 24 municipalities of the Apulia region, which are in 3 provinces: Brindisi, Taranto and Lecce (see Appendix).

Study Area - South of Italy

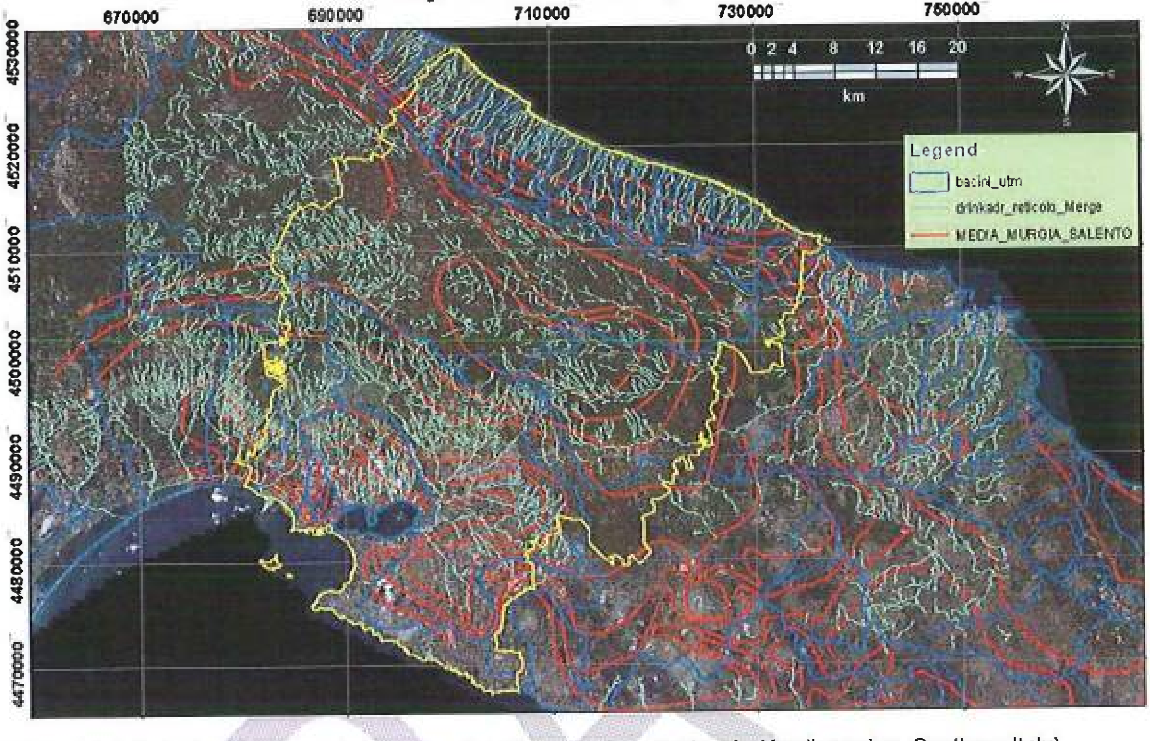


Figure 4.2.2. Ostuni pilot area and stream basins of the Salento peninsula (Apulia region, Southern Italy).

The climate is markedly Mediterranean, with mild wet winters and hot dry summers (the coldest month is January and the warmest is July). Climate variables and rainfall in particular, exhibit a marked inter-annual variability which makes water availability a permanent threat to the economic development and ecosystem conservation of the region. In addition, rainfall has also experienced a declining trend, on average, over the past four decades.

Due to the dominant carbonate nature of rocks (high substrate permeability and infiltration of rainwater), the region has almost no rivers, except in its northern part, where the presence of alluvial materials is favourable to shallow groundwater and permanent (or seasonal) rivers. Instead, in the karst area some basins related to a fossil hydrographical network, present a superficial flow only during intense events.

The region is mainly dominated by agriculture that is a vital economic resource for the region, with more than 70% of the total area occupied by cropped land. The water resources derived from surface water bodies are limited causing a major constraint to the social and economic development of the region. To overcome this problem, a great aqueduct was built at the beginning of the twentieth century which supplies the region collecting drinking waters coming from some carbonate Apennine springs of Cassano Irpino (mean annual discharge of $2.65 m^3/s$) and Caposele (Table 2). Moreover, an interconnected system of artificial reservoirs was built between 1960 and 1990 to collect and transfer drinking water from the bordering regions, thus making the region very much relying on the external water resources. This water infrastructure is among the biggest over Europe. Furthermore, a fast growing trend in the last four decades towards irrigation farming has led to a massive exploitation of groundwater resources. As a result, the groundwater level has dramatically decreased in the river plain aquifers while sea water intrusion is observed in most of the coastal zones [3]. The basic feature of water resources exploitation in the study region is summarized in the following table.

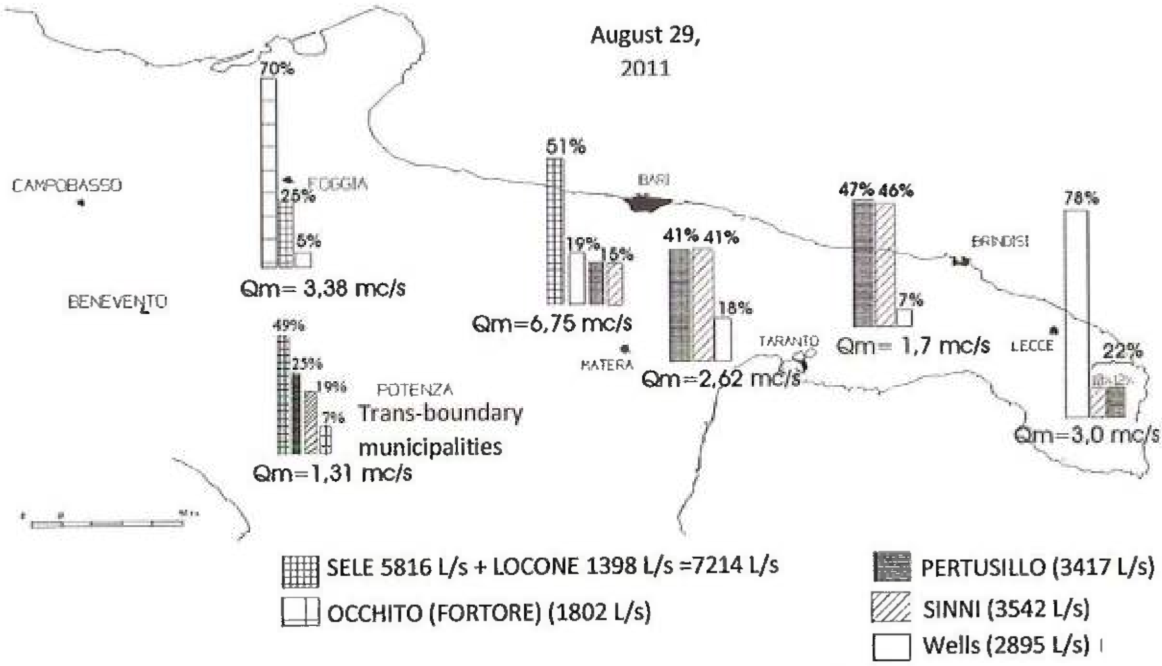
Table 1. Main features of water use and water supply for the Apulia region.

Water use	Drinking	Agricultural	Industrial
TOTAL 1700-2400 Mm^3	546-580 Mm^3 (24%)	812÷1400 Mm^3 (~58%)	430 Mm^3 (18%)
Regional resources	23%	78%	85%
Extra-regional resources	76%	22%	15%
Surface water bodies	54%	24%	15%
External springs	23%	1%	26%
Groundwater bodies	23%	75%	59%

It is therefore crucial to investigate the possible impacts of climate projections in such a hydro-climatic context. Agriculture, water supply and tourism are sectors vulnerable to climate change in the region. In this complex framework, climate change effects on regional water balance were analyzed.

Water availability in the next future is one of the main problems of the people of Mediterranean areas, as well as in areas where water is increasingly in short supply. Water resources of good quality have been seriously damaged by human activities and the application of laws and regulations is not always sufficient to protect springs and water reserves. It thus becomes extremely important to define a term of *per capita* consumption at the municipal level that will be adequate for the actual needs and accurate forecasts of the quantity of water to be supplied, in order to avoid the impoverishment of water resources [5]. Italian legislation has always aimed at regulating water use, albeit in a piecemeal fashion. The result has inevitably been a conflict of responsibility between the Central Government, Regions, Provinces, Municipalities,

Consortia and local Authorities. Only few years ago a law (no. 36/94) has provided a number of provisions intended to regulate the water resources management. This law represents an essential point of reference for planning the use of both surface and groundwater resources. The most innovative features of this law include the definition of priorities for water uses; for example, drinking water is followed by irrigation. The Authority responsible of water resources management is empowered to perform a water balance between the available resources and the ascertained requirements.



Qm= Mean annual flow rate = 17.77 m^3/s

Qp= Maximum daily flow rate = 18.87 m^3/s

Figure 4.2.3. Drinking water distribution in Apulia region during August 2011(SELE = spring) [4].

The water supply for drinking water in Puglia (Southern Italy), is prevalently based on groundwater resources (Figure 4.2.3). The Master Plan of the drinking water programmed the following withdrawal from groundwater (see Table 2).

The recent climate changes has increased in the Southern part of Europe the extreme events, that is the rainfalls are concentrated in few days of year and the are very long droughts. Consequently, the water resources have diminished their natural replenishment and encouraged local Authorities to study strategies and plans to control territorial desertification. In arid region around the world a common strategy to contrast droughts is the artificial recharge of groundwater and wastewater reclamation in agriculture. In Puglia there are 157 municipal treatment plants, with a total discharge of 236,5 Million of m^3/y, which could satisfy the 20% of annual water requirement for agricultural demand in the whole region 1100 Mm^3/y (Master Plan *PS14*, 1984 in [3]) and about the 40% of the regional current drinking water requirement (592 Mm^3/y). Moreover, during winter the treated wastewater could be used for artificial recharge in coastal fractured aquifer, to reduce the saltwater wedge.

Table 2. Groundwater for drinking water supply (Italian Master Plan, last update 1998)

Groundwater name	Withdrawal l/s 2001	2016	2031
Falda Gargano	423	423	423
Falda Tavoliere	60	60	60
Falda Murgia	1291	813	813
Falda Salento	2053	1175	1175
Falda Bradano	50	50	50
Springs:			
Caposele	3500	3500	3500
Cassano Irpino	1500	1500	1500
Morano Calabro	-	-	500
Vico Ischitella	-	-	16
Total (L/s)	8877	7521	8037

Nevertheless there are a lot of constrains that limit this practice in Puglia. The principal obstacle is due to economics aspects. A recent study reports that in this region, about 185000 ha of soil are irrigated with private wells and only 75000 ha are irrigated with a public aqueducts (i.e. Consortia). Moreover the total of water withdrawn from private wells in '97 was 541 Mm^3/y, which is near of drinking water requirement of the whole Apulia region.

1.1.2 Actual drinking water deficit

The water balance of drinking water resouces has been estimated on the basis of the specific standards for water requirement of different types of drinking consummers (see Table 3).

Table 3. Comparison of water requirement standard proposed by different Master Plans in Italy.

Total polulation (P) of munipality	Drinking water STANDARD (L/inhab/d)		
	PRGA (1967)	PS14 (1981)	Update PRGA (1998)
Single huose	80	150	170
P < 5,000	120	150÷170	170
5,000 < P < 10,000	150	160÷235	170
10,000 < P < 50,000	200	170÷340	250
50,000 < P < 100,000	250	270÷340	300
100,000 < P	300	340	340
Province	350	375÷445	375
Principal town (Bari)	350	480	420
Tourists in hotels	100	350÷500	500
Tourists not in hotels	100	100	200
Workers in industries	---	150	100
Extra (non resident) daily population	100	150	100

The total water requirement is then defined when the future trend of population, industry and tourists. The difference between the water demand and the actual water resource availability defines the water deficit in drinking water. The actual estimated value of the deficit of the region is 53 Mm^3, including water losses of 15%, which will be covered by including new artificial lakes.

The drinking water supply information at the 24 municipalities of the Ostuni pilot area has been reported in APPENDIX.

1.1.3. Recovery of water losses

The recovery of water by reducing losses from pipelines should be considered a very priority from drinking water communalities. Technology can assist (see for instance geo-radars) operators in the ducting break and pipe failures or leakages from joints. An experimental study carried out from Apulia communality [6] on a sample of 25 municipalities of region has shown a percentage of water losses ranging from 10%-15% in large city to 30-35% in small towns. This because there are important water losses that are probably localized on the main pipelines that supply the distribution network. These produce the majority of water leakage and, subsequently the water loss volume is reduced in percentage, when the total volume provided for supply is higher. The mean water losses of the Apulian municipalities were estimated to be 16.08% of the total volume supplied.

1.2.1 Hydrogeological systems

The carbonate limestone of the Salento platform is very permeable because most of the joints and fractures caused by tectonic movements are karstified. The hydrological studies at the Ostuni site show that the fractured aquifer, in which groundwater flows along preferential horizontal pathways, has a variable saturated thickness averaging 30 m.

The investigated Murgia region (Puglia, Italy) is characterized by a Cretaceous geologic formation named *Calcare di Altamura* (limestone). The Mesozoic formation is locally covered by Plio-Quaternary deposits (sandstone) in littoral facies. The stratigraphic sequence observed during drilling of wells, from bottom upward, is: Jurassic dolomites (with a thickness of 20 m), Cretaceous limestone (with a thickness of 30 m) and Pleistocene sandstone (with a thickness of 5 m). The groundwater flows in preferential horizontal fractures of the limestone. Hydraulic properties of the aquifer are mainly due to the secondary permeability, which depends on the presence of joints and karst channels. At the regional scale, the groundwater discharge, piezometric heads and velocities have been obtained by using another conventional meshed model [Masciopinto, 2006]. Macroscopic global parameters, such as hydraulic transmissivity T [L^2/t] or conductivity K [L/t], have been determined by applying the semi-analytic solution of steady radial flow to a well (i.e. the Thiem's equation) [Masciopinto et al., 2008] to the results of fifty-eight pumping tests carried out on wells of the same aquifer. The flow in the conventional model was discretized as in a parallel set of horizontal fissures with impermeable rock matrix and variable apertures. The model implemented the approximated analytic flow solution to determine the mean fracture aquifer conductivities, by using $K = nb^2/3\ \gamma_w/\mu$, where n [-] is the effective aquifer porosity.

Analyses of tension disc infiltrometer data were carried out on top sol at the Ostuni (PRIMAC, http://primac.ba.cnr.it/). They were based on multiple heads approach requiring two or more steady-state flow values for a single disc radius at different pressure heads. Results at steady state flow rates [$cm^3\ s^{-1}$] due to different pressure heads have been obtained from cumulative infiltration curves are reported in Table 4.

Table 4. Results of the tension infiltrometer experiments: steady state flow rate, $Q(h_0)$, at pressure head h_0

	$Q(h_0)$, $cm^{-3}s^{-1}$								
h_0, cm	*Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*	*Run 6*	*Run 7*	*Run 8*	*Run 9*
-12		0.1096	0.0526	0.0332		0.0324	0.0496	0.0532	0.0256
-9	0.3330	0.3830	0.1929	0.1211	0.1036	0.0444	0.1135	0.1201	0.0440
-6	1.8318	1.9296	1.0034	0.4901	0.2226	0.0648	0.4066	0.5683	0.1150
-3	3.8643	5.7498	4.1343	2.9871	0.5808	0.2013	2.9911	2.2540	1.1683
-1									3.3507

$Q(h_0)$ shows considerable variations among the nine sites. Most of variation occurred at –6 cm pressure head. This is likely caused by an uneven distribution of pore sizes.

The hydraulic conductivities $K(h_0)$ [cm s^{-1}] for each measurement were estimated (see Table 5 and Fig 4. 2.4).

Table 5. Results of the tension infiltrometer experiments: Hydraulic conductivity $K(h_0)$ (cm s^{-1}) at pressure head h_0 (cm)

	$K(h_0)$, cm s^{-1}									
h_0, cm	*Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*	*Run 6*	*Run 7*	*Run 8*	*Run 9*	*Mean*
-12.0		2.6x10^{-4}	1.3x10^{-4}	8.1x10^{-5}		4.5x10^{-5}	1.1x10^{-4}	1.1x10^{-4}	4.7x10^{-5}	1.1x10^{-4}
-10.5		4.9x10^{-4}	2.5x10^{-4}	1.5x10^{-4}		5.3x10^{-5}	1.6x10^{-4}	1.7x10^{-4}	6.1x10^{-5}	2.0x10^{-4}
-9.0	8.6x10^{-4}	9.5x10^{-4}	4.8x10^{-4}	3.0x10^{-4}	2.2x10^{-4}	6.5x10^{-5}	2.6x10^{-4}	2.8x10^{-4}	9.0x10^{-5}	4.2x10^{-4}
-7.5	2.0x10^{-3}	2.3x10^{-3}	1.1x10^{-3}	6.0x10^{-4}	3.2x10^{-4}	8.3x10^{-5}	5.2x10^{-4}	6.6x10^{-4}	1.6x10^{-4}	9.9x10^{-4}
-6.0	4.3x10^{-3}	4.7x10^{-3}	2.5x10^{-3}	1.2x10^{-3}	4.8x10^{-4}	1.3x10^{-4}	1.0x10^{-3}	1.4x10^{-3}	2.8x10^{-4}	2.2x10^{-3}
-4.5	5.5x10^{-3}	7.8x10^{-3}	5.1x10^{-3}	3.1x10^{-3}	8.1x10^{-4}	2.7x10^{-4}	2.9x10^{-3}	2.8x10^{-3}	9.9x10^{-4}	4.0x10^{-3}
-3.0	8.0x10^{-3}	1.3x10^{-2}	1.0x10^{-2}	7.8x10^{-3}	1.3x10^{-3}	4.7x10^{-4}	7.9x10^{-3}	5.5x10^{-3}	3.1x10^{-3}	8.2x10^{-3}
-2.0									5.0x10^{-3}	
-1.0									8.5x10^{-3}	

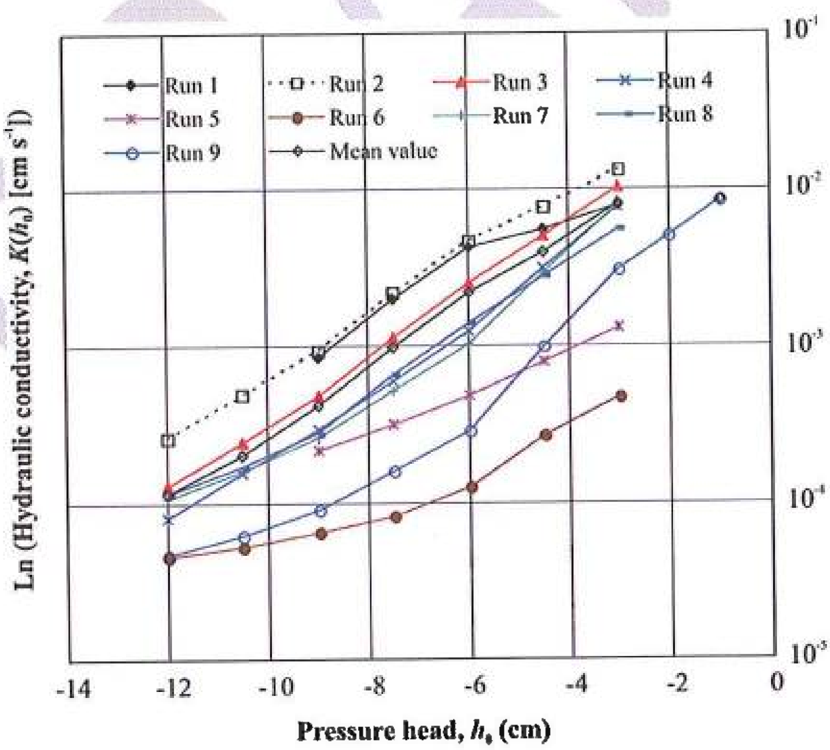


Fig 4.2.4. Soil hydraulic conductivity $K(h_0)$ versus pressure head h_0.

Hydraulic conductivity values showed considerable variations between the nine sites. The mean values were calculated following a lognormal distribution.

1.1.4 Drought and desertification

About one third of the country is vulnerable to varying degrees to the processes of land degradation. A classification of the vulnerability of the Italian territory to land degradation and desertification, based on the Environmentally Sensitive Area Index (ESAI) showed that (in 2000) Sicilia was affected by a regional medium-high degree of environmental vulnerability (sensitive areas represented about 70% of the regional territory), followed by Molise (58%), Apulia (57%) and Basilicata (55%). Six regions (Sardegna, Marche, Emilia-Romagna, Umbria, Abruzzo and Campania) had similar conditions (between 30% and 50%); for seven other regions (Calabria, Toscana, Friuli-Venezia-Giulia, Lazio, Lombardia, Veneto and Piemonte) sensitive areas represented between 10% and 25%, while in three regions (Liguria, Valle d'Aosta and Trentino Alto Adige) the percentages were fairly small (2% - 6%).

More recent studies show the sensitivity to desertification and drought of the Italian territory based on the Sensitivity to Desertification Index (SDI), which considers soil quality, climate and vegetation parameters. The gradual worsening of desertification trends, already observed in the whole country, can be accelerated from climate change by increasing the actions of erosion, salinization, loss of organic matter and drying up of soil.85 About 30% of the Italian territory can be considered at risk of desertification, with the key vulnerabilities located in the South. Furthermore, especially vulnerable areas are farmlands with intensive and marginal production, areas at risk of accelerated erosion (e.g. coastal areas), areas damaged by contamination, pollution and fires, and fallow and abandoned lands.

Severe indirect socio-economic impacts of this desertification process may follow, including: decline in agriculture and tourism productivity, growing unemployment in rural areas with consequent migration, conflicts over water uses, harm to properties and people, due to increased frequency of fires, overall biodiversity loss. [7], [8].

1.1.3 Water quantity and quality

Water quantity/availability and quality in Italy could be affected by [9]:

- reduced water availability, especially in summer;
- increased water stress;
- severe negative impacts in the South, where vegetation and territory are already experiencing a marginal water supply regime;
- increased seasonal water deficit due to significant pressures of summer tourism peaks in small Italian islands;
- potential increased conflicts among multiple uses of water resources.

Minimum quality requirement for irrigation are defined in Table 6.

Table 6. Main quality parameters (D.M. 185/03 [10]) for agricultural reuse of municipal wastewater. Exceptions valid in Apulia are marked with star (*).

Parameter	Value
pH	6–9.5
Coarse solids (mg/L)	absent
TSS (mg/L)	10
COD (mg/L)	100–(50)*
BOD_5 (mg/L)	20–(10)*
Boron (mg/L)	1.0–(2.0)*
Chlorides (mg/L)	250–(500)*
Sulphates (mg/L)	500
Electrical Conductivity (μS/cm)	3,000
Total Phosphorus (mg/L)	10
Total Nitrogen (mg/L)	35
Grease and Oil (mg/L)	10
Aldehydes (mg/L)	0.5
Surfactants	0.5
Chlorinated Pesticides	0.0001
Escherichia coli (CFU/100ml)	10
Salmonella (CFU/100ml)	absent
Sodium Adsorption Ratio	10

Notes: In addition to B also Al, As, Ba, Be,Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Si, Th, V, Zn, THM, CN, SO_3, Benzene, Benzo(a)pyrene and other organics are considered.

1.3 Status of WFD implementation regarding groundwater

Seawater intrusion and over-abstraction of aquifers are very relevant problems in Apulia as in many other Mediterranean coastal regions. Italian legislation for pollution prevention in natural water resources (D. Lgs. 152/1999 [11]) includes several measures for preserving the global groundwater balance by considering not only water demand and resource availability, but also potential sources for groundwater replenishment. The authorization procedures are regulated by D. Lgs. 152/2006[12], which also establishes measures (art. 76–77), such as the creation of barriers, artificial recharge, etc., in order to improve groundwater quality. Regional authorities must apply these measures to preserve and protect groundwater, within 2015. Specifically, a subsequently national regulation (D. Lgs. n. 4/16–01, 2008 [13]) has required that only projects for the artificial recharge plants with annual recharged volumes above 10 million cubic meters must be verified for their environmental impacts. Other proposed measures aimed at limiting seawater intrusion in groundwater consist of best management actions of groundwater volumes by reducing groundwater pumping and by increasing seawater desalination plants. Several Italian Regional governments have planned groundwater remediation measures in Master Plans named *"Piani di Tutela delle Acque"* (PTA) (i.e. Water Regulation and Protection Plans). The PTA has already been published for the Apulia Region. In particular, the PTA according to Directive 2006/118/EU [14] and Directive 2008/105/EC [15] the Italian legislation (D. Lgs. 30, 2009 [16]) establishes criteria for the assessment of both quantitative and qualitative (i.e. chemical) status of groundwaters. These criteria must be applied by regional water management Authorities to the entire Apulia region in order to ensure both good quality and quantity status of groundwater reservoirs before the end of 2015. Recommended threshold values to achieve the good standard of groundwater chemical quality are those reported in the above mentioned EU groundwater Directive 118.

2. Methodology

When considering the impacts of global climate change on fresh water the focus is primarily on environmental responses at the local and regional scale, taking into account the roles of the meso scale features, orography, land–sea interaction and regional mechanisms characterizing local climate. Output of model (see DRINKADRIA Report WP4, activity 4.1) leads to the conclusion that during the next 50 years, temperature increase will be limited to about 1°C from December to June but may exceed 2° C from July to October, that minimum temperature may be more affect than maximum temperature, and that precipitation may decrease in April, July and September while increase in October and December.

The study of piezometric heads of the deep Apulia groundwater has enhanced several areas of the Apulia region where, the increasing drinking water demand has strongly influenced the irrigation areas with a general water scarcity. Furthermore the watertable drawdowns have shown that groundwater over-pumping increased in the last years, and that a strategic political control of groundwater withdrawals is required. The groundwater over-pumping has caused the reduction of groundwater specific discharge outflowed into the sea and, subsequently, the landward seawater movement in the coastal aquifers. As a consequence the groundwater cannot be anymore utilized by causing economic and environmental damages. Moreover, due to the increase of untreated wastewater release on ground and channels (i.e., *lame*), waste percolations in groundwater caused water contamination in several areas of the Apulia region and, in particular at Salento, along the Brindisi coast.

Consequently in the Ostuni area several wells, previously utilized for domestic and irrigation purposes, have been abandoned. Four of these wells, located at Villanova (Ostuni) area, will be monitored from the IRSA.

2.1 Definition of the goal

The wastewater **reuse** after treatment can significantly contribute to supply the soil irrigation, especially during summer and drought periods. In Italy the standard of quality of reclaimed water in irrigation areas have been defined in the following regulations: D. Lgs. n. 185/2003, D. Lgs. n. 152/1999 and D. Lgs n. 152/06 (modified and integrated with D. M. n. 4/2008). For this scope the Regional government increased the number of the tertiary treatment plants able to provide enough reclaimed water in the irrigated areas. Moreover, during winter it has been verified an excessive water production of reclaimed water, which caused an overflow. Consequently, there was a high quantity of reclaimed water, which has been outflowed into the sea (or in the lama d'Antelmi) along the coast. Really this overflow could be conveniently utilized for the artificial recharge by **dynamic barriers** of wells, in order to stop and reverse the progressive movement of seawater in the groundwater. In DRINKADRIA project will be tested the efficacy of the artificial barriers along the OSTUNI coast, by using the results of groundwater monitoring and mathematical model simulations. The model, on the basis of the data collected from field/lab tests, will be able to quantify the volumes of groundwater which can be annually restored with the proposed barriers and that could be potentially reused for drinking and in particular for tourist purposes.

Subsequently the IRSA has programmed following next activities:

2.1.1 Actions: monitoring/project

- Monitoring of groundwater and surface water in the experimental area of the Ostuni (Villanova). The water samples will be tested at the Bari IRSA Laboratory in order to detect water pollutants, pathogens and toxics compounds;
- Model simulations to define the length of barriers (dynamic and static) required in the specific intruded area. The simulation will consider water volumes derived from wastewater treatment plants or other sources (i.e. lame or streams, channels, etc.) in order to fed the dynamic barriers; and finally
- Definition of the annual volume of groundwater that can be restored by barriers on the coastal areas.

2.1.2 Specific phases of IRSA activities

The specific steps of the CNR/IRSA activities can be synthesized as in the following:

PHASE A: Data and background information collection, status and database implementation.

It included the estimation of the annual water volume as budget component of the hydrogeological water cycle; constituents of the ground water quality, water salinity, etc..

PHASE B: Integration of data collected and actual groundwater monitoring network.

It was identified a specific study area where will be carried out an intensive groundwater/surface water monitoring. The monitoring of wells will be supported by a geostatistical analysis and by specific multi-parametric probes installed into the Ostuni monitored wells. The activity included the definition of new possible sampling wells for groundwater monitoring due to intensive soil irrigation or wastewater infiltration. This methodology may be included in a general framework in order to apply similar measures in other areas of Mediterranean coastal areas that are subject to seawater intrusion.

PHASE C: Modelling of the impact due to wastewater leakages in saturated/unsaturated subsoil and in groundwater and efficacy of the measures for groundwater restoration.

Model simulations will be used to define the optimal position of dynamic and static barriers in order to restore coastal polluted aquifers. On the basis of data collected the model simulations will be defined water flow rate for dynamic barriers, the position and length of the static barriers and the potential volume of restored groundwater. Results on the pathogens transport in fractured subsoils and artificially injected will be described. At the end of this step, the simulations provided also the best positions for monitoring wells to control the artificial recharge efficacy in the Salento/Murgia fractured aquifers.

PHASE D: Integrated actions and guide-lines to protect groundwater and improve water quality along the coastal areas

As main results of the model simulation and studies IRSA will provide to the management Authority the best management practices (i.e., **measures**) in costal groundwater, which may produce the maximum environmental benefits as a consequence of the combination of artificial recharge and dynamic barriers with the wastewater reuse for soil irrigations.

3. Quantitative ASSESSMENT of groundwater stress

3.1 Volume availability in coastal area

At the first step an estimation of the reduction in the amount of "withdrawals" from the groundwater during the irrigation season were carried out by considering the municipality wastewater treatment plant of Ostuni, i.e. the location where of the only reuse plant currently operating in the Apulia region.

The plant in question has a daily capacity of 6,562 m^3/d (75.9 L/s) of treated sewage.

As regards irrigation, the coastal zone of the Ostuni, which is served from the Irrigation Arneo Consortium, is not homogeneous: parts of this area are not supplied from Consortium, but they are supplied from private wells. The water requirements for irrigated crops in the area are shown in the following table, which also provides data on the surface areas affected:

Table 7. Culture, extensions e water requirements at the Ostuni coastal area

CULTURE type	ESTENSION [ha]	Irrigation annual demand [m^3/ha]
Fruit	964	3250
horticultural crops during summer/autumn period	199	2800
Olive	98	1400
Grapes	56	2750

horticultural crops during whole spring	10	2200
horticultural crops during spring/summer period	4	4800

Table 8. Volume (in m^3) for irrigation deficit and treatment plant surplus at the Ostuni coastal area.

Month	Requirement for irrigation	Integrated requirement	Treated water	GW supply	Total volume for irrigation	Surplus from WWTP	Potential surplus from WWTP
Jen	0	0	203422	0	0	203,422	203,422
Feb	0	0	183736	0	0	183,736	387,158
Mar	0	0	203422	0	0	203,422	590,580
Apr	42,262	42,262	196860	0	0	154,598	745,178
May	594,662	636,924	203422	391,240	391,240	0	745,178
Jun	1,143,008	1,779,933	196860	946,148	1,337,388	0	745,178
Jul	1,478,399	3,258,332	203422	1,274,977	2,612,366	0	745,178
Aug	759,307	4,017,639	203422	555,885	3,168,250	0	745,178
Sept	5,444	4,023,083	196860	0	3,168,250	191,416	936,594
Oct	0	4,023,083	203422	0	3,168,250	203,422	1,140,016
Nov	0	4,023,083	196860	0	3,168,250	196,860	1,336,876
Dec	0	**4,023,083**	203422	0	**3,168,250**	203,422	**1 ,540,298**

The highlighted figures in Table 7 for December emphasize the importance of reuse both in terms of the reduction in the amount of water taken from the groundwater and of replenishing it.

The cumulative volume requirement denotes the amount of water that is necessary to supply from groundwater in order to meet irrigation requirements, without water reuse: that is 4,023,083 m^3/year, only in the coastal area.

Moreover, in the coastal area, cumulative integration volume denotes the annual volume of water requirement that would be supplied from groundwater if treated wastewater is not reused during the irrigation season, is about 3,168,250 m^3/year.

Clearly, the difference between the above-quoted figures corresponds to the reduction in the amount of water that would be supplied from the groundwater if reuse is adopted, i.e. 854,833 m^3/year. In percentage terms, this amounts to 21% of the total irrigation requirement in the coastal area.

Furthermore the Table 7 shows also the surplus of treated sewage that might be used during the irrigation season to replenish the groundwater (1,540,298 m^3/year). This possible "refund" of about 49% of the volume of water, could be pumped and reused for drinking purposes during summer period.

In other words, the combination of reuse during the irrigation season and replenishment during rest of the year would lead to an overall reduction in pressure on the coastal groundwater and may provide water useful for drinking leading to obvious benefit for the overall water balance of the coastal area.

3.2 Water quality assessment and safety in coastal area

At each sampling site we will collect two liters of water in a sterile container to detect *Salmonella* spp., one liter to detect the indicators of faecal contamination and a third sample of twenty liters to detect somatic coliphage viruses. The coliphages were determined after concentration to 50-100 mL of water sample by tangential ultrafiltration (VIVAFLOW 200 with 10,000 MWCO PES, *Sartorius*).

Sampled water was analyzed for total bacterial count (TBC) at 22° and 37°, coliforms, Escherichia coli, spores of sulphate-reducing clostridia, somatic coliphages, and *Salmonella* spp., *Campylobacter* spp. and physico-chemical constituents, such as ammonia, nitrates, chemical oxygen demand (COD). The physical, microbiological and chemical parameters were determined using Standard Methods ([17-18].

Large volumes of 5-120 L and 200-250 L will be sampled for the protozoa and virus analyses, respectively. The groundwater will be filtered (at pH 3.5) by a 142 mm diameter glass fiber pre-filter and then in a nitrocellulose membrane in a Sartorius filter holder at a maximum rate of 1.5 L min_1 nitrocellulose membranes with elution and organic flocculation [19]. The filtrate will be run to waste and the virus will be then eluted from the membrane by slow passage (10 min) of 200 ml skimmed milk solution (0.1% in 0.05 M glycine buffer). The eluate was flocculated by reducing its pH to 4.5 with M HCl and centrifuging as above.

Cysts and oocysts will be purified by means of immune-magnetic separation (*Dynabeads*® Crypto-Combo), and stained with fluorescently labelled monoclonal antibodies (*MERIFLUOR*® *Crypto & Giardia* kit, Meridian Bioscience, Europe) and with DAPI (0.4 µg/mL of phosphate buffered saline (PBS) at 37 °C for 15 min). Giardia and Cryptosporidium cysts and oocysts were finally enumerated by epifluorescence microscopy (Olympus BX-51) and phase contrast observation.

During PRIMAC project, microbial and chemical constituents (average values) of surface water and seawater were collected during benthos sampling campaigns. Results are reported on Table 9.

Table 9. Water quality at Ostuni coastal area (from PRIMAC project: http://primac.ba.cnr.it/)

	Sampling site	
Microbiological parameters	**Surface water (channels)**	**Ostuni Port (sea)**
Total bacterial count 22°C [CFU /mL]	34000 ± 43350	30
Total bacterial count 37°C [CFU /mL]	18900 ± 15550	700
Total coliforms [MPN/100mL]	5800 ± 8900	5
Fecal coliforms [MPN/100mL]	922 ± 1289	2
E. coli [MPN/100mL]	888 ± 1315	0
Enterococci [CFU /100mL]	1560 ± 1380	0
Somatic coliphages [PFU/mL]	274 ± 354	0
Clostridium perfringens [CFU /100mL]	2300 ± 2000	5
Sulfite-reducing clostridium spores [CFU/100 mL]	1800 ± 2800	0
Campylobacter spp [presence/absence]	1 positive	0
Salmonella spp [presence/absence]	1 positive strain of *Salmonella enterica* sub-specie *Arizonae*	0
Physical and chemical parameters		
Temperature [°C]	26.6 ± 1.6	22.8 ± 3.1
pH	8.91 ± 0.18	8.43 ± 0.11
Electrical conductance [mS/cm 20 °C]	1.67 ± 0.85	59.45 ± 0.65
Salinity [g/L]	0.84 ± 0.42	29.7 ± 0.32
Dissolved Oxygen [mgO_2/L]	2.85	5.5
Chemical oxygen demand (COD) [mgO_2/L]	24.6 ± 3.3	99 ± 3.2
Dissolved organic carbon (DOC) [mg/L]	10.6 ± 3.1	54 ± 11.3
Ammonium [N-NH_4 mg/L]	1.6 ± 1.5	6 ± 0.7
Nitrates [N-NO_3 mg/L]	4.1 ± 0.5	0
Total suspended solids [mg/L]	68 ± 90	62 ± 3

The principal benefits of the concept of Managed Aquifer Recharge (MAR) for water management are twofold:

- It allows storage of large quantities of surface water (including surface runoff, storm water, reclaimed water, and also freshwater from desalination) at those periods of the hydrological year when availability exceeds demand and to restore them when demand exceeds availability.
- The underground passage (unsaturated and saturated zone) can constitute a complementary treatment step, due to physical, chemical and biological processes that will affect water quality.

The major challenge to meet is thus a potential conflict of the MAR system with other uses, mainly in terms of water quality (risk of degradation of chemical or biological background quality for one or more parameters due to infiltration or infiltration-induced chemical processes in the storage medium). In order to address those benefits and risks, the designer or operator of any MAR system will need to address the following key questions:

(1) How efficient is my system in terms of recovery of the recharged water?

(2) How long will the water and solutes reside in the system and be in contact with reactive minerals and biofilms?

(3) In which way will the recharge-recovery cycles affect the quality of the recovered water and the background water, on short term and long term?

These questions will be asked from the very beginning of the planning phase and over the whole lifetime of the MAR project and groundwater models provide the unique possibility to preview the feasibility of the MAR system in the regional context, to optimize the choice of the site, the configuration of an appropriate recharge-recovery system, to optimize operating conditions in a way to meet fixed quantity and quality targets. Those targets are most frequently quantified through the key parameters recovery efficiency, residence time, and recovered water quality compared to target quality. Recovery efficiency [20] as a measure of success of a MAR system, is defined either by the percentage of injected water that can be recovered or by the percentage of usable water (meeting a defined target quality, e.g. drinking or irrigation water standards) compared to the injected volume per cycle of injection.

Residence time or transfer time (in the case of Aquifer Storage, Transfer and Recovery, ASTR) will be the average duration of water and solutes in the reservoir determining the time available for water-rock interactions and bio-geochemical reactions. Residence time will largely influence the potential for degradation of pollutants and thus the efficiency of Soil Aquifer Treatment (SAT) systems and to estimate this parameter may therefore be legally compulsory. A typical example is the Californian draft regulations applying to new recharge projects [21].

They define the minimum retention time to allow identification of treatment failures and implement remediation actions and to guarantee the overall treatment efficiency. Target quality for the groundwater quality is generally defined by law and water reuse guidelines. Potential use of recovered water is also defined in these guidelines. The quality of the recovered water has to be constantly compared to this target quality and is determined by the quality of recharged water, the attenuation potential of the unsaturated and saturated aquifer and the background water, frequently but not necessarily of lower quality than the recharged water (e.g. freshwater injection into saline aquifers). The underlying processes controlling water quality are (1) mixing by advection and hydrodynamic dispersion (2) density dependent stratification (3) ambient groundwater displacement and (4) reactions within the aqueous phase induced by mixing and reactions with aquifer material and subsurface microbial communities.

Those key parameters are determined by intrinsic, physical factors (aquifer properties like permeability, effective porosity, dispersivity, preferential flow zones and the natural hydraulic gradients, aquifer mineralogy and background water quality) and by operational variables (e.g. storage period, volumes recharged, and recharge/recovery rates). The intrinsic properties are generally constant but may evolve over the lifetime of a MAR system (e.g. through clogging [22]; [23]). Intrinsic factors will depend on the selection and design of the system, operational variables on the strategy for MAR operation. Groundwater models can help for both purposes.

Currently available groundwater models allow quantifying recovery efficiency, residence time and quality of recovered water. However, a complete response to the questions listed above may need the use of state of the art models (reactive transport models) or go beyond the current capacities of the state of the art (bio-geochemical reaction modelling). Even simple models (analytical models) can provide sufficient information at least for preliminary design or evaluation of MAR systems but, most frequently, numerical models will be used. Standard numerical models will nowadays be able to simulate up to full 3D advective (e.g. through particle tracking) and dispersive flow and transport of water and solutes. Supplementary features may be needed as, in the order of increasing complexity:

- Density driven flow (in the context of highly saline waters, like in coastal aquifers)
- Sorption and (bio-) degradation of solutes (e.g. through sorption isotherms, degradation factors)
- Variable saturation flow (in the case of a significant thickness of the unsaturated zone, in particular if the latter plays an important role for water quality improvements in SAT systems)
- Geochemical reactions through the combined use of flow-transport models and thermodynamic equilibrium models or thermo-kinetic models taking into account the reaction kinetics
- Biologically mediated geochemical reactions (specific models available)
- Aquifer ecosystem simulation accounting for changing microbial communities and their assimilation of nutrients, competencies for metabolism of organic contaminants, enzymatic attack on pathogens and their influences directly and through microbial products (such as polysaccharides) on aquifer porosity and hydraulic conductivity.

In this chapter the IRSA will outline the use of groundwater models for MAR focusing on the strategic phases of a MAR system (site selection, MAR design, MAR operation), on the data needs to build and run such models. Applications of models within the pilot area of DRINKADRIA will be carried out.

3.2.1 Pathogen transport models

Traditionally, mathematical models treating pathogens either as finite particles or as dissolved molecules, are used for a preliminary estimation of pathogen movement in aquifers [24]-[25], and subsequent evaluation of setback distances [26]. Colloids present in subsurface formations are mainly mineral micro particles in the form of metal oxides, humic macromolecules, bacteria and viruses [27]. Colloids generally range in size from 1 nm to 10 µm; although, biocolloids such as bacteria range in size from 0.2 to 5 μm and they are much larger than dissolved contaminant molecules [24].

Consequently, the sorption of bacteria onto solids is described by colloid filtration theory [28]. Viruses are at the lower end of the colloid size distribution with size ranging from 0.02 to 0.3 μm [29]. Traditionally, the sorption of viruses behaving as solutes is represented by a non-equilibrium, first-order kinetic process [30]; whereas, the sorption of viruses behaving as colloids can be described by colloid filtration theory [24]-[31]. Pathogen count variations caused by particle desorption/sorption phenomena on rock/soil surfaces have been also described by Wang et al. [32], Meschke & Sobsey [33], Hendry et al. [34] and Mallén et al. [35].

The theory of the kinetics and dynamics of particles deposition has been also developed by Johnson and Elimelech [36], considering the effects of geochemical heterogeneity [37] on the surface charge of soil particles. In the rock fractures favorable and unfavorable patches may also occur on the surface of the fractures. Thus, as suggested by Johnson & Elimelech [36], the whole surface of fracture can be partitioned in several patches which are favorable or unfavorable for colloids deposition by having different charge characteristics.

Anyway, at a regional scale, continuous recharge operations may saturate soil and rock surfaces for both attachment/detachment and sorption/desorption effects and, consequently, the effects during the non-stationary phase of pathogen transport in groundwater caused by geochemical heterogeneity can be assumed negligible. On the contrary, at a laboratory scale, the attachment/detachment and sorption/desorption effects may produce non negligible effects on particle count and specific model equations able to account for the non-stationary phase of the pathogens transport are required.

4. Preliminary CONCLUSIONS

The study undertaken made it possible to:

- Determine the nature and levels of the fluctuations in irrigation needs in the coastal areas of the Puglia Region in relation to crop types;
- Highlight the impact of water shortages on typical crop distribution in the various provinces;
- Carry out the first evaluation of irrigation needs on a provincial scale in relation to current crop distribution;
- Identify treatment plants within the coastal area and quantify the availability of treated sewage water that might be reused in agriculture, the aim being to discourage the removal of water from the deep groundwater, which is already seriously over-exploited;
- Quantify the water deficit in the irrigation season and the treated water surplus in the non-irrigation season;
- Achieve an overall balance between reductions in withdrawal of water from the groundwater on the coastal strip in each province and quantification of the potential volumes of treated sewage water that might be used to combat saline intrusion.

The percentage of 17% of reduction in water withdrawal that might be achieved by using treated water from the sewage plants in the coastal area in the irrigation period, and the percentage of water supplied for irrigation purposes that might be restored, during the non-irrigation season, in the shape of the surplus of treated effluent is 27%, which might be used to create "dynamic barriers" against saline intrusion.

In this context it is to be hoped that the EC Directive 60/2000 [38] and Regulation (EC) No. 1882/2003 [39] impact upon Italian Law 152/99, and the subsequent 152/06. On the basis of the directive, in fact, it is possible to contemplate replenishing the groundwater with purified effluent from the same plants as provide water for reuse in agriculture, given that during the autumn-winter period the farming sector has drastically reduced water needs.

It must be pointed out, however, that the percentages so far provided represent the maximum results achievable using the treatment plants considered in the coastal area. Furthermore there some factors that should be taken into account:

- It is advisable to prioritise the areas where the groundwater is being impoverished: providing an economically competitive substitute resource is the first step towards recovery.
- In cases where water is to be reused in already-existing irrigation areas, the benefit obtained is twofold: a reduction in operational costs and immediate use of the water.
- Where incomplete, work on the water distribution networks should be finished in order to enable land to be cultivated: this work needs to be given priority if investments already made are not to prove fruitless and if the rapid deterioration of facilities already in place is to be avoided. The level of investment will be lower for those plants which already have purification facilities suitable for producing reusable water but for which a distribution network is not yet in place.

- Master Plans should take into account of the high demand for irrigation water in certain predominantly agricultural areas of the region where, owing to geographical location or the disastrous state of the local groundwater, no other resources are available.

As regards smaller-capacity wastewater treatment plants, it would be advisable for their reuse output of treated effluent to be combined so as to obtain more substantial amounts of water.

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APPENDIX

COMUNE	PROV	node	Flow rate supplied L/s	Population 01/01/2013 (ISTAT)	Non Resident	Tourists in hotel	Tourist not in hotel	Workers in industries	Actual drinking demand	Actual deficit	Demand (L/s) for Tourist
SAN MICHELE SALENTINO	BR	131	16.3	6359	138	0	1096	492	23	7	2
FRANCAVILLA FONTANA	BR	134	137.7	36908	2372	42	11056	2126	199	61	14
CAROSINO	TA	354	14.0	6963	135	0	138	193	24	10	1
ROCCAFORZATA	TA	6111	5.3	1797	24	18	123	88	6	1	0
MONTEPARANO	TA	6111	5.3	2410	25	0	83	145	8	3	0
PULSANO	TA	6111	61.3	11221	468	405	15975	460	69	7	12
FASANO	BR	128	183.3	39431	2578	1603	29270	2736	227	44	30
OSTUNI	BR	130	178.6	31709	2068	2148	40259	4365	197	19	39
LOCOROTONDO	BA	129	50.2	14258	581	44	5120	2057	78	28	7
CISTERNINO	BR	129	44.9	11678	499	124	4078	936	63	18	5
MARTINA FRANCA	TA	129	205.5	48958	2970	350	33280	3874	277	72	32
CAROVIGNO	BR	130	66.0	16187	670	98	13844	1183	93	27	12
SAN VITO DEI NORMANNI	BR	131	77.6	19494	1349	121	5358	1322	105	28	8
CEGLIE MESSAPICO	BR	131	81.1	20089	1343	22	8285	1254	110	29	10
LATIANO	BR	358	57.2	14919	17504	0	700	3031	113	56	39
CRISPIANO	TA	347-348	45.5	13646	585	0	861	831	71	25	3
VILLA CASTELLI	BR	132	21.0	8965	181	0	1594	384	32	11	2
GROTTAGLIE	TA	133	116.7	32544	2062	14	1162	1547	169	52	7

MONTEMESOLA	TA	350	8.8	4037	50	0	111	235	14	5	0
TARANTO	TA	349	1093.8	198728	22178	2269	0	44301	1763	669	96
MONTEIASI	TA	352	12.3	5530	123	0	65	129	19	7	0
SAN GIORGIO JONICO	TA	6111	51.9	15480	681	32	181	880	80	28	2
FAGGIANO	TA	6111	8.8	3558	42	0	84	114	12	4	0
LEPORANO	TA	6111	27.4	7873	141	210	12899	704	37	9	10
TOTAL			2570.5	572742	58767	7500	185622	73387	3789	1219 (47%)	330 (9%)

The estimation of the drinking water demand was based on the drinking water standards (Table 4) by considering the seasonality of 60 days for tourists and a worker presence of 200 days per year. Thus we have

Average water demand= $\sum$ (Water standard x Population x seasonality/365)/86400 x Water losses coefficient (=1.15)

and

Maximum (or actual) water demand = Average water demand x Coefficient of water demand fluctuation (=1.5)

Table A1 provides the water requirement for tourists of 330 L/s, which is approximately 9% of the total drinking requirement. This means that 9% of the actual drinking water, i.e. 224 L/s is provided from actual water resources, whereas the actual deficit for tourists is about 106 L/s. A fraction of this flow rate, i.e. 76 L/s may be provided by groundwater, along the Ostuni coast. The remaining deficit of 30 L/s may be easily supplied by replenishments and successive pumping from the Ionian coastal groundwater, by using effluent of nearby municipal wastewater plants of (Taranto, Monteiasi, San Giorgio Ionico, Faggiano, Leporano, Carosino, Roccaforzata, Pulsano and Monteparano) after appropriate water treatments.

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Cross Border Cooperation 2007-2013

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WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: Water Utility of Nova Gorica, FB4
Contact person of the Final Beneficiary: Matjaž Hvalič, univ. dilp. ing.

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.
   - From DEM (digital elevation model) or with other devices determinate missing height of aqueduct in GIS. Manufacture hydraulic model of the existing data from the GIS and data from water sales department. Based on the hydraulic model set measurements points. Construction and installation of monitoring points with flow meters. Analyses data and comparison with the optimal situation in hydraulic model. Determination of the area with the most losses.
   - It is implemented in the area of Nova Gorica and the surrounding area, on a network that has a direct impact on water exports to Italy

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.
   - Annex 1- Pilot area

PART B – PILOT DATA

1. Describe which parameters do you want to monitor.
   - flow
   - preasure
2. Describe which performance index do you want to calculate.
   - Based on years of experience, we decided to use the method of comparing measurements of flow rates and pressures with hydraulic model.

3. Do you have data already relevant to the project? YES☒ NO☐
   If Yes, describe :
   - We have information on existing SCADA monitoring sites (see Annex 1)
   - We expanded our GIS elevation data
   - We listed facilities with all the necessary information for input into the hydraulic model
4. Do you need equipment or investment? Yes☒ No☐
   If Yes, describe :
   - We need additional monitoring sites for the precise calibration of the hydraulic model and for the measurements in separate zones
   - We also need devices to transfer data on SCADA system

5. Is the project already start? YES☒ NO☐

If Yes, indicate the starting date: 16.12.2013
IF No, indicate when it will likely start

6. Indicate the time line chart.
   - Annex 2

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources:	1
2. Population served by your system:	31492
3. Total length of water system:	280 Km
4. Service area (Km^2):	31 Km^2
5. Total number of connections/customers:	6113
6. Total number of retail connections:	5951
7. Amount of water produced (monthly and yearly average):	581.148 m^3/month 6.973.774 m^3/year2012
8. Average annual water volume delivered to customers:	3.970.002 m^3/year2012
a. supply capacity;	
b. percent imported water supply;	0
c. percent surface water supply;	0
d. percent potable groundwater supply.	100
9. Service area elevation range.	40 – 473 m.w.l
10. Total number of pressure zones in service area.	2+3
11. Approximate elevation range in each pressure zone.	50,80,60
12. Average number of customer connections per pressure zone.	
13. Average static pressure delivered to pressure zone (Bar).	4

Is your project about water losses? YES☒ NO☐
If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1.Indicate:
pipe materials, the percent in place and the length in Km;
water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

Material	Lengt (m)	%
AC	50779	18,29%
Ductile	80556	29,02%
Steel	16920	6,10%
Cast iron	23485	8,46%
Unknown	36537	13,16%

PE, PEHD	44710	16,11%
Galvanized steel - plasticized	6811	2,45%
Galvanized steel	17785	6,41%

Pressure: from 2 – 6 bar

2. Are all water service connections metered? YES☐ NO☐
   What exactly is meant by this ??
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☒
   Not yet. We plan that will be.

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☒ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

   a. water volume (m^3) input to distribution (produced and purchase)
   b. billed authorized consumption volume
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
   d. total authorized consumption volume (sum of **b** and **c**)
   e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
   f. list approximate percentage of water losses believed to exist as apparent losses (%)
   g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
   h. list what you believe to be the greatest source of apparent losses
   i. list approximate percentage of water losses believed to exist as real losses (%)
   j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
   k. list what you believe to be the greatest source of real losses
   l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

year 2012

Water Balance in m3 for a period of 365 Days

Home System Input Volume 6.973.774 [m3] Error Margin [+/-]: 1,2%	Authorised Consumption 3.970.002 [m3] Error Margin [+/-]: 0,0%	Billed Authorised Consumption 3.967.962 [m3]	Billed Metered Consumption 3.966.962 [m3]	Revenue Water 3.967.962 [m3]
			Billed Unmetered Consumption 1.000 [m3]	
		Unbilled Authorised Consumption 2.040 [m3] Error Margin [+/-]: 1,0%	Unbilled Metered Consumption 1.040 [m3]	Non-Revenue Water 3.005.812 [m3] Error Margin [+/-]: 2,8%
			Unbilled Unmetered Consumption 1.000 [m3] Error Margin [+/-]: 2,0%	
	Water Losses 3.003.772 [m3] Error Margin [+/-]: 2,8%	Apparent Losses 104.945 [m3] Error Margin [+/-]: 0,7%	Unauthorised Consumption 24.638 [m3] Error Margin [+/-]: 2,1%	
			Customer Meter Inaccuracies and Data Handling Errors 80.308 [m3] Error Margin [+/-]: 0,7%	
		Real Losses 2.898.826 [m3] Error Margin [+/-]: 2,9%		

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☒Listening sticks
☒Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☒Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☒Other:_ hydrogen probe, water and pressure meters in main branches

3. Indicate annual expenditure for losses management activities (€/yr), if available.
apr. : 480.000,00 €/2013

4. Does your utility have a water loss reduction target? YES☒ NO☐
If Yes, describe, In five to ten years from 2010 we planning to reduce water losses to 20-25 %.

check all that apply below and provide the date the program began, if available:

☒Meter replacement or calibration program	1998	☐Meter service connections	
☒Water line replacement		☐Meter Sources	
☐Reduce tank overflows		☒Line Looping	

☒Leak detection/elimination	1990	☒Flushing Program	
☒Theft Prevention	2008	☐Other	

5. Does any state or other agency require you to address water losses and loss reduction? YES☒ NO☐
   If Yes, describe. Indirectly by charging collected quantities of water at source

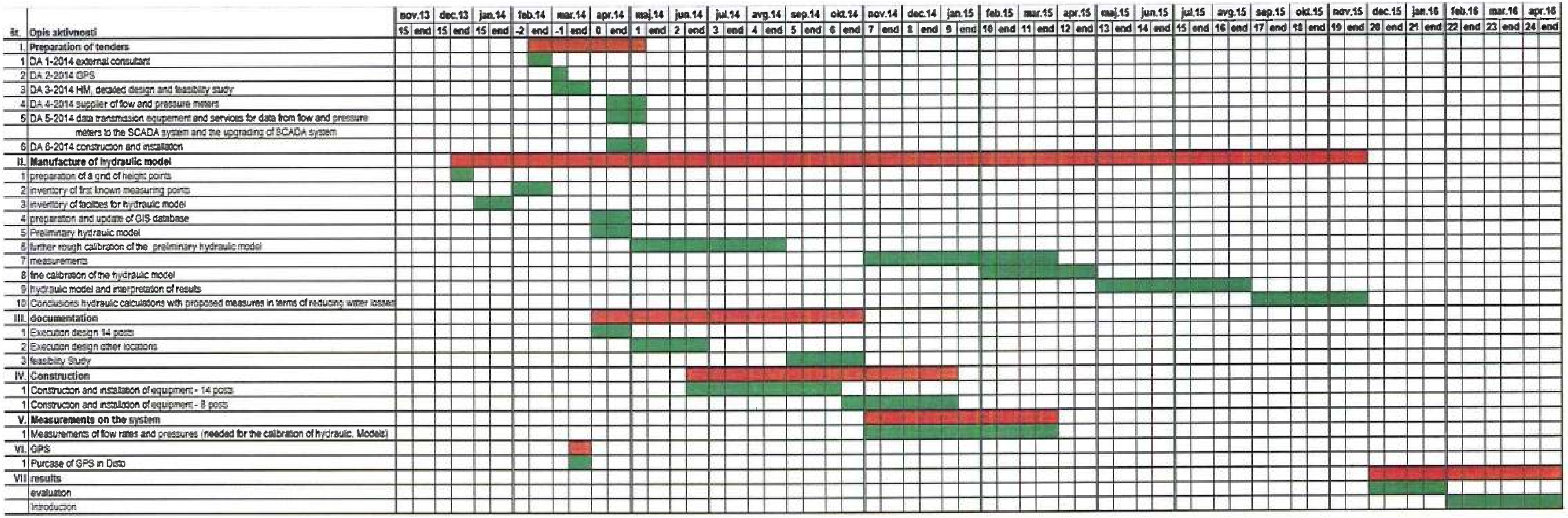
PART F– RESULTS

1. Describe expected results (max 2000 caracters).

Manufacture hydraulic model of the existing data from the GIS and data from water sales department. Based on the hydraulic model all measurements points will be set.
Construction and installation of monitoring points with flow and preasure meters will follow.

By separating the network and measuring the individual zones, and by comparing the results from the hydraulic model, we expect to identify areas with the most losses. We will focus primarily on the water network that directly affect the export of water in Italy.

In the end, we expect that from the economic analysis we can calculate the needed cash injection to eliminate defects and efficiency of interventions in relation to the percentage of loss.


št. Opis aktivnosti
nov.13 dec.13 jan.14 feb.14 mar.14 apr.14 maj.14 jun.14 jul.14 avg.14 sep.14 okt.14 nov.14 dec.14 jan.15 feb.15 mar.15 apr.15 maj.15 jun.15 jul.15 avg.15 sep.15 okt.15 nov.15 dec.15 jan.16 feb.16 mar.16 apr.16
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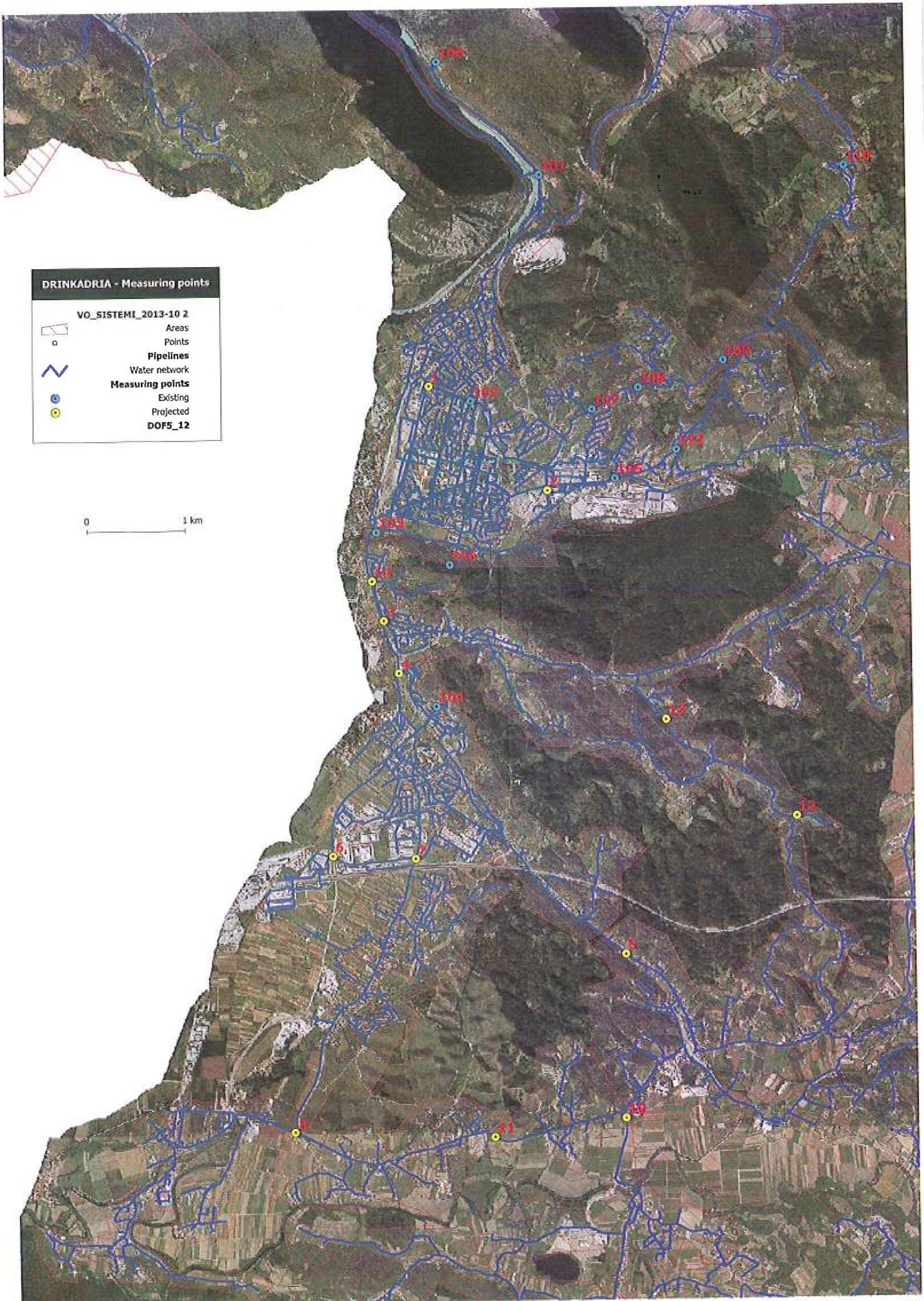
I. Preparation of tenders
1 DA 1-2014 external consultant
2 DA 2-2014 GPS
3 DA 3-2014 HM, detailed design and feasibility study
4 DA 4-2014 supplier of flow and pressure meters
5 DA 5-2014 data transmission equpement and services for data from flow and pressure meters to the SCADA system and the upgrading of SCADA system
6 DA 6-2014 construction and installation
II. Manufacture of hydraulic model
1 preparation of a grid of height points
2 inventory of first known measuring points
3 inventory of facilities for hydraulic model
4 preparation and update of GIS database
5 Preliminary hydraulic model
6 further rough calibration of the preliminary hydraulic model
7 measurements
8 fine calibration of the hydraulic model
9 hydraulic model and interpretation of results
10 Conclusions hydraulic calculations with proposed measures in terms of reducing water losses
III. documentation
1 Execution design 14 posts
2 Execution design other locations
3 feasibility Study
IV. Construction
1 Construction and installation of equipment - 14 posts
1 Construction and installation of equipment - 8 posts
V. Measurements on the system
1 Measurements of flow rates and pressures (needed for the calibration of hydraulic, Models)
VI. GPS
1 Purcase of GPS in Disto
VII results
evaluation
introduction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INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: Water Utility of Istria – Team for installation remote reading system for water meters – FB 7
Contact person of the Final Beneficiary:

PART A – PILOT DESCRIPTION

APPENDIX A.

1. Describe in detail Pilot action and Pilot area and possibly attach.
2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.

PART B – PILOT DATA

1. Describe which parameters do you want to monitor.
   m^3/h, m^3/day, l/s, preasure, losses inside zones,
2. Describe which performance index do you want to calculate.
   Losses by m^3
3. Do you have data already relevant to the project? YES☐X NO☐
   Yes. Current water losses inside zones
4. Do you need equipment or investment? YES☐X NO☐
   Equipment: ultrasound watermeaters, preasure meaters
5. Is the project already start? YES☐ NO☐X
   If Yes, indicate the starting date
   IF No, indicate when it will likely start 30.06.2014
6. Indicate the time line chart.

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources 3.
2. Population served by your system. 100.000
3. Service area (Km^2). 1.706 km^2
4. Total number of connections/customers. 63.000 connections
5. Total number of retail connections.
6. Amount of water produced (monthly and yearly average). 1.500.000/month; 20.000.000/year

7. Average annual water volume delivered to customers:
   a. supply capacity; 2.400 l/s
   b. percent imported water supply; 0,0015%
   c. percent surface water supply; 100%
   d. percent potable groundwater supply. 0%
8. Service area elevation range. 0-500 m
9. Total number of pressure zones in service area. 129
10. Approximate elevation range in each pressure zone.0 - 750 m
11. Average number of customer connections per pressure zone. Not available
12. Average static pressure delivered to pressure zone (Bar).4 Bar

Is your project about water losses? YES☐X NO☐

If Yes, fill part D-E. YES

If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar). LSP – 1 Bar; HSP – 40 Bar
2. Are all water service connections metered? YES☐ NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.
   INFO WORKS WS
3. Which parameters are metered?
   Preasure, Turbirity, Flow, Ph, Losses
4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☐X

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? Datasheet in Excel YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

   a. water volume (m^3) input to distribution (produced and purchase) 18.673.406 m^3
   b. billed authorized consumption volume 15.494.405 m^3
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.) 53.466 m^3
   d. total authorized consumption volume (sum of **b** and **c**) 15.547.879 m^3
   e. water losses (water volume input to distribution indicated in a minus total authorized consumption indicated in **d**) 3.125.535 m^3
   f. list approximate percentage of water losses believed to exist as apparent losses (%) 2%

g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**) 62.510 m^3
h. list what you believe to be the greatest source of apparent losses metering error
i. list approximate percentage of water losses believed to exist as real losses (%) 16.4 %
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**) 3.069.024 m^3
k. list what you believe to be the greatest source of real losses bad pipe material
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**) 18.679.406 m^3

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
X ☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
X ☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other____

3. Indicate annual expenditure for losses management activities (€/yr), if available.
Not available
4. Does your utility have a water loss reduction target? YES☐ X NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

X☐Meter replacement or calibration program ________ ☐Meter service connections ________
☐Water line replacement ________ ☐Meter Sources ________
☐Reduce tank overflows ________ ☐Line Looping ________
X☐Leak detection/elimination ________ ☐Flushing Program ________
X☐Theft Prevention ________ ☐Other ________

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐ X
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 caracters).

From this pilot project the expected results are: reduce water losses in water supply system; reduce energy consumption; better and safer water supply for all users; faster detection of failures in the distribution system; greater accuracy and precision of the new water meter readings in comparison to existing; data obtained through this system will be used for mathematical modeling, development and expansion of water supply networks in the future (for example, network reconstruction and new branches).

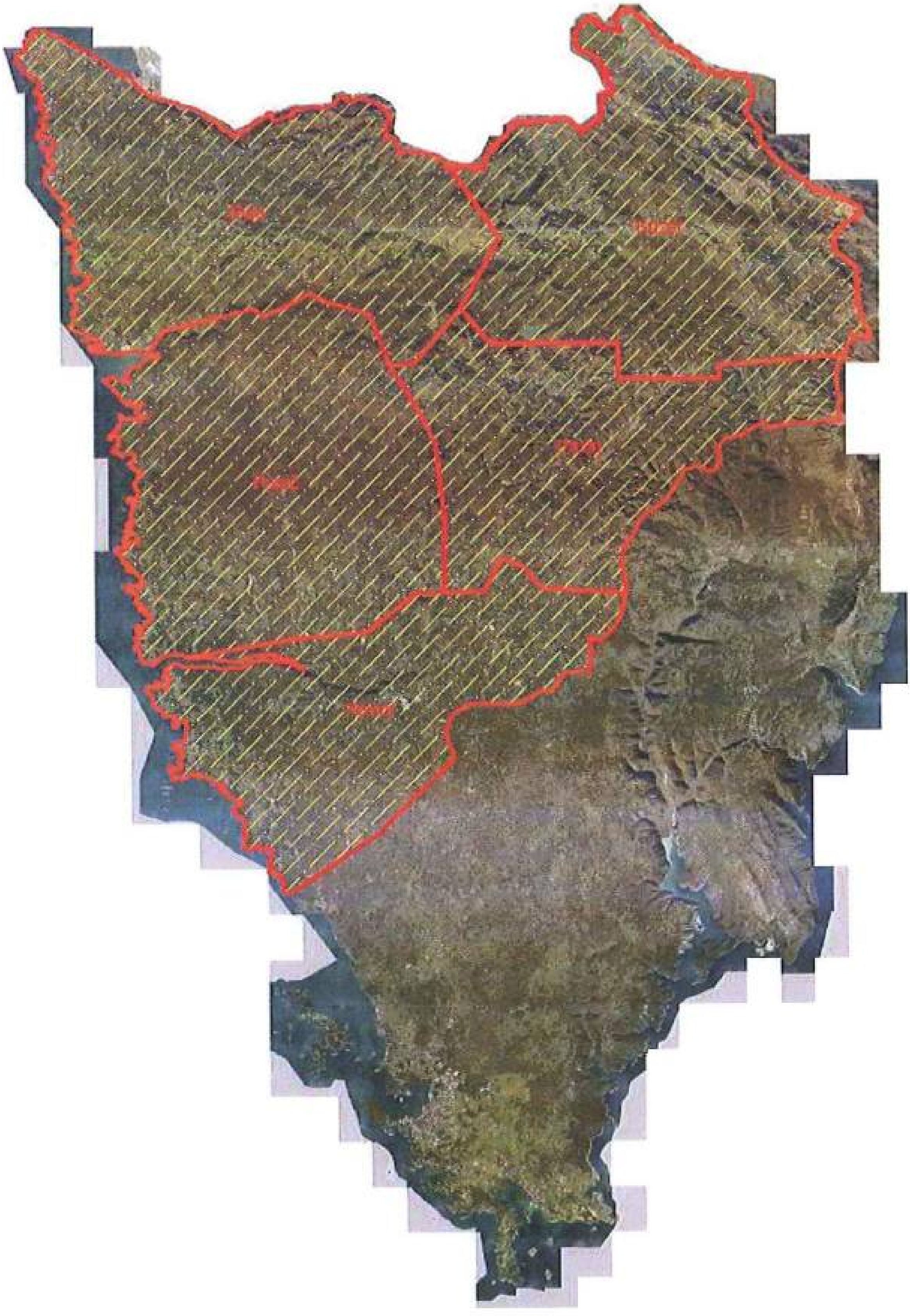
APPENDIX A

PART A – PILOT DESCRIPTION

1. DETAIL PILOT ACTION AND PILOT AREA

The project "Control water meters for more water " will ensure an increase in the available quantity of water that has already been produced by reducing network losses control of all zones and timely interventions. This would ensure the long term effects of the increasing availability of the required quantity of water for citizens and economy. The project will reduce water losses and thus operating costs and increase revenues. The revenue growth has a long term effect, because the financial savings as a result of the project can be related on the development projects that finally indirectly affect the provision of sufficient quantities of drinking water in the long term. The project leader is Istarski vodovod d.o.o. that works in the area of Istria in Croatia, which is located in the northwestern area of Croatian and one around 230,000 inhabitants and an additional approximately 200,000 tourists in the summer. Istarski vodovod d.o.o. is a regional water supply and covers 20 District (Bale, Brtonigla, Funtana, Gračišće, Grožnjan, Kanfanar, Karojba, Kaštelir-Labinci, Lanišće, Lupoglav, Motovun, Oprtalj, Sv.Lovreč, Sv.Petar u šumi, Tar-Vabriga, Tinjan, Višnjan, Vižinada, Vrsar, Žminj, Pićan) and 7 cities (Buje, Buzet, Pazin, Poreč, Rovinj, Novigrad, Umag) which is about 60% of the entire county.

2. MAP VIEW OF THE PILOT AREA



INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary:
P. C. Utility Neum, FB 13
Hydro Engineering Institute of Sarajevo Faculty of Civil Engineering, FB 12
Contact person of the FB 13: Ljuba Goluža
Contact person of the FB 12: Admir Ćerić

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

   The pilot area is cross-border water supply system (CB WSS) in B&H-Croatia area. The pilot action will be implemented in Bosnia and Herzegovina in the municipality of Neum.

   Neum municipality is supplied by drinking water by regional water supply system "Gabela-Svitava-Kozarica-Hutovo-Neum". The system is one of the most complex water supply systems in Bosnia and Herzegovina and it operates since 1982. It is a huge system to operate and to maintain and it demands all time care and financial investments. Total length of distribution system is 38 km, through an extremely difficult and inaccessible terrain.

   Apart from water supply city of Neum and settlements of Neum municipality, this regional system also supplies settlements in Popovo Polje, Municipality Ravno, and part of the settlements of Dubrovnik area in Republic of Croatia.

   As a result of the lack of maintenance due to lack of funds, CB WSS is in a poor condition and needs more funds for rehabilitation and bringing in good condition. Non-revenue water (NRW) percent is about 72 % of the produced water quantity. Physical losses percent, which are NRW part, can be only estimated, since there is no data about these water quantities (Study for water supply system of Neum municipality, 2011.).

   Pilot action will include the following activities implemented in cooperation of FB 12 and FB13:

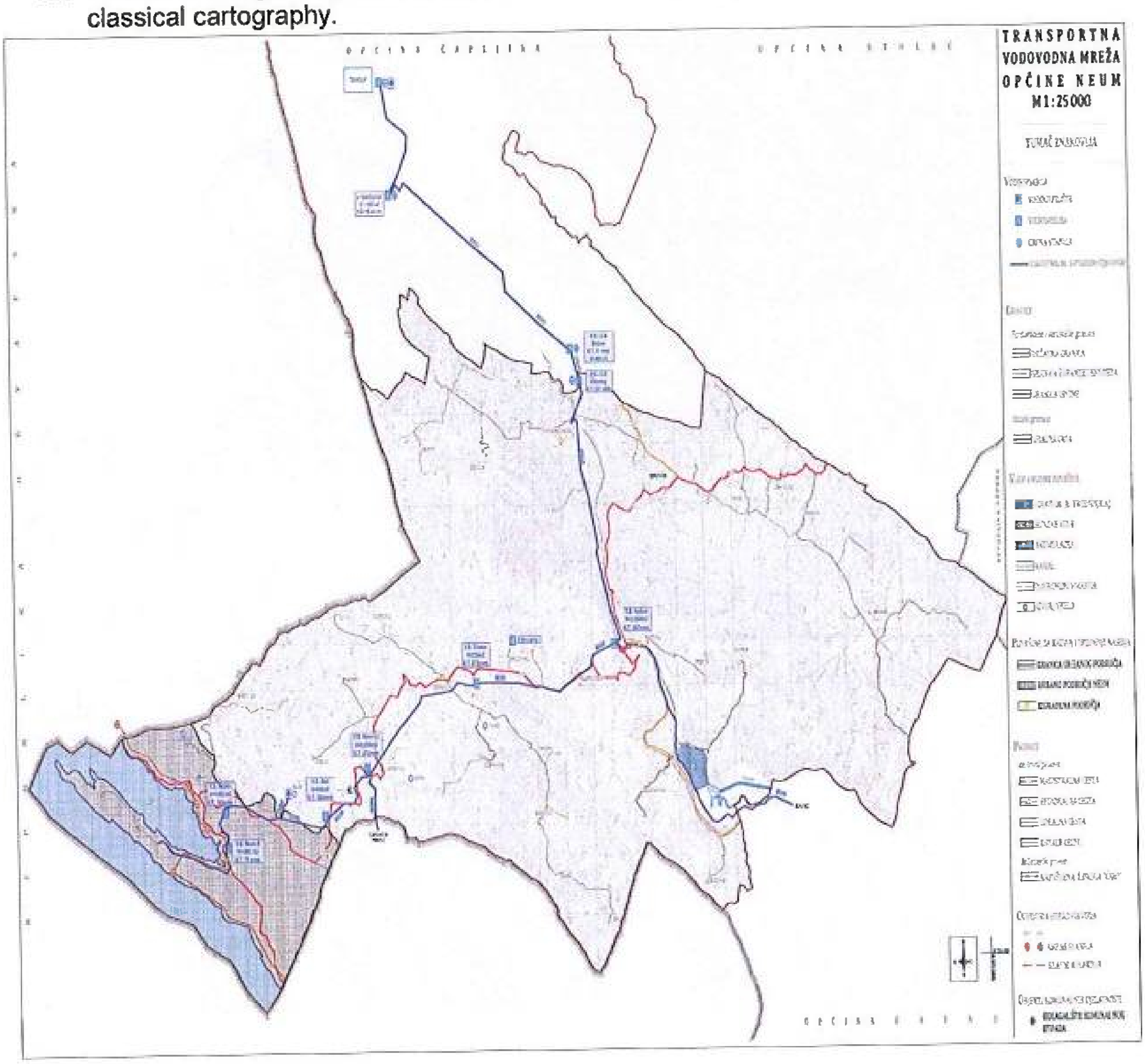
   a) The initial measurement and Sound Leak Detection using Pre-location approach in order to determine pipelines which need to be replaced or repaired (FB12) and preparation for reconstruction action at urgent water supply system part (FB13);

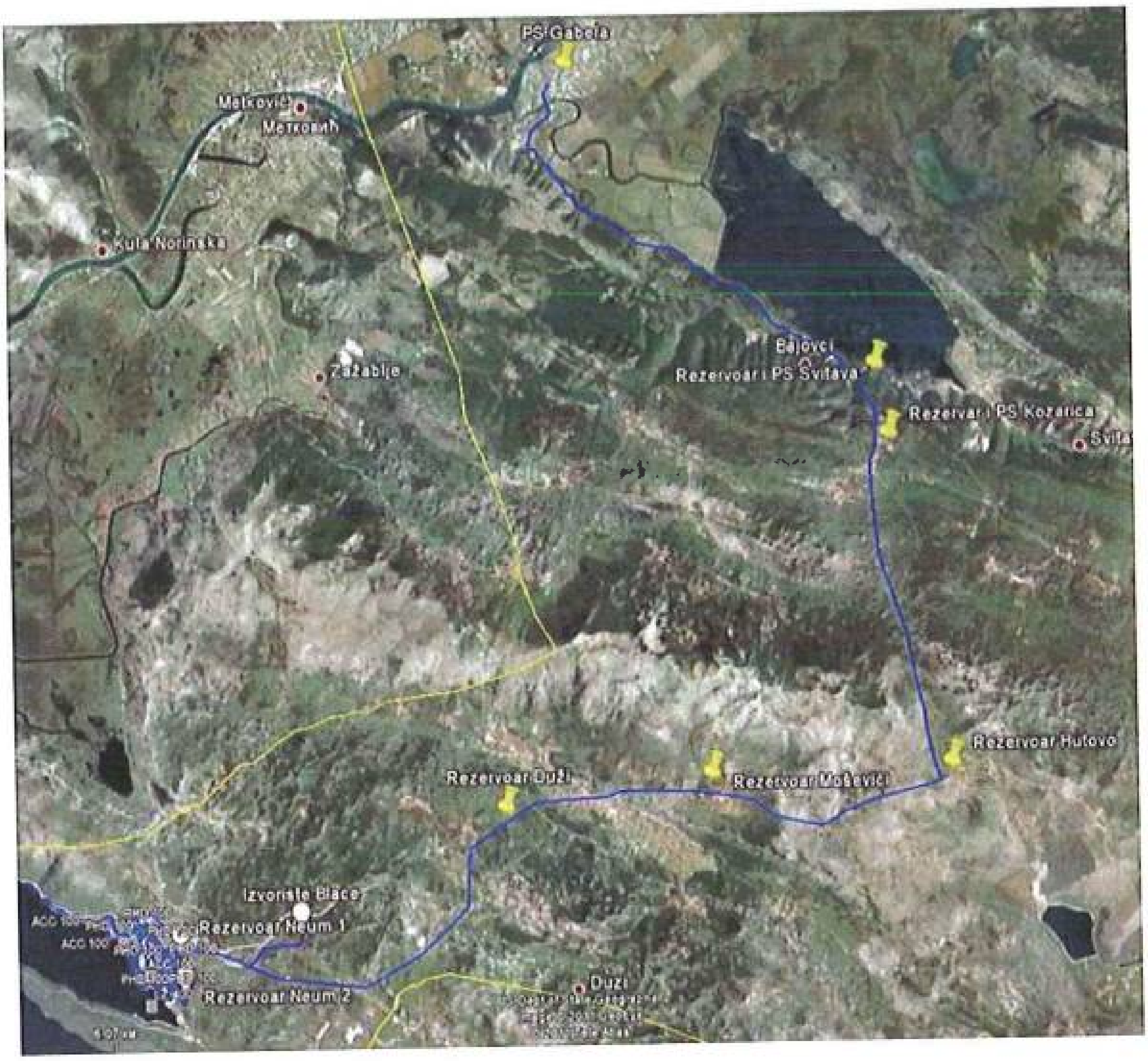
b) Reconstruction activities
Considering the urgent condition, appropriate reconstruction will be implemented at one part of the network. It is assumed approximately 1500 m pipeline in very bad condition and will be reconstructed.

c) Final measurements in order to verify the results achieved (FB12);

d) The testing of IWA methodology in order to determine savings in the water supply system (FB12);
e) Recommendation and conclusions for improvements (FB12).

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.





PART B – PILOT DATA

1. Describe which parameters you want to monitor.

   The flow and pressure will be monitored in the system.

2. Describe which performance index you want to calculate.

   - Unavoidable Annual Real Losses,
   - Current Annual Real Losses,
   - Infrastructure Leakage Index,

- Three another Key Performance Indicators in dependence of water supply system condition.

3. Do you have data already relevant to the project? YES☐ NOX
   If Yes, describe
   What kind of data?

4. Do you need equipment or investment? YES X NO☐
   If Yes, describe

   Investment:
   The project will include the purchase and installation of equipment (new pipelines) to decrease water losses in the system.

5. Is the project already start? YES X NO☐
   If Yes, indicate the starting date

Supply contract notice for purchase and installation of ductile pipes officially published on 24.02.2014. for reconstruction of the most urgent part of water supply system.

6. Indicate the time line chart.

   a) The initial measurement and Sound Leak Detection using Pre-location approach in order to determine pipelines which need to be replaced or repaired (FB12) and preparation for reconstruction action (FB13) – March - May 2014;
   b) Reconstruction activities at urgent water supply system part – June 2014 – December 2014;
   c) Final measurements in order to verify the results achieved (FB12) – 2015 ;
   d) The testing of IWA methodology in order to determine savings in the water supply system (FB12) - 2015;
   e) Recommendation and conclusions for improvements (FB12) - 2015.

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources:

   2 water sources: Gabela and Blace

2. Population served by your system:

   4800 Neum (B&H) + 600 Ravno (B&H) + 1000 Dubrovačko primorje (Croatia) = 6400 total.

3. Service area:
   cca. 230 km^2

4. Total number of connections/customers:

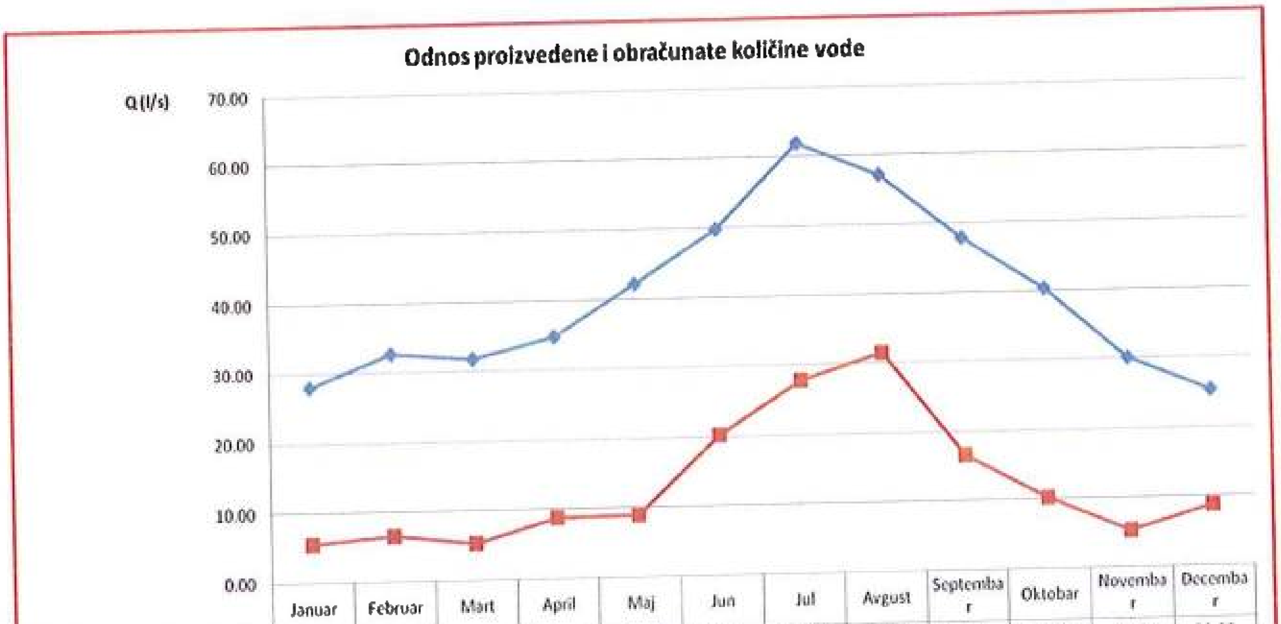
   2.119 connections, 2.365 customers.

5. Total number of retail connections.
   -

6. Amount of water produced (monthly and yearly average):

Water supply system	Month	Produced water amount – Blaca source		Produced water amount – Gabela source (measurements at Kozarica)		In total	
		Average in l/s	m^3/monthly	Average in l/s	m^3/ monthly	Average in l/s	m^3/ monthly
Regional water supply system "Gabela - Neum"	January	16,80	45.000,00	11,20	30.000,00	28,00	75.000,00
	February	18,19	44.000,00	14,47	35.000,00	32,66	79.000,00
	March	16,80	45.000,00	14,93	40.000,00	31,74	85.000,00
	April	17,36	45.000,00	17,36	45.000,00	34,72	90.000,00
	May	22,03	59.000,00	20,16	54.000,00	42,19	113.000,00
	June	16,59	43.000,00	33,18	86.000,00	49,77	129.000,00
	July	17,17	46.000,00	44,80	120.000,00	61,98	166.000,00
	August	16,05	43.000,00	41,07	110.000,00	57,12	153.000,00
	September	22,76	59.000,00	25,08	65.000,00	47,84	124.000,00
	October	23,52	63.000,00	16,80	45.000,00	40,32	108.000,00
	November	16,20	42.000,00	13,89	36.000,00	30,09	78.000,00
	December	13,07	35.000,00	12,32	33.000,00	25,39	68.000,00
	Total for 2005:	18,04	569.000,00	22,17	699.000,00	40,21	1.268.000,00

Water production in CB WSS "Gabela - Neum" in 2005.



	Januar	Februar	Mart	April	Maj	Jun	Jul	Avgust	Septembar	Oktobar	Novembar	Decembar
Proizvedena količina vode	28.00	32.66	31.74	34.72	42.19	49.77	61.98	57.12	47.84	40.32	30.09	25.39
Obračunata količina vode	5.57	6.52	5.33	8.72	8.97	20.21	27.77	31.55	16.54	10.20	5.34	8.79

Relation chart between produced and non-revenue water quantity in 2010.

7. Average annual water volume delivered to customers:
   a. supply capacity;
   b. percent imported water supply - N/A
   c. percent surface water supply - N/A
   d. Percent potable groundwater supply. 100%

8. Service area elevation range:

   5 - 365 m.a.s.l.

9. Total number of pressure zones in service area.

   Three pressure zones

10. Approximate elevation range in each pressure zone.

    - Gabela - Svitava 5 -11 m.a.s.l.
    - Svitava – Kozarica 11- 222 m.a.s.l.
    - Kozarica – Hutovo 222 – 367 m.a.s.l.
    - Hutovo – Neum gravity flow.

11. Average number of customer connections per pressure zone.

There is no exactly data about customer number per pressure zone.

12. Average static pressure delivered to pressure zone (Bar).
    - Gabela - Svitava 1 Bar
    - Svitava - Kozarica 21 Bar
    - Kozarica - Hutovo 14,5 Bar
    - Hutovo - Neum 12 Bar

Is your project about water losses? YES X NO☐

If yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   Pipe materials, the percent in place and the length in km:
    - Iron pipes – 29.900 m or 78%,
    - Ductile pipes – 300 m or 2%,
    - PHD material – 7.800 m or 20%.

   Water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).
   Static water pressure depends on the elevation range where the measure is taken.
   Low static pressure is 0 Bar and high static pressure is 28 Bar.Average static water pressure is 16 Bar.

2. Are all water service connections metered? YES X NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modeling:

   "SCADA" software

3. Which parameters are metered?

   Continuous monitoring of water levels in reservoirs, pressures, water flow.

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO X

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES X NO☐

If Yes, describe and indicate the following water supply data for last available year:

a. water volume (m^3) input to distribution (produced and purchase) - 1.100.000 m^3
b. billed authorized consumption volume - 384.377 m^3
c. unbilled authorized consumption volume (internal uses, flushing, cleaning, Irrigation etc.) - 2000m^3
d. total authorized consumption volume (sum of **b** and **c**) - 386.377 m^3
e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**) - 713.623 m^3
f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%) - 64%
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses - pipe bursting,
l. calculate water volume input to distribution (sum of total authorized consumption indicated in d and water losses indicated in e) - 1.000.000 m^3.

2. Check all that apply below about leak detection and location survey methods:

X Passive only (only locate/repair)
X Listening sticks
☐ Ground microphones
☐ Noise loggers
☐ District metered areas (short description of instruments)
☐ Leak noise correlation
☐ Water pressure regulation at various times during the day as a means of leakage reduction
☐ Other____________________

3. Indicate annual expenditure for losses management activities (€/yr), if available. 33.000,00 € (gross amount) per year is the cost of three wages for three persons working on water losses detection/passive method- locate/repair. This cost doesn't cover the costs of actual repair of the pipes, only water losses tracking.

4. Does your utility have a water loss reduction target? YESX NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO X
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters)

   Having in mind the urgency of one part in the system, first initial measurement in this zone and after that appropriate reconstruction measures will be implemented at the beginning of the project. Further the comprehensive flow and pressure campaign will be implemented. On the basis of obtained results, the calculation of the water balance and performance indicators will be realized using "Bottom – up" approach in accordance with IWA methodology.

   Considering water balance results, the set of measures for improving will be proposed with defining of priorities.

INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: Public Utility "Vodovod i kanalizacija" Niksic – Technical Department – FB 14
Contact person of the Final Beneficiary:

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

The city of Niksic is supplied by water from three sources: Gornji Vidrovan, Donji Vidrovan and Poklonci. Water is distributed by gravity from sources Gornji and Donji Vidrovan and by pressure from source Poklonci to the buster pumping station Duklo through which the users are supplied with water. The water supply system of the city of Niksic is jagged in the length of about 450 km; it dates from different periods from the thirties in the previous century to the present day. It is made of different types of materials (galvanized, cast-iron, asbestos-cement, steel, PVC, PE and ductile pipelines) and it supplies water to approximately 66000 users.

In Niksic pilot area the following sub-activities have been planned:

Activity 1. To develop Geographic Information System (GIS) of the water supply system of the city of Niksic
GIS database is a set of information about all the elements of the water supply system. MapInfo software is used for creating GIS in Niksic. Layers are connected in the SQL database. This database is connected with the existing business information system by a code of a measuring point. With reference to this activity, it is necessary to update the existing GIS database with all elements of the water supply system and adapt existing layers for exporting into the program for hydraulic modelling of water supply network.

Activity 2. To create hydraulic model of the water supply system

Public Utility- Niksic has software for hydraulic modeling of the water supply network - AQUANET. After entering all the necessary data from the GIS, a hydraulic model will be created. After conducting field measurements, all the data will be entered into the hydraulic model and its calibration will be carried out i.e. a comparative analysis of the state.

The hydraulic model and analysis will be made by the Institute for the Development of Water Resources "Jaroslav Černi"

Activity 3. To divide the water supply system into district metering areas

After analyzing GIS and hydraulic model, the water supply system will be divided into district metered areas (DMAs). A DMA is a part of the water supply network that serves up to 2000 users and is preferably supplied with water from one place. The places for the construction of measuring points will be defined at the inlet to DMAs. This activity will also include dimensioning and identifying required characteristics of the measuring equipment (flow and pressure meters).

Activity 4. To procure measuring equipment and to integrate it into SCADA information system

With reference to this activity, tender documentation will be prepared and the invitation to tender will be published for the selection of the most favourable bidder for the procurement, delivery and installation of measuring equipment and system for control, monitoring and data transfer.

For the construction of manholes, the invitation to tender will be published as well as for the procurement of building material and pipe fittings.

Activity 5. To link GIS and SCADA information system

This activity refers to creating software solutions to connecting GIS database and SCADA information system on pressure and flow measurements in the water supply system. This activity will be carried out by the employees of Public Utility-Niksic.

Activity 6. To define procedures for managing and reducing losses in the water supply system

The preparation of the methodology and procedures for the implementation of activities to reduce losses will be done in relation to the recommendations of International Water Association (*IWA*). This work will be done by the representatives of the Institute for the Development of Water Resources "Jaroslav Černi". In addition, a new organizational unit will be established by Public Utility Niksic whose task will be the implementation of the methodology and procedures after the completion of the project implementation period.

Activity 7. Balancing and analysis of the water supply system

This activity will include sub-activities such as: creating databases, continuous collection and analysis of distributed and billed water quantities for each DMA separately in order to determine the level of losses; field measurements and the analysis of water supply network in order to detect irregularities in it by using hydraulic model.

Activity 8. Field visits and removal of identified irregularities

After conducting analyses, continual field visits will be organized in order to remove identified irregularities (failures, illegal users). Using the equipment for testing water mains (owned by PE "Vodovod i kanalizacija" Niksic), the accurate position of leaks in the network will be located and they will be removed.

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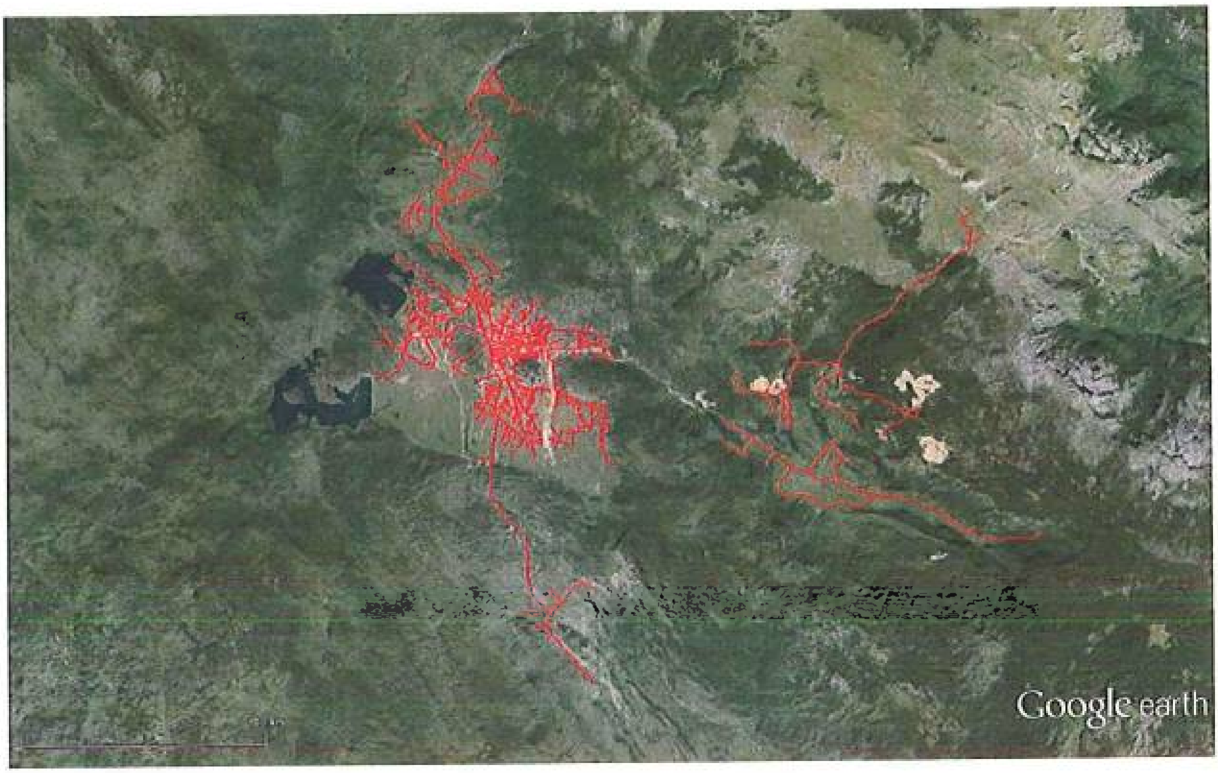
2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.



PART B – PILOT DATA

1. Describe which parameters do you want to monitor.
   We want to monitor flow and pressure.

2. Describe which performance index do you want to calculate.
3. Do you have data already relevant to the project? YES☒ NO☐
   If Yes, describe
   Since we have already done measurements on some parts the system, we have an insight into this parameter, however, for a complete analysis it is necessary to install measuring equipment.

4. Do you need equipment or investment? YES☒ NO☐
   If Yes, describe
   For the implementation of the planned activities in our pilot area it is necessary to procure the equipment and investment works.
5. Is the project already start? YES☒ NO☐
   If Yes, indicate the starting date
   IF No, indicate when it will likely start
   24. 12. 2013-the date of the start of the project

6. Indicate the time line chart.

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources. 3
2. Population served by your system. 66000
3. Service area (Km^2).752
4. Total number of connections/customers. 22000
5. Total number of retail connections. 1300
6. Amount of water produced (monthly and yearly average).330000 monthly, 3900000 yearly
7. Average annual water volume delivered to customers:
   a. supply capacity; 1200l/s
   b. percent imported water supply;0
   c. percent surface water supply;0
   d. percent potable groundwater supply.100%
8. Service area elevation range. 615-694
9. Total number of pressure zones in service area. 1
10. Approximate elevation range in each pressure zone. 615-694
11. Average number of customer connections per pressure zone. 23300
12. Average static pressure delivered to pressure zone (Bar). 3.5

Is your project about water losses? YES☒ NO☐

If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

2. Are all water service connections metered? YES☐ NO☒
   If no, what is the number of un-metered connections? 5500
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?
   flow

4. Does your software for water distribution system modelling interface with a GIS? YES☒ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

a. water volume (m^3) input to distribution (produced and purchase)
b. billed authorized consumption volume
c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
d. total authorized consumption volume (sum of **b** and **c**)
e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%)
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

☐ Passive only (only locate/repair)
☒ Listening sticks
☒ Ground microphones
☐ Noise loggers
☒ District metered areas (short description of instruments)
☒ Leak noise correlation
☐ Water pressure regulation at various times during the day as a means of leakage reduction
☐ Other ______________________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐ Meter replacement or calibration program	________	☐ Meter service connections	________
☐ Water line replacement	________	☐ Meter Sources	________
☐ Reduce tank overflows	________	☐ Line Looping	________
☐ Leak detection/elimination	________	☐ Flushing Program	________
☐ Theft Prevention	________	☐ Other	________

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters).

Result 1

- *To reduce the level of losses in the water supply system by creating measurement points, defining DMAs and applying an active loss control.*
- *To reduce the level of actual loss by 10% compared to the level before the start of the project implementation.*
- *To reduce the number of illegal users by 50%*
- *To reduce the amount of water that is distributed into the system by 20%*

Result 2

To raise public awareness on the rational use of water

INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary:
Contact person of the Final Beneficiary:

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

   ____

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.

PART B – PILOT DATA

1. Describe which parameters do you want to monitor.
2. Describe which performance index do you want to calculate.
3. Do you have data already relevant to the project? YES☐ NO☐
   If Yes, describe
4. Do you need equipment or investment?
   If Yes, describe YES☐ NO☐
5. Is the project already start? YES☐ NO☐
   If Yes, indicate the starting date
   IF No, indicate when it will likely start
6. Indicate the time line chart.

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources.
2. Population served by your system.
3. Service area (Km^2).
4. Total number of connections/customers.
5. Total number of retail connections.
6. Amount of water produced (monthly and yearly average).

7. Average annual water volume delivered to customers:
   a. supply capacity;
   b. percent imported water supply;
   c. percent surface water supply;
   d. percent potable groundwater supply.
8. Service area elevation range.
9. Total number of pressure zones in service area.
10. Approximate elevation range in each pressure zone.
11. Average number of customer connections per pressure zone.
12. Average static pressure delivered to pressure zone (Bar).

Is your project about water losses? YES☐ NO☐

If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

2. Are all water service connections metered? YES☐ NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

   a. water volume (m^3) input to distribution (produced and purchase)
   b. billed authorized consumption volume
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning,

irrigation etc.)

d. total authorized consumption volume (sum of **b** and **c**)
e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%)
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other ____________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program	________	☐Meter service connections	________
☐Water line replacement	________	☐Meter Sources	________
☐Reduce tank overflows	________	☐Line Looping	________
☐Leak detection/elimination	________	☐Flushing Program	________
☐Theft Prevention	________	☐Other	________

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 caracters).

INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

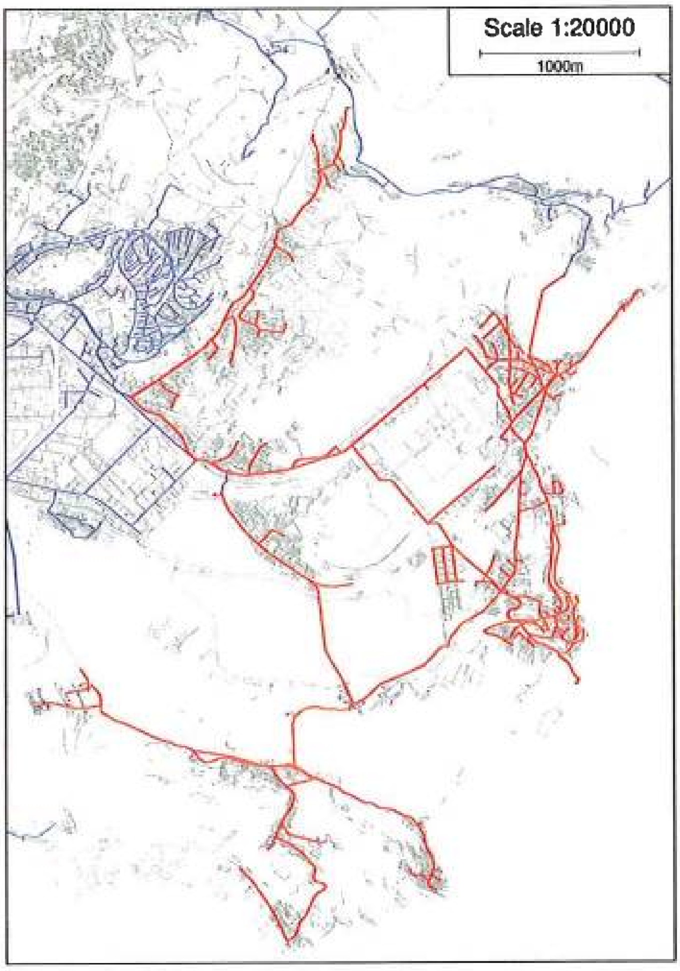
Name (in English) and number of Final Beneficiary: : Area Council for Eastern Integrated Water Service of Trieste (CATO) - LB

Contact person of the Final Beneficiary:

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.
   The target of the project is to reduce the real loss in a pilot aqueduct of San Dorligo della Valle. The aqueduct is divided into three DMAs (district metered area). The activity will be organized following the steps below:
   1. Zone Flow Analysis
      a. District Metered Areas (DMA)
      b. Minimum night flow analysis
      c. Step testing
   2. Acoustic Leak Surveys
      a. Basic Hydrant Survey
      b. Comprehensive Survey
      c. Noise and leak mapping
      d. Leak pinpointing & correlation
   3. Acoustic Noise Logging
      a. Basic Noise Logging
      b. Correlating Noise Logging
   4. Pressure Management
   5. Numerical modelling of the water supply network.

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.



PART B – PILOT DATA

1. Describe which parameters do you want to monitor.
   Flow, pressure, PH, Cl, temperature, turbidity and other quality parameters.
2. Describe which performance index do you want to calculate : **ILI** is defined as the current annual real losses divided by the unavoidable annual real losses.
3. Do you have data already relevant to the project? YES☒ NO☒
4. Do you need equipment or investment? If Yes, describe YES☒ NO☐
5. Is the project already start? YES☒ NO☐
   If Yes, indicate the starting date: on **March 2014**

   ~~IF No, indicate when it will likely start~~

6. Indicate the time line chart: **start March 2014 end March 2015.**
   - 1. Zone Flow Analysis **March-June 2014**
     a. District Metered Areas (DMA)
     b. Minimum night flow analysis
     c. Step testing
   - 2. Acoustic Leak Surveys **June-October 2014**

- 3. Acoustic Noise Logging **June-October 2014**
- 4. Pressure Management **October 2014 -. March 2015**
- 5. Numerical Modelling **October 2014 -. March 2015**

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources: **5**
2. Population served by your system: about **5000 ab**
3. Service area (Km^2): **9.3**
4. Total number of connections/customers: **2360**
5. Total number of retail connections: **ND**
6. Amount of water produced (monthly and yearly average): **ND**

7. Average annual water volume delivered to customers: **903 Mm^3**
   a. supply capacity:ND
   b. percent imported water supply: ND
   c. percent surface water supply: ND
   d. percent potable groundwater supply: ND
8. Service area elevation range: **96.5 m**
9. Total number of pressure zones in service area: **4**
10. Approximate elevation range in each pressure zone.
    - dma SD01: **64 m**,
    - dma SD02: **152 m**,
    - dma SD03: **31 m**,
    - dma SD04: **76 m**.
11. Average number of customer connections per pressure zone:
    - dma SD01: **484**,
    - dma SD02: **744**,
    - dma SD03: **849**,
    - dma SD04: **283**.
12. Average static pressure delivered to pressure zone (Bar).
    - dma SD01: **5.0 bar**,
    - dma SD02: **7.0 bar**,
    - dma SD03: **6.0 bar**,
    - dma SD04: **10.0 bar**.

Is your project about water losses? YES☒ NO☐

If Yes, fill part D-E.

~~If No, fill part F.~~

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:

pipe materials, the percent in place and the length in Km;
Iron 53%, ND 14%, Cast Iron 27%, Polyethylene 6% for a total length **48 km**
water pressure: average static water pressure (**7 bar**), low static pressure (**1.5 bar**) and high static pressure (**15 bar**).

2. Are all water service connections metered? YES☒ NO☐
   If no, what is the number of un-metered connections?
   4
   ~~If Yes, list software used for water distribution system modelling.~~

3. Which parameters are metered? Flow

4. Does your software for water distribution system modelling interface with a GIS? YES☒ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☒ NO☐
   If Yes, describe and indicate the following water supply data for last available year (**2012**):

   a. water volume (m^3) input to distribution (produced and purchase): **51Gm^3**
   b. billed authorized consumption volume: **30Gm^3**
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.): **ND**
   d. total authorized consumption volume (sum of **b** and **c**): **30Gm^3**
   e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**): **21 Gm^3**
   f. list approximate percentage of water losses believed to exist as apparent losses: **20 %**
   g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**) **4.2 Gm^3**
   h. list what you believe to be the greatest source of apparent losses:
      - Customer Meter Inaccuracies
   i. list approximate percentage of water losses believed to exist as real losses: **80%**
   j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**) **16.8 Gm^3**
   k. list what you believe to be the greatest source of real losses:
      - Leakage in Transmission and Distribution Mains
      - Service Connections Leaks up to the Meter
   l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**): **51Gm^3**

2. Check all that apply below about leak detection and location survey methods:

   ☒Passive only (only locate/repair)
   ☒Listening sticks

☐Ground microphones
☒Noise loggers
☒District metered areas (cross correlation ultrasonic flow meters, ultrasonic transit time flow meters, electromagnetic or insertion sensors)
☒Leak noise correlation
☒Water pressure regulation at various times during the day as a means of leakage reduction
☐Other ______

3. Indicate annual expenditure for losses management activities (€/yr), if available.
   ND
4. Does your utility have a water loss reduction target? YES☒ NO☐
   If Yes, describe, check all that apply below and provide the date the program began, if available:

☒Meter replacement or calibration program	2013	☒Meter service connections	
☒Water line replacement	ND	☐Meter Sources	
☐Reduce tank overflows		☐Line Looping	
☒Leak detection/elimination	ND	☐Flushing Program	
☐Theft Prevention		☐Other	

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☒
   If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters).

The experimental project involves a small town in the province of Triest, San Dorligo Della Valle, which, due to its transboundary characteristics and its water criticalities is well suited for a forced experimentation.
It is known that the level of water loss is very high (about 40%), mainly due to the high pressure level inside the pipes (5-7 bar).

The purpose of the whole project is to get at a real-time management of the water distribution network that will not only lower the pressure of at least 1- 2 bar, through better dynamic adjustment (insertion of pressure regulating valves), but also to have a direct control of both the leakage level and losses research, setting the losses at the target value of the 35% in the years of the project.

DRINK ADRIA PROJECT
WP 6
PILOT TEST
LEAKAGE MANAGEMENT

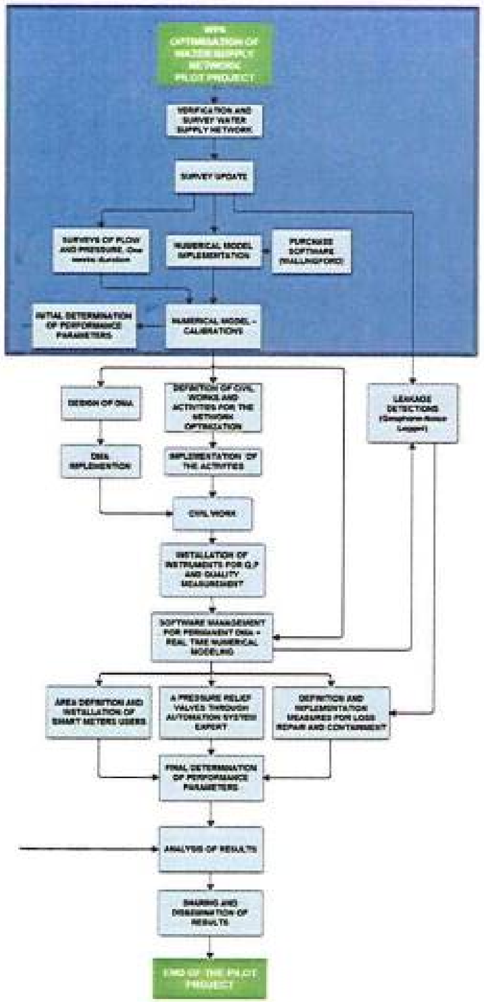
Dr. Eng. Luca Falcomer, falcomer@idrostudi.it, Idrostudi, Trieste, Italy

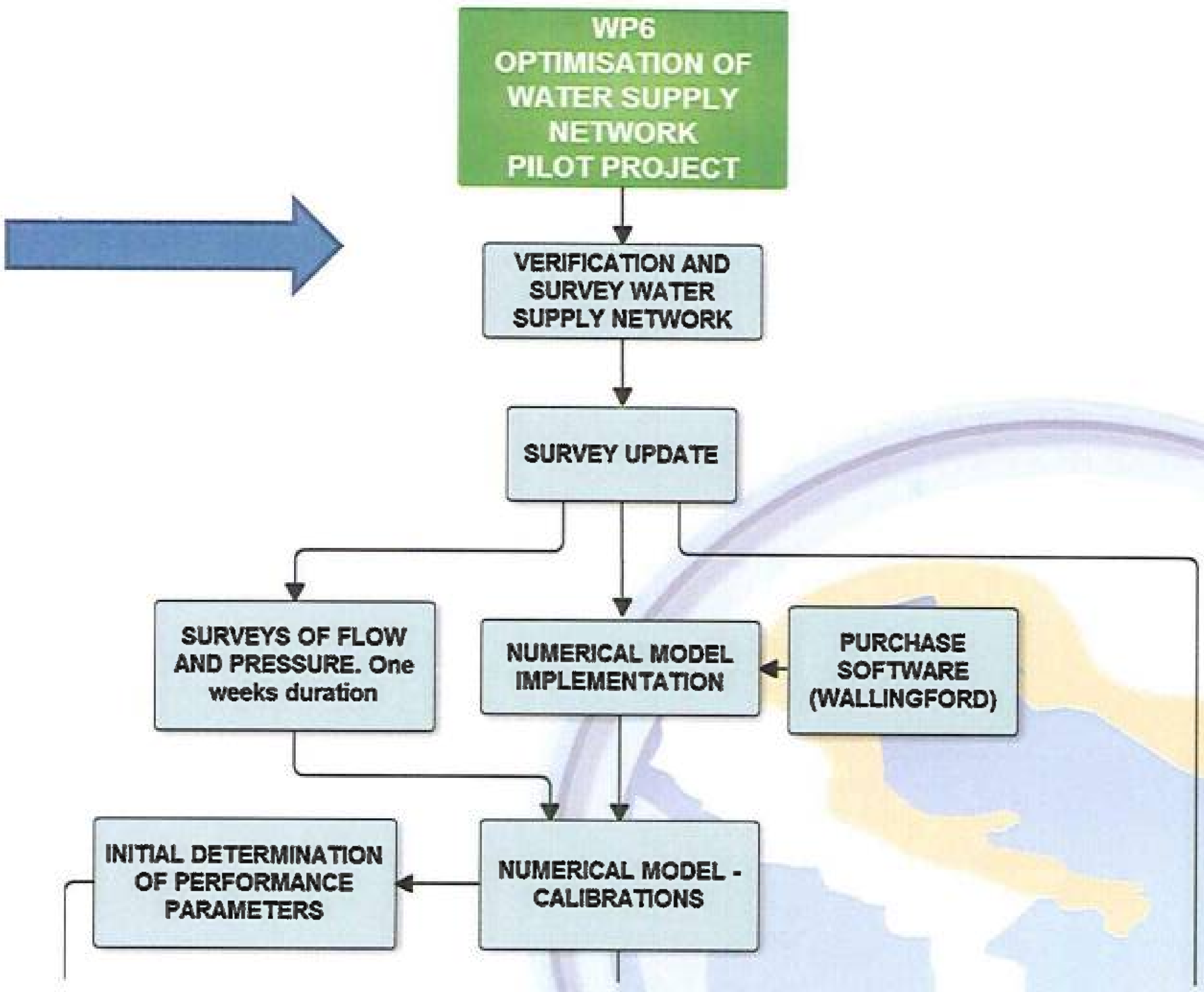
RIJEKA, FEBRUARY, 12TH, 2014

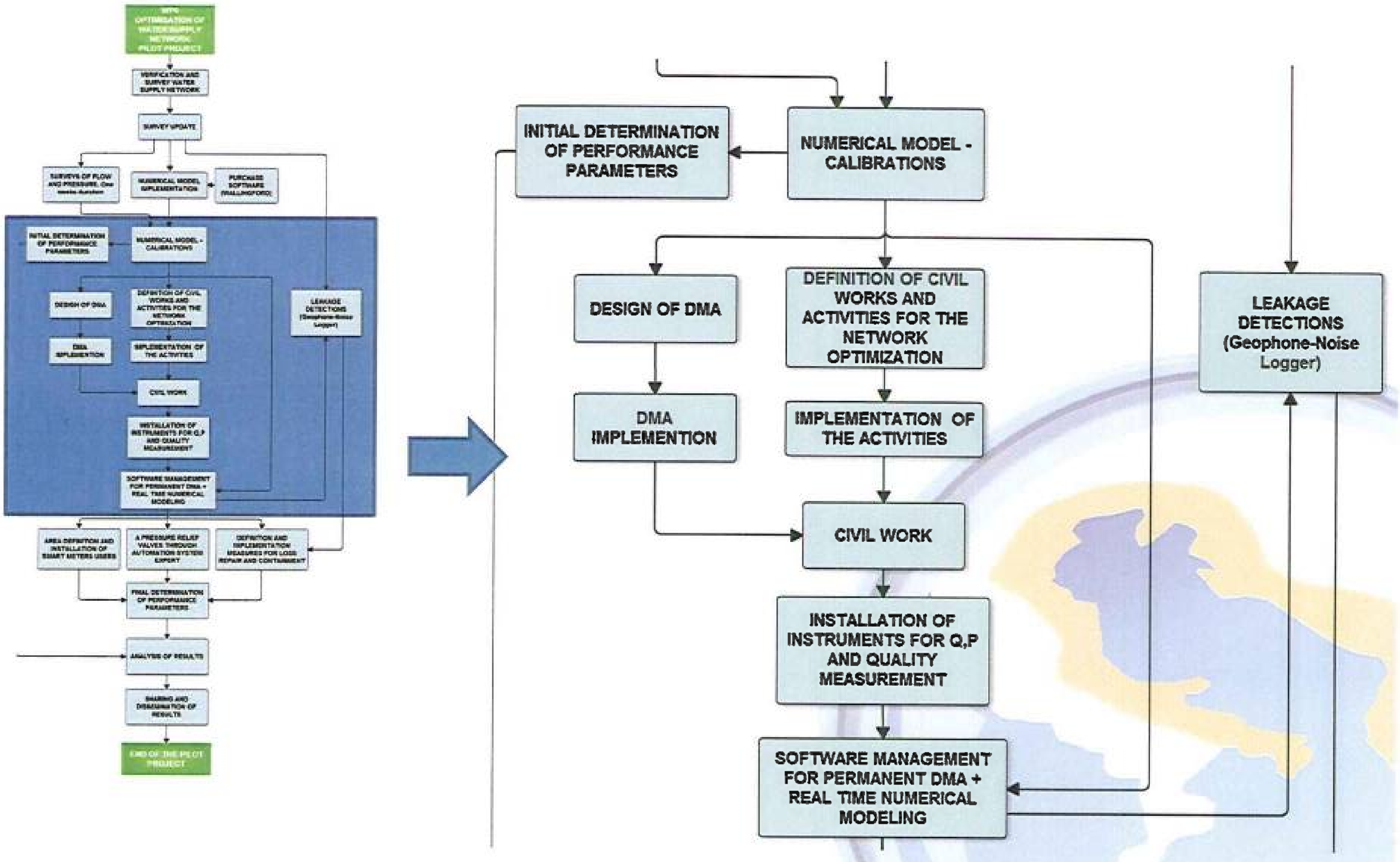
Outline

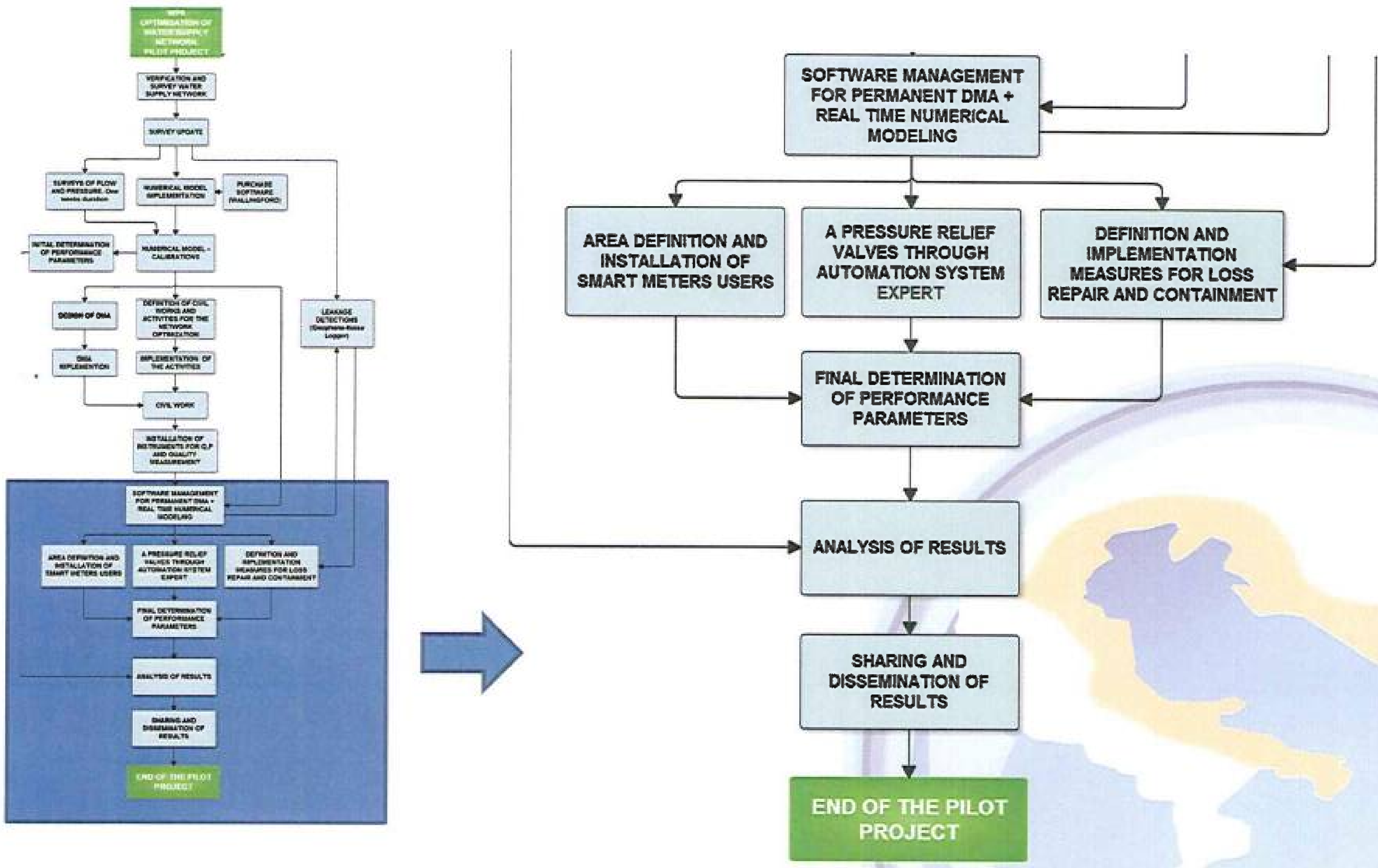
- Methodology
- San Dorligo della Valle (Trieste) – Pilot Test
- Venice - Murano Island – Pilot Test
- Example of software for the DMA management

DRINKADRIA PROJECT



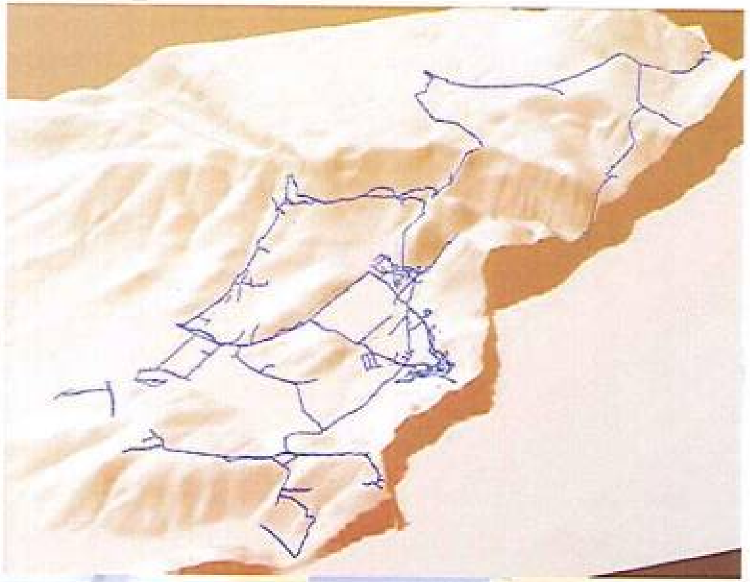


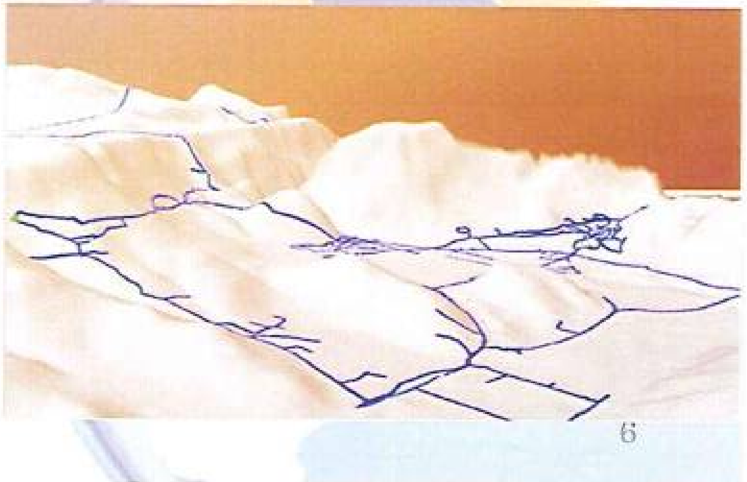

INITIAL DETERMINATION OF PERFORMANCE PARAMETERS
NUMERICAL MODEL - CALIBRATIONS
DESIGN OF DMA
DEFINITION OF CIVIL WORKS AND ACTIVITIES FOR THE NETWORK OPTIMIZATION
LEAKAGE DETECTIONS (Geophone-Noise Logger)
DMA IMPLEMENTION
IMPLEMENTATION OF THE ACTIVITIES
CIVIL WORK
INSTALLATION OF INSTRUMENTS FOR Q,P AND QUALITY MEASUREMENT
SOFTWARE MANAGEMENT FOR PERMANENT DMA + REAL TIME NUMERICAL MODELING


SOFTWARE MANAGEMENT FOR PERMANENT DMA + REAL TIME NUMERICAL MODELING
AREA DEFINITION AND INSTALLATION OF SMART METERS USERS
A PRESSURE RELIEF VALVES THROUGH AUTOMATION SYSTEM EXPERT
DEFINITION AND IMPLEMENTATION MEASURES FOR LOSS REPAIR AND CONTAINMENT
FINAL DETERMINATION OF PERFORMANCE PARAMETERS
ANALYSIS OF RESULTS
SHARING AND DISSEMINATION OF RESULTS
END OF THE PILOT PROJECT

Pilot Case
Supply network of San Dorligo della Valle

- Extension: 65 km
- Residents: 7000 people
- Leakage: 60%
- Altimetry: from 0 to 350 m. a.m.s.l.

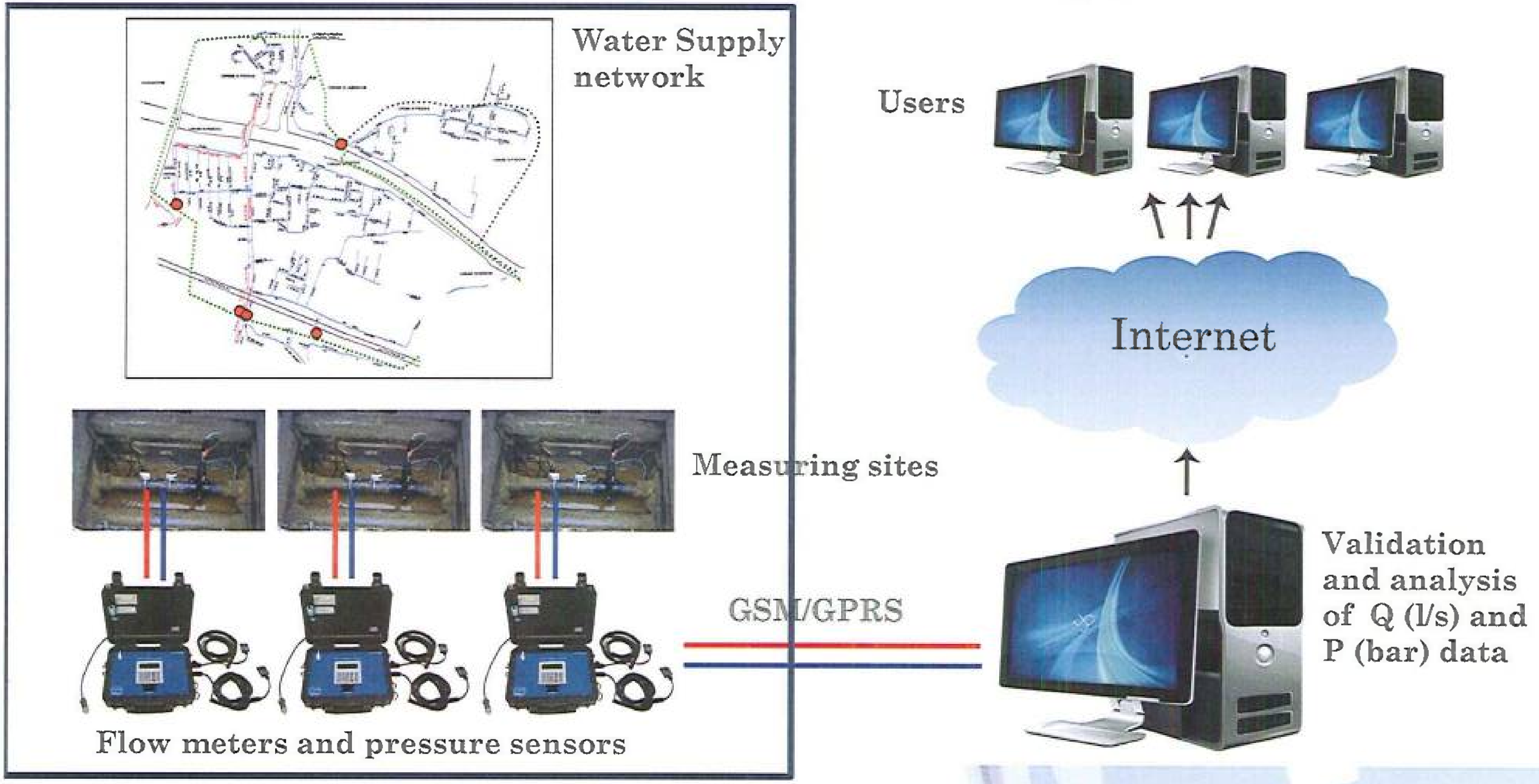




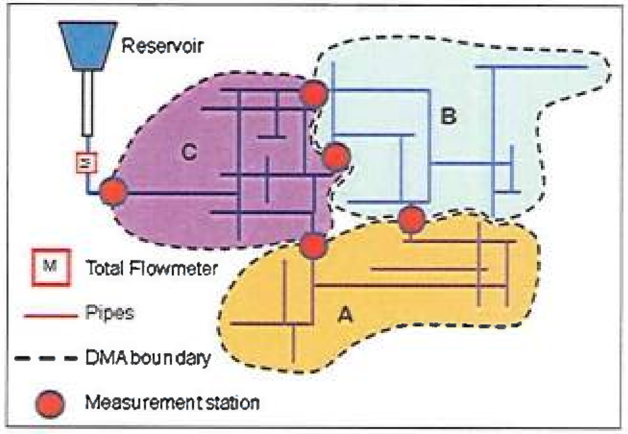
Pilot Case
Supply network of Venice – Murano Island

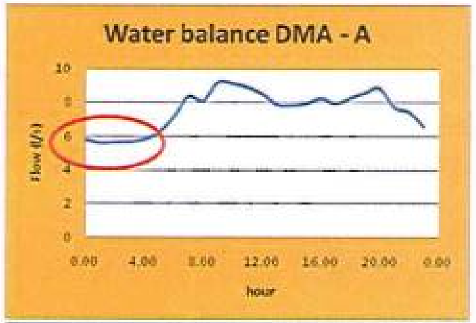
- Extension: 15 km
- Residents: 10000 people
- Leakage: 40%
- Altimetry: 1-1.5 m. a.m.s.l.

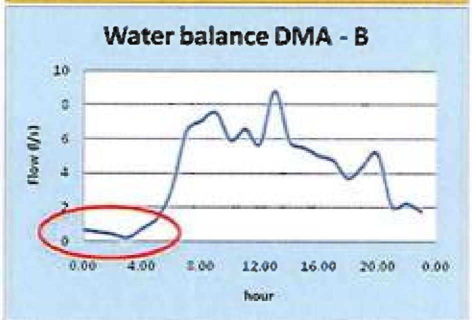
DMA Methodology

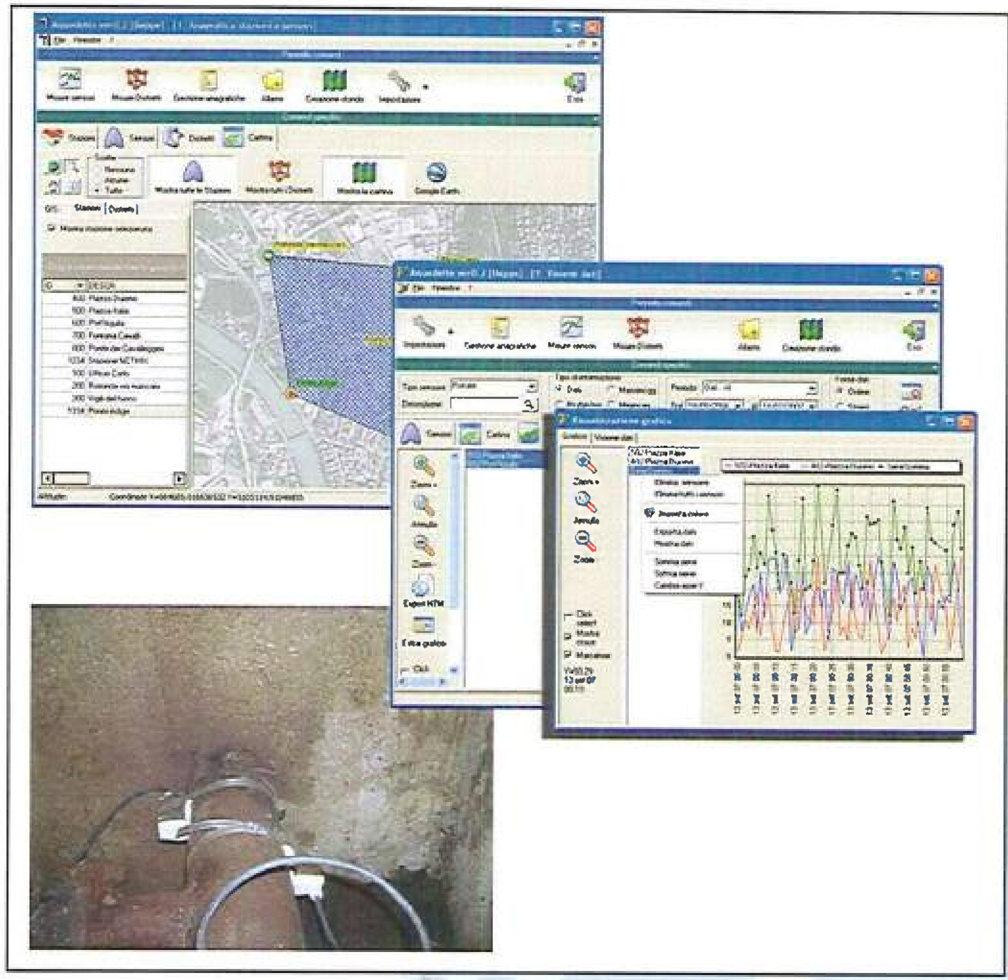


Data validation and analysis









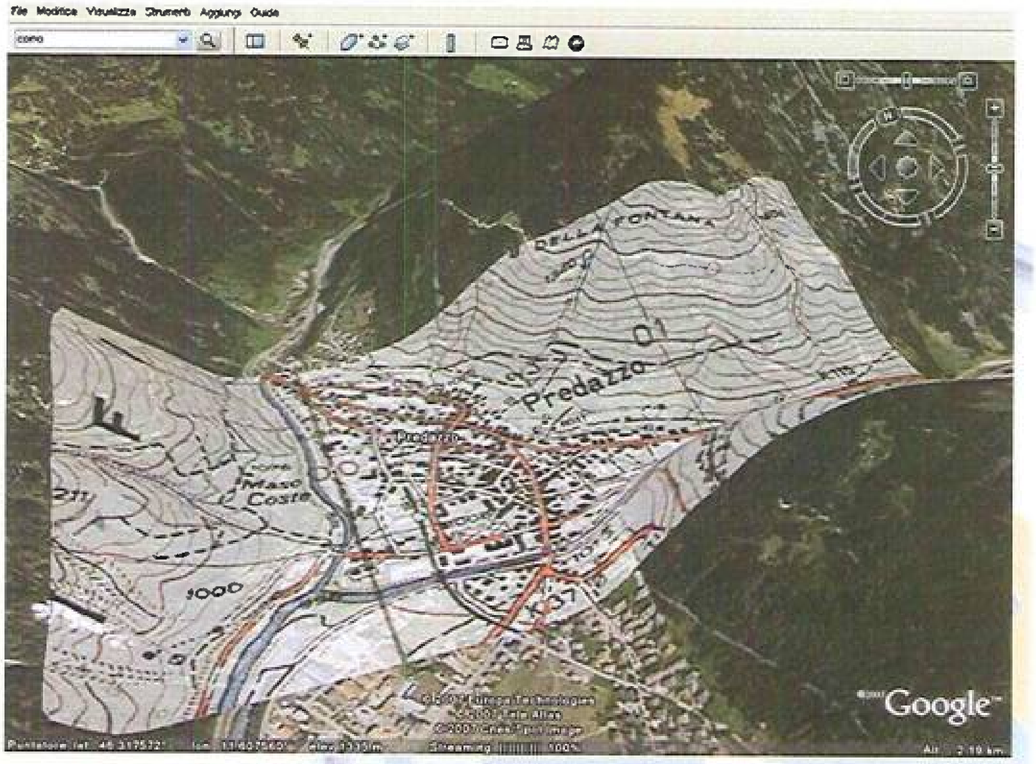
Waterguard

We have identify the software Waterguard for the management of the data of the DMA

Waterguard's main characteristics:

- user friendly
- integrated GIS

Georeferenced network & instruments



Waterguard

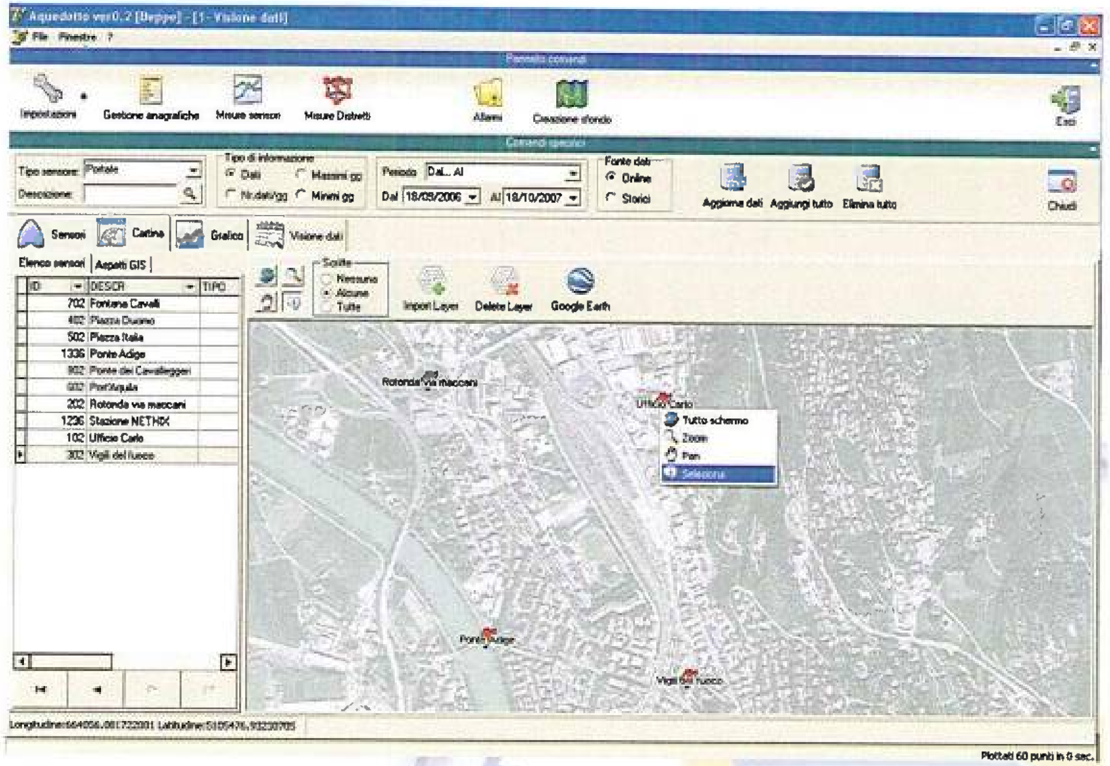
Geometrical data of the network can be imported in different formats, i.e.:

- *.shp
- *.dxf
- *.dwg,
- *.inp

It is possible to import georeferenced data from the instruments:

- installation date
- check dates
- type of instrument
- settings and associated phone number...

It is possible to upload photographic documentation of the installations

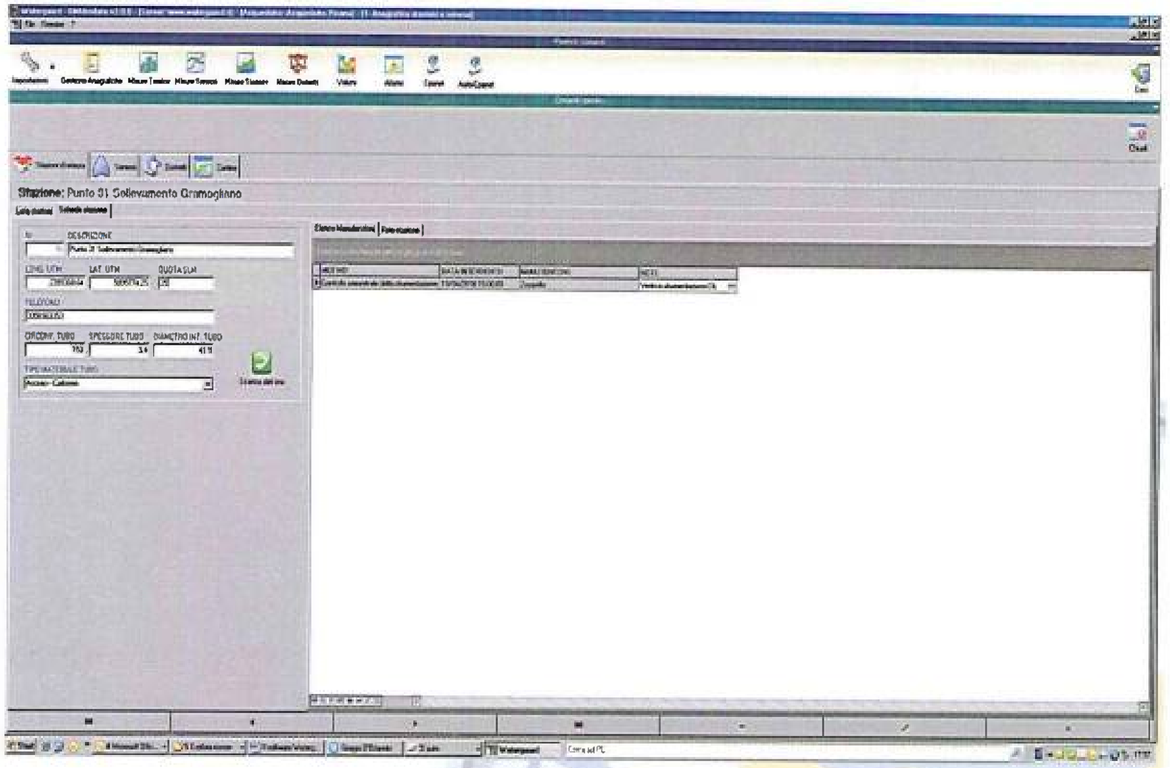


Allows for keeping all the maintenance activities updated.

REGISTRIES

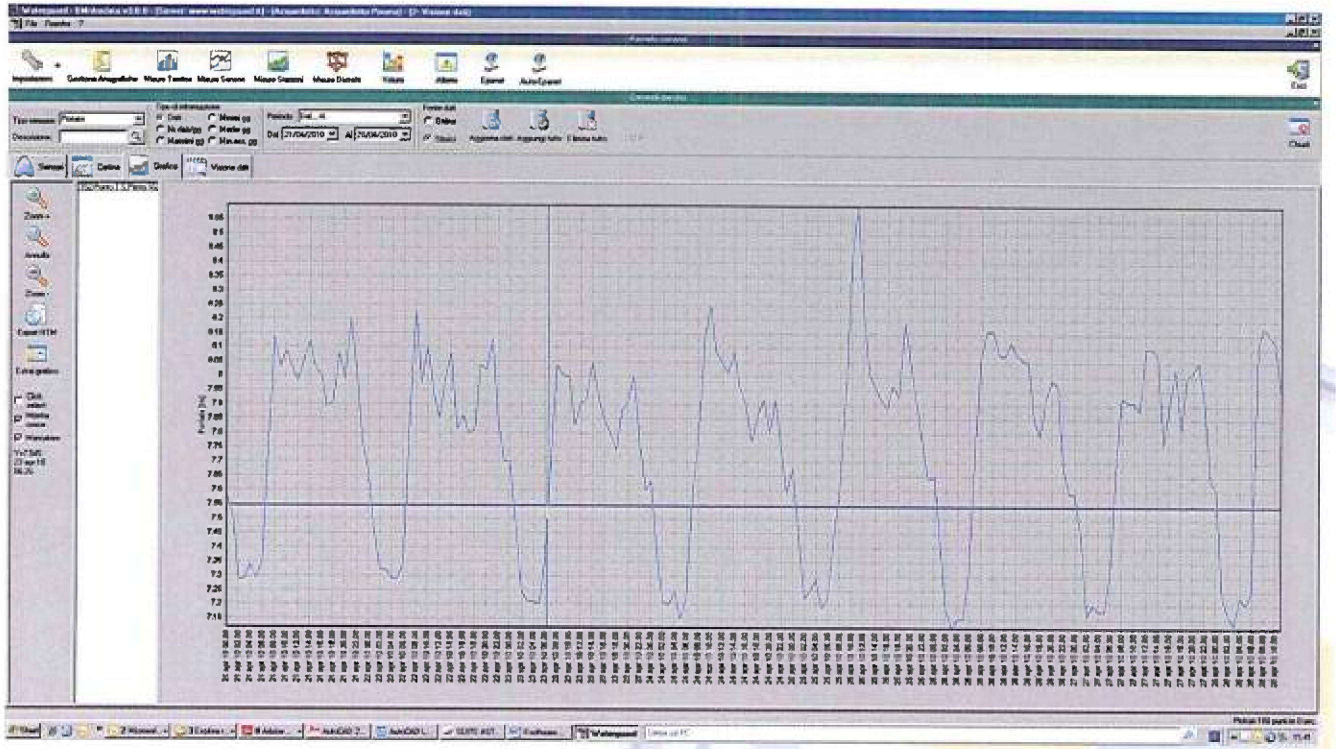
Gives the possibility of inserting all the information relative to the meter:

- **type** of instrument installed;
- **elevation above sea level** of the pipes in order to define the absolute value of the pressure;
- **characteristics of the pipes** on which are carried out the measurements;
- **geographical coordinates** of the measurement points can also be obtained through the integrated GIS;
- **Maintenance works** with description of the kind of intervention.



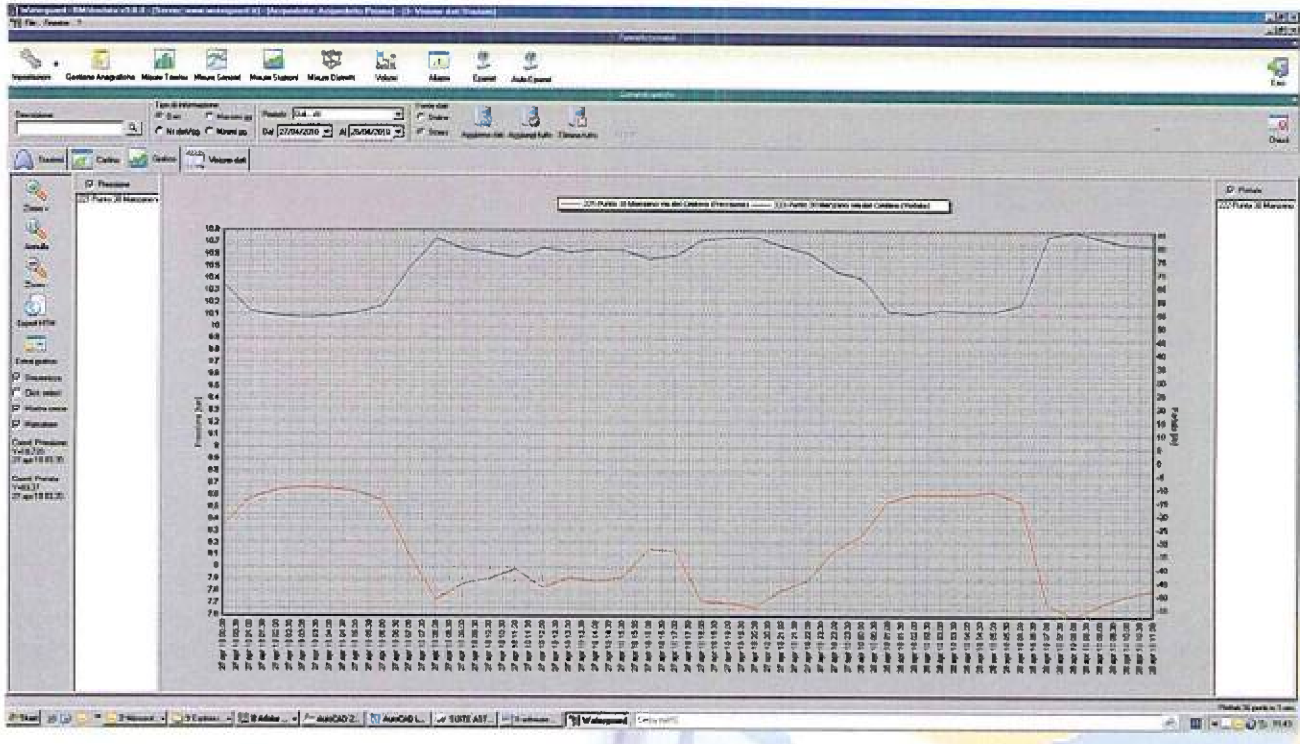
SENSOR MEASUREMENTS

- **graphical** and **tabular** view of validated data from different measurement points;
- The data can be visualized as **stored** data or as **on-line** data;
- Visualized data can be **exported** in *.csv format for further analysis.



MEASUREMENT POINTS

It is possible to visualize many signals of different type in the same graph.

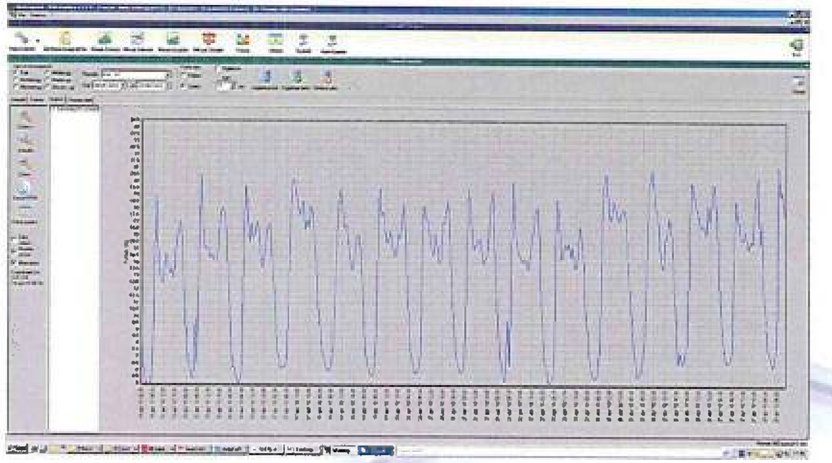


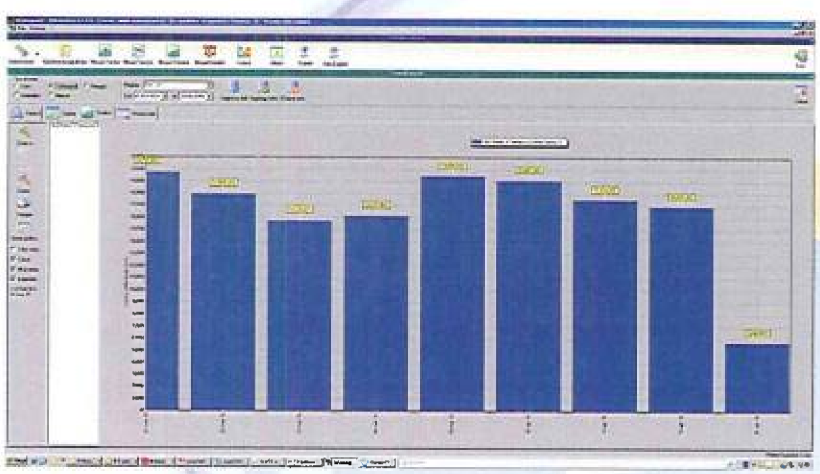
This allows to visualize in the same graph both flow and pressure measured at a specific point

DISTRICT BALANCE

Once defined in the registry the measurement points that define a district, Waterguard automatically:

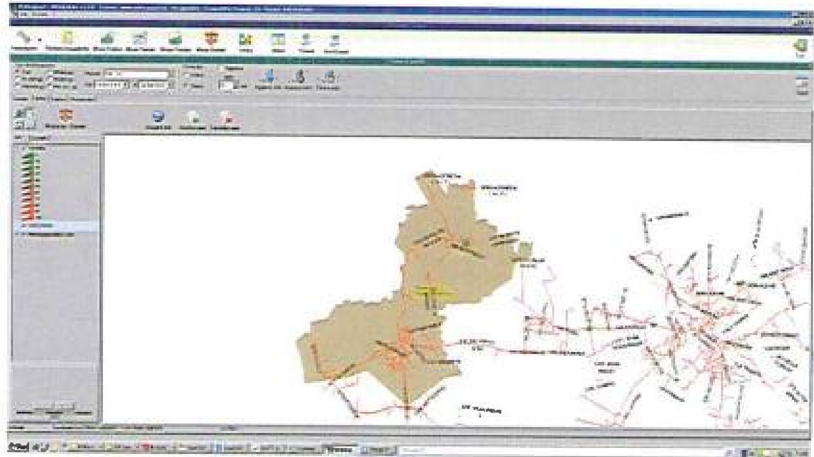
- Executes **water balances** of the consumptions in the district analyzed putting in evidence **mean**, **maximum** and **minimum** values to better evaluate the water losses of the district.
- executes **a quantification** of continuous industrial water consumptions
- gives the possibility of viewing data as **stored** (mean value in one hour) or **complete**.
- gives the possibility of viewing the water volumetric balance once the desired period is set.

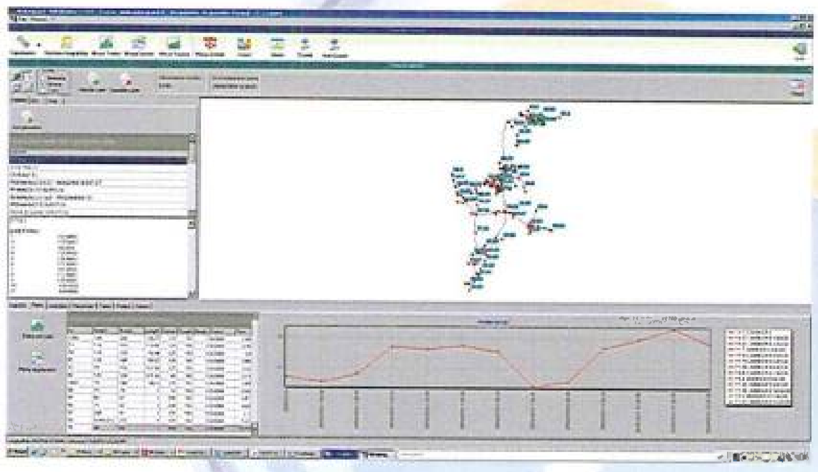




NUMERICAL MODELING

The Epanet computation code developed by the US Environmental Protection Agency (US EPA) has been implemented in the software Waterguard



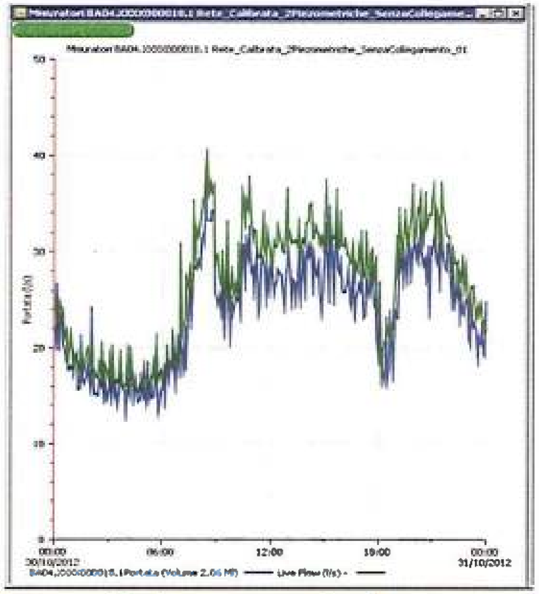


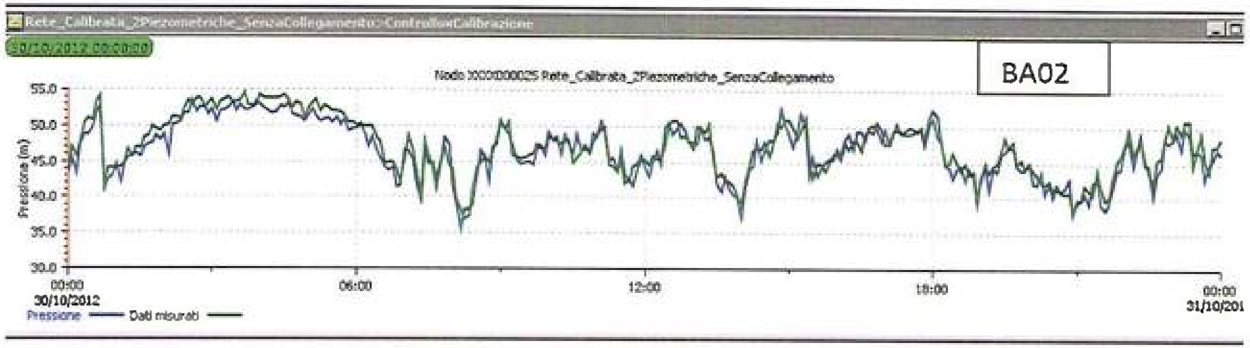
- Simulation of a quasi real-time functioning of the network
- Allows to study some particular critical event also after a long time

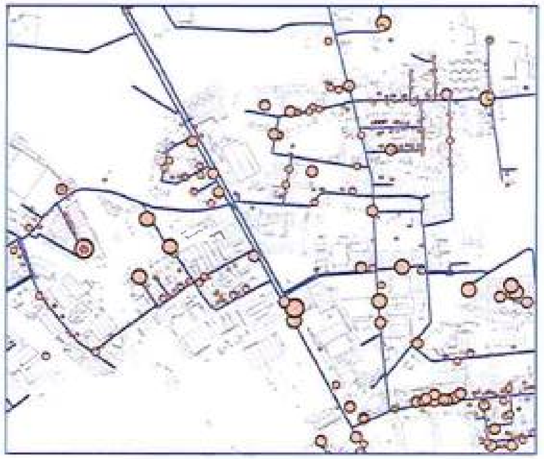
Waterguard

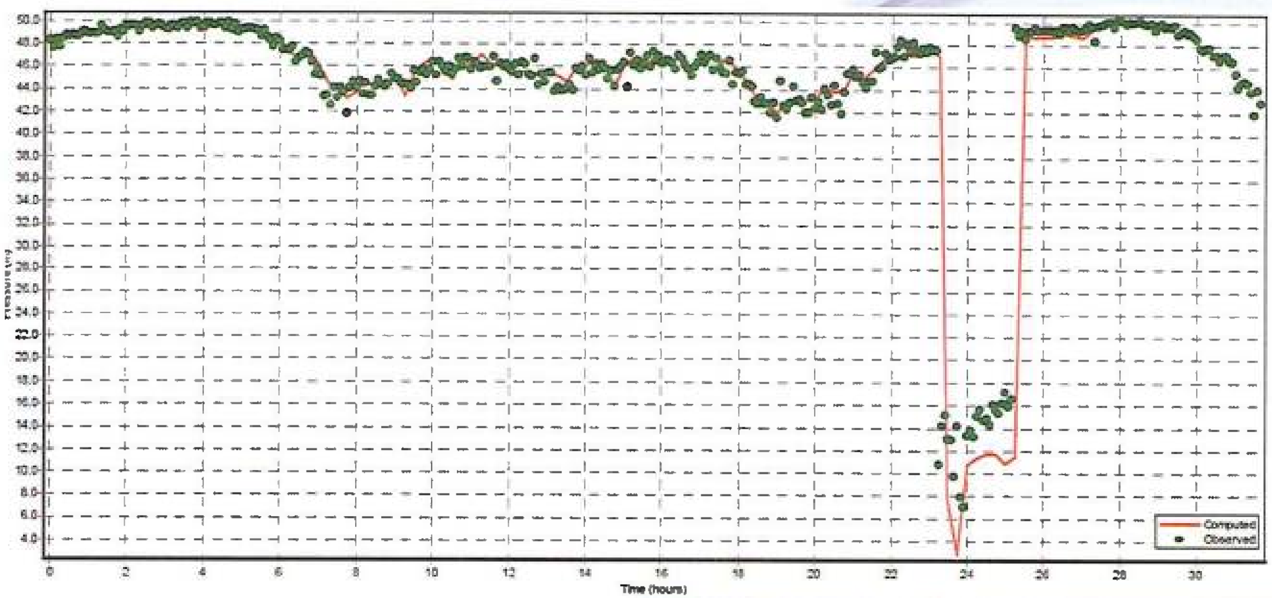
DRINKADRIA PROJECT

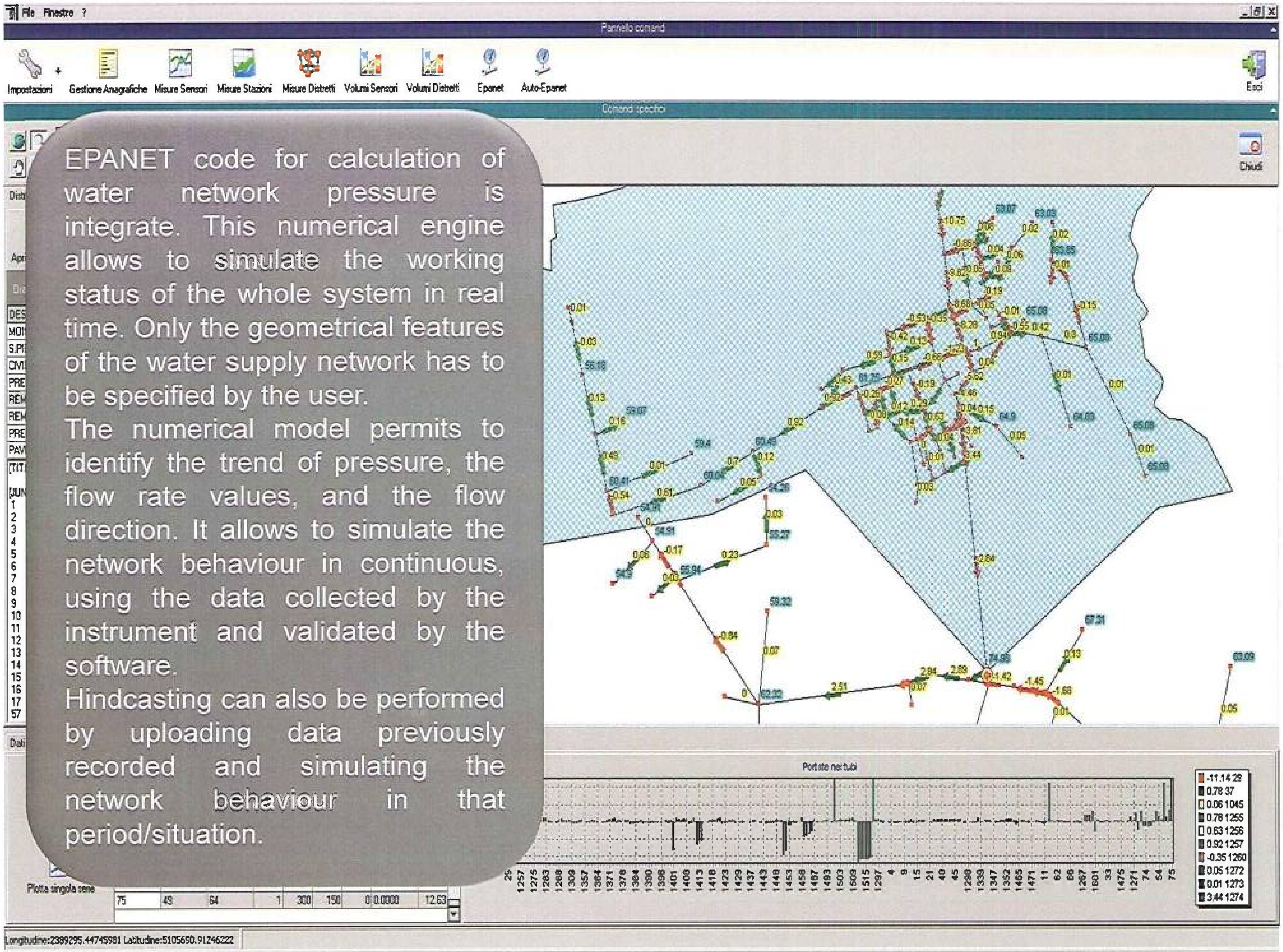
NUMERICAL MODELING











EPANET code for calculation of water network pressure is integrate. This numerical engine allows to simulate the working status of the whole system in real time. Only the geometrical features of the water supply network has to be specified by the user.

The numerical model permits to identify the trend of pressure, the flow rate values, and the flow direction. It allows to simulate the network behaviour in continuous, using the data collected by the instrument and validated by the software.

Hindcasting can also be performed by uploading data previously recorded and simulating the network behaviour in that period/situation.

Thank you
for your attention!

INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: VERITAS Joint Stock Company – Multiutility Water Service of Venice – FB 1
Contact person of the Final Beneficiary: Stefano della Sala

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

As a result of the particular nature of the town, the works necessary for the substitution of the pipes and the construction of new water supply lines are very complex and expensive.

It is of vital importance to adopt a type of management and construction techniques that allow to increase the life of the waterworks, lower the costs of management and limit the value of water losses.

To achieve these tasks, a detailed study of the water supply network will be carried out.
This study will be based on the implementation of a numerical model and a series of short period measurements (flow, pressure and quality) necessary for its calibration.

The numerical model will be built on the basis of the geometrical characteristics of the network and water withdrawal data, this information is present within the company's information system.

After the implementation of the model, on the basis of the measurements registered, the calibration will be achieved through the application of algorithms of operational research (i.e. genetic algorithms).

The next step will be to design a permanent division in districts of the network through the instalment of self powered meters that will measure flow, pressure and the quality of water. All the data will be transmitted through GSM/GPRS or radio systems to a server and then analyzed by a dedicated software.

The software will give an indication of the consumption in the districts and anomalies in the measurements and will also calculate efficiency parameters of the network as defined in the WP4. The water consumption, quality and pressure data will be automatically updated and it will be possible to analyze their fluctuation in time.

Through the application of the numerical model and the information derived from the permanent monitoring system, it will be possible to carry out the best operations necessary to optimize the distribution of pressure, flow and quality of the water in the network.

The regulation of the pressure in the network can be also controlled trough the instalment of variable pressure relief valves continuously remote controlled on the basis of the measurements registered in the most critical points of the network.

The control of the valves will be managed by a software based on neural networks or fuzzy logic type algorithms. This software, once it has been set, will permit a continuous adjustment of the pressure regulator valves (it is possible that there can be 48 daily variations) to obtain an optimization of the distribution.

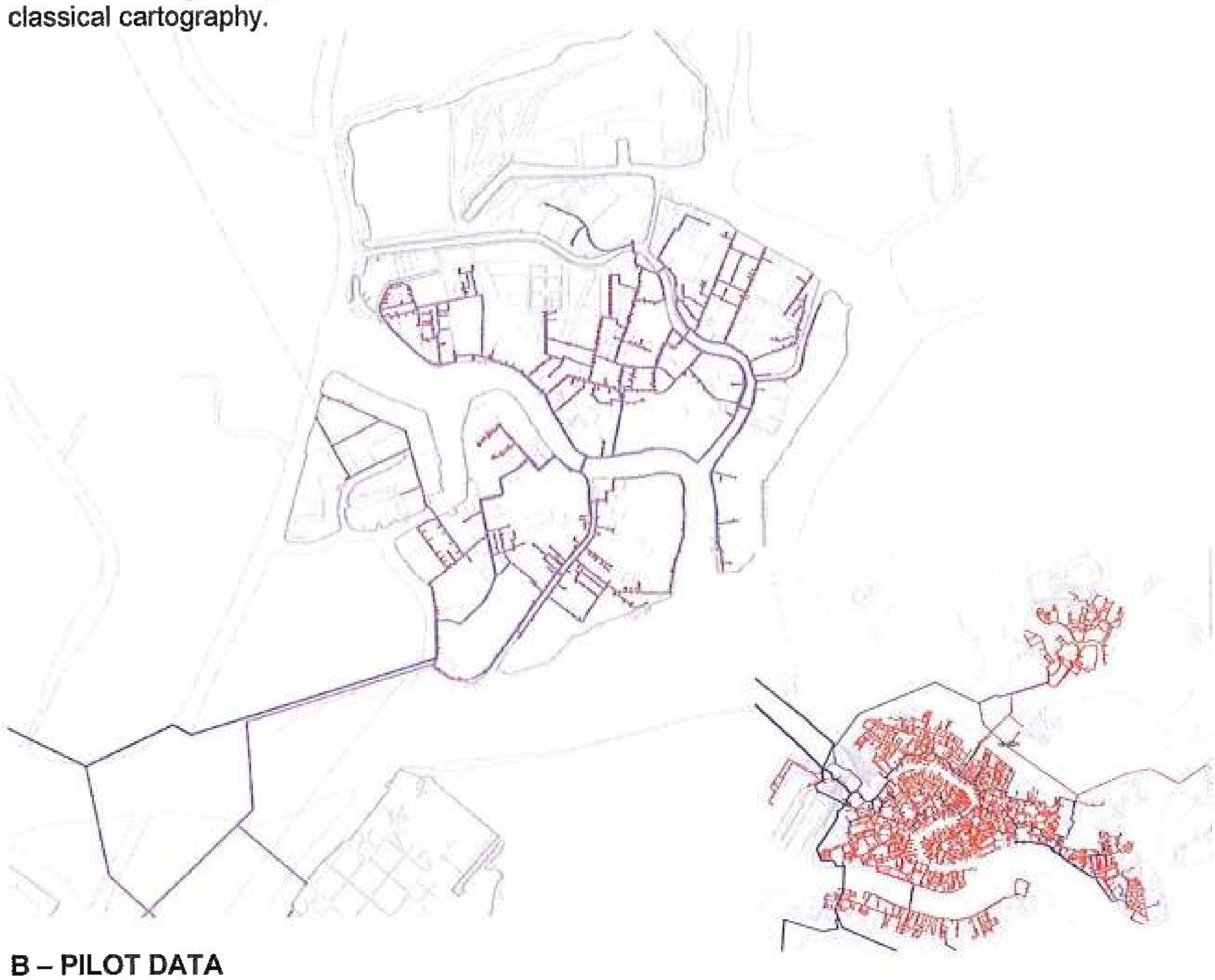
This system will also help to define the procedures that have to be applied in case of emergencies, such as the input in the network of contaminants or pollutants caused by ruptures or terrorist attacks.

On the basis of the results of the permanent monitoring, it will be possible to organize punctual water loss detection campaigns, these will be carried out using noise loggers, correlators and geophones.

The target of the project is to reduce the real loss in a pilot aqueduct of Murano Island in Venice Lagoon. Murano is an indipendent DMA (district metered area). The activity will be organized following the steps below:

1. Zone Flow Analysis
   a. District Metered Areas (DMA)
   b.Minimum night flow analysis
   c. Step testing
2. Pressure Management
3. Numerical modelling of the water supply network.

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.



PART B – PILOT DATA

1. Describe which parameters do you want to monitor.
   Flow, pressure, PH, Cl, temperature, turbidity and other quality parameters.

2. Describe which performance index do you want to calculate.
   % of water losses and Infrastructure Leakage Index (ILI), defined as the current annual real losses divided by the unavoidable annual real losses.

3. Do you have data already relevant to the project? YES☒ NO☐
   If Yes, describe:
   Self powered meters
   Variable pressure relief valves continuously remote controlled

4. Do you need equipment or investment? YES☒ NO☐
   If Yes, describe

5. Is the project already start? YES☐ NO☒
   If Yes, indicate the starting date

IF No, indicate when it will likely start: *June 2014*

6. Indicate the time line chart: **start June 2014 end September 2015.**
   1. Zone Flow Analysis: **June - September 2014**
      a. District Metered Areas (DMA)
      b. Minimum night flow analysis
      c. Step testing
   2. Acoustic Leak Surveys and Logging (if necessary): **October – December 2014**
   3. Pressure Management: **January 2015 - May 2015**
   4. Numerical Modelling: **May 2015 - September 2015**

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources: *2 (groundwater and treatment plant)*
2. Population served by your system: *5253*
3. Service area (Km^2): *1,1*
4. Total number of connections/customers: *2612*
5. Total number of retail connections: *579*
6. Amount of water produced (monthly and yearly average): *ND for pilot area*
7. Average annual water volume delivered to customers: *500.000* m^3
   a. supply capacity: ND
   b. percent imported water supply: *0%*
   c. percent surface water supply: *10%*
   d. percent potable groundwater supply: *90%*
8. Service area elevation range: *+1,5 m above sea level*
9. Total number of pressure zones in service area: *1*
10. Approximate elevation range in each pressure zone: *0*
11. Average number of customer connections per pressure zone: *2612*
12. Average static pressure delivered to pressure zone (Bar): *2/2.2 bar*

Is your project about water losses? YES☒ NO☐

If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in m;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

Material	***Length [m]***	%
Total	*25'131*	
IRON	964	3.8%
CAST IRON	6'982	27.8%
LEAD	264	1.1%
POLYETHYLENE	11'567	46.0%
ND	5'354	21.3%

2. Are all water service connections metered? YES☒ NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered? *Flow*

4. Does your software for water distribution system modelling interface with a GIS? YES☒ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☒
   If Yes, describe and indicate the following water supply data for last available year:

   a. water volume (m^3) input to distribution (produced and purchase)
   b. billed authorized consumption volume
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
   d. total authorized consumption volume (sum of **b** and **c**)
   e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
   f. list approximate percentage of water losses believed to exist as apparent losses (%)
   g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
   h. list what you believe to be the greatest source of apparent losses
   i. list approximate percentage of water losses believed to exist as real losses (%)
   j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
   k. list what you believe to be the greatest source of real losses
   l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

   ☒Passive only (only locate/repair)
   ☐Listening sticks
   ☒Ground microphones
   ☐Noise loggers
   ☐District metered areas (short description of instruments)
   ☒Leak noise correlation
   ☐Water pressure regulation at various times during the day as a means of leakage reduction
   ☐Other____

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☒
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program	______	☐Meter service connections	______
☐Water line replacement	______	☐Meter Sources	______
☐Reduce tank overflows	______	☐Line Looping	______
☐Leak detection/elimination	______	☐Flushing Program	______
☐Theft Prevention	______	☐Other	______

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☒
If Yes, describe.

PART F– RESULTS

Describe expected results (max 2000 caracters).

The dedicated software, after calibration, will give an indication of the consumption in the districts and anomalies in the measurements. The water consumption, quality and pressure data will be automatically updated and it will be possible to analyze their fluctuation in time.
To reduce water losses in water supply system.
Through the application of the numerical model and the information derived from the permanent monitoring system, it will be possible to carry out the best operations necessary to optimize the distribution of pressure, flow and quality of the water in the network.
Data obtained through this system will be used for mathematical modeling, development and expansion of water supply networks in the future (for example, network reconstruction and new branches)

INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: VERITAS Joint Stock Company – Multiutility Water Service of Venice – FB 1
Contact person of the Final Beneficiary: Stefano Della Sala

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

   The Pilot area of Mogliano showed presence of incremental amounts of Mercury and Iron in some wells
   Thus, we decided to test two different treatment methods systems based on reverse osmosis Vs activated coal. We studied and implemented a monitoring plan to evaluate the biological and chemical quality of the pilot area according to the Italian regulations concerning drinking water (Directive 98/83/CE; D.Lgs 31/01/CE)

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.

PART B – PILOT DATA

1. Describe which parameters do you want to monitor.

   Mercury and Iron in wells

2. Describe which performance index do you want to calculate.

   Mercury and iron abatement percentage

3. Do you have data already relevant to the project? YES☐X NO☐
   If Yes, describe

4. Do you need equipment or investment?
   If Yes, describe YES☐X NO☐

   Equipment: pilot plants for groundwater treatment

5. Is the project already start? YES☐X NO☐
   If Yes, indicate the starting date
   IF No, indicate when it will likely start

   November 2013

6. Indicate the time line chart.

   September 2014 – march 2015 implementation of reverse osmosis treatment plant
   April 2015 – October 2015 implementation of activated coal treatment plant

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources. **5** wells in working order; **2** closed for Mercury contamination
2. Population served by your system. **60.000**
3. Service area (m^2). **3.750**
4. Total number of connections/customers. **8.983**
5. Total number of retail connections. **19.468**
6. Amount of water produced (monthly and yearly average). **43.8147** (yearly average)
7. Average annual water volume delivered to customers: **4.458.033** m^3

   a. supply capacity; **5.991.840**
   b. percent imported water supply; **1,2 %**
   c. percent surface water supply; **0,9 %**
   d. percent potable groundwater supply. **99,1 %**
8. Service area elevation range. **11** masl
9. Total number of pressure zones in service area. **3**
10. Approximate elevation range in each pressure zone.

Preganziol: **12** masl
Quinto: **14** masl
Mogliano: **8** masl

11. Average number of customer connections per pressure zone.

    Preganziol: **3.150**
    Quinto: **220**
    Mogliano: **5.613**

12. Average static pressure delivered to pressure zone (Bar). **2,5**

Is your project about water losses? YES☐ NO☐X

If Yes, fill part D-E.
If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

2. Are all water service connections metered? YES☐ NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

   a. water volume (m^3) input to distribution (produced and purchase)
   b. billed authorized consumption volume
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
   d. total authorized consumption volume (sum of **b** and **c**)
   e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)

f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%)
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e)**

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other______________________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program ________
☐Water line replacement ________
☐Reduce tank overflows ________
☐Leak detection/elimination ________
☐Theft Prevention ________
☐Meter service connections ________
☐Meter Sources ________
☐Line Looping ________
☐Flushing Program ________
☐Other ________

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters).

The main expected result is the assessment of efficiency and economic impact of the two different techniques in order to improve the quality of drinkable groundwater.

INTERNAL USE NOT TO BE DISTRIBUITED

WORK PACKAGE 6: PILOT ACTIONS QUESTIONNAIRE

Name (in English) and number of Final Beneficiary: VERITAS Joint Stock Company – Multiutility Water Service of Venice – FB 1
Contact person of the Final Beneficiary: Stefano Della Sala

PART A – PILOT DESCRIPTION

1. Describe in detail Pilot action and Pilot area and possibly attach.

   The microbiological quality will be assessed according national and European regulations (Directive 98/83/CE; D.Lgs 31/01/CE) based on traditional and consolidated "Fecal Contamination Indicators":

   - *Escherichia coli*
   - Total Coliform bacteria
   - Intestinal Enterococci
   - *Clostridium perfringens*

   and to determine the presence of specific and relevant pathogenic microorganisms:

   - *Salmonella*
   - *Legionella*

   by bio-molecular technique (q-PCR).

   - *Salmonella* enrichments
   - Protozoa: *Giardia* and *Cryptosporidium.*

   by Fluorescence in situ hybridization (FISH)

2. Provide a Google map view of the Pilot Area with the approximate scale or dimension or/and a classical cartography.

f. list approximate percentage of water losses believed to exist as apparent losses (%)
g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
h. list what you believe to be the greatest source of apparent losses
i. list approximate percentage of water losses believed to exist as real losses (%)
j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
k. list what you believe to be the greatest source of real losses
l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other ______________________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program	______	☐Meter service connections	______
☐Water line replacement	______	☐Meter Sources	______
☐Reduce tank overflows	______	☐Line Looping	______
☐Leak detection/elimination	______	☐Flushing Program	______
☐Theft Prevention	______	☐Other	______

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters).

The main expected result is the assessment of efficiency and economic impact of the two different techniques in order to improve the quality of drinkable groundwater.

PART B – PILOT DATA

1. Describe which parameters do you want to monitor.

   Fecal contamination indicators and relevant pathogenic bacteria

2. Describe which performance index do you want to calculate.

   Selectivity, sensitiveness, quantification and detection time

3. Do you have data already relevant to the project? YES☐X NO☐
   If Yes, describe

   Venice drinking water biological monitoring data

4. Do you need equipment or investment?
   If Yes, describe YES☐X NO☐

   Equipment: q-PCR

5. Is the project already start? YES☐X NO☐
   If Yes, indicate the starting date
   IF No, indicate when it will likely start

   November 2013

6. Indicate the time line chart.

PART C – WATER SYSTEM INFORMATION FOR PILOT AREA

Indicate, if available :

1. Number of supply sources.
2. Population served by your system.
3. Service area (Km^2).
4. Total number of connections/customers.
5. Total number of retail connections.
6. Amount of water produced (monthly and yearly average).
7. Average annual water volume delivered to customers:
   a. supply capacity;
   b. percent imported water supply;
   c. percent surface water supply;
   d. percent potable groundwater supply.
8. Service area elevation range.
9. Total number of pressure zones in service area.
10. Approximate elevation range in each pressure zone.
11. Average number of customer connections per pressure zone.
12. Average static pressure delivered to pressure zone (Bar).

Is your project about water losses? YES☐ NO☐X

If Yes, fill part D-E.

If No, fill part F.

PART D – SERVICE CONNECTION INFORMATION

1. Indicate:
   pipe materials, the percent in place and the length in Km;
   water pressure: average static water pressure (Bar), low static pressure (Bar) and high static pressure (Bar).

2. Are all water service connections metered? YES☐ NO☐
   If no, what is the number of un-metered connections?
   If Yes, list software used for water distribution system modelling.

3. Which parameters are metered?

4. Does your software for water distribution system modelling interface with a GIS? YES☐ NO☐

PART E – WATER LOSS MANAGEMENT AND UN-METERED USE

1. Does your utility have a program to track water loss and un-metered use? YES☐ NO☐
   If Yes, describe and indicate the following water supply data for last available year:

   a. water volume (m^3) input to distribution (produced and purchase)
   b. billed authorized consumption volume
   c. unbilled authorized consumption volume (internal uses, flushing, cleaning, irrigation etc.)
   d. total authorized consumption volume (sum of **b** and **c**)
   e. water losses (water volume input to distribution indicated in **a** minus total authorized consumption indicated in **d**)
   f. list approximate percentage of water losses believed to exist as apparent losses (%)
   g. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of apparent losses indicated in **f**)
   h. list what you believe to be the greatest source of apparent losses
   i. list approximate percentage of water losses believed to exist as real losses (%)
   j. volume (m^3) of apparent losses (water losses indicated in **e** multiplied by the percentage of real losses indicated in **i**)
   k. list what you believe to be the greatest source of real losses
   l. calculate water volume input to distribution (sum of total authorized consumption indicated in **d** and water losses indicated in **e**)

2. Check all that apply below about leak detection and location survey methods:

☐Passive only (only locate/repair)
☐Listening sticks
☐Ground microphones
☐Noise loggers
☐District metered areas (short description of instruments)
☐Leak noise correlation
☐Water pressure regulation at various times during the day as a means of leakage reduction
☐Other ____________________

3. Indicate annual expenditure for losses management activities (€/yr), if available.

4. Does your utility have a water loss reduction target? YES☐ NO☐
If Yes, describe, check all that apply below and provide the date the program began, if available:

☐Meter replacement or calibration program	____________	☐Meter service connections	____________
☐Water line replacement	____________	☐Meter Sources	____________
☐Reduce tank overflows	____________	☐Line Looping	____________
☐Leak detection/elimination	____________	☐Flushing Program	____________
☐Theft Prevention	____________	☐Other	____________

5. Does any state or other agency require you to address water losses and loss reduction? YES☐ NO☐
If Yes, describe.

PART F– RESULTS

1. Describe expected results (max 2000 characters).

The expected result is to evaluate the applicability of q-PCR to determine by bio-molecular technique to determine by bio-molecular technique the presence of specific and relevant pathogenic microorganisms such as the bacteria *Salmonella* and *Legionella* and fecal contamination indicators, since this new method is becoming more and more used in this field because of its precision and time saving in fast management of organisms in drinking water especially arising in biological threats.

COUNCIL DIRECTIVE 98/83/EC

of 3 November 1998

on the quality of water intended for human consumption

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community and, in particular, Article 130s(1) thereof,

Having regard to the proposal from the Commission [1],

Having regard to the opinion of the Economic and Social Committee [2],

Having regard to the opinion of the Committee of the Regions [3],

Acting in accordance with the procedure laid down in Article 189c [4],

(1) Whereas it is necessary to adapt Council Directive 80/778/EEC of 15 July 1980 relating to the quality of water intended for human consumption [5] to scientific and technological progress; whereas experience gained from implementing that Directive shows that it is necessary to create an appropriately flexible and transparent legal framework for Member States to address failures to meet the standards; whereas, furthermore, that Directive should be re-examined in the light of the Treaty on European Union and in particular the principle of subsidiarity;

(2) Whereas in keeping with Article 3b of the Treaty, which provides that no Community action should go beyond what is necessary to achieve the objectives of the Treaty, it is necessary to revise Directive 80/778/EEC so as to focus on compliance with essential quality and health parameters, leaving Member States free to add other parameters if they see fit;

(3) Whereas, in accordance with the principle of subsidiarity, Community action must support and supplement action by the competent authorities in the Member States;

(4) Whereas, in accordance with the principle of subsidiarity, the natural and socio-economic differences between the regions of the Union require that most decisions on monitoring, analysis, and the measures to be taken to redress failures be taken at a local, regional or national level insofar as those differences do not detract from the establishment of the framework of laws, regulations and administrative provisions laid down in this Directive;

(5) Whereas Community standards for essential and preventive health-related quality parameters in water intended for human consumption are necessary if minimum environmental-quality goals to be achieved in connection with other Community measures are to be defined so that the sustainable use of water intended for human consumption may be safeguarded and promoted;

(6) Whereas, in view of the importance of the quality of water intended for human consumption for human health, it is necessary to lay down at Community level the essential quality standards with which water intended for that purpose must comply;

(7) Whereas it is necessary to include water used in the food industry unless it can be established that the use of such water does not affect the wholesomeness of the finished product;

(8) Whereas to enable water-supply undertakings to meet the quality standards for drinking water, appropriate water-protection measures should be applied to ensure that surface and groundwater is kept clean; whereas the same goal can be achieved by appropriate water-treatment measures to be applied before supply;

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[1] OJ C 131, 30.5.1995, p. 5 and OJ C 213, 15.7.1997, p. 8.
[2] OJ C 82, 19.3.1996, p. 64.
[3] OJ C 100, 2.4.1996, p. 134.
[4] Opinion of the European Parliament of 12 December 1996 (OJ C 20, 20.1.1997, p. 133), Council common position of 19 December 1997 (OJ C 91, 26.3.1998, p. 1) and Decision of the European Parliament of 13 May 1998 (OJ C 167, 1.6.1998, p. 92).
[5] OJ L 229, 30.8.1980, p. 11. Directive as last amended by the 1994 Act of Accession.

(9) Whereas the coherence of European water policy presupposes that a suitable water framework Directive will be adopted in due course;

(10) Whereas it is necessary to exclude from the scope of this Directive natural mineral waters and waters which are medicinal products, since special rules for those types of water have been established;

(11) Whereas measures are required for all parameters directly relevant to health and for other parameters if a deterioration in quality has occurred; whereas, furthermore, such measures should be carefully coordinated with the implementation of Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market [1] and Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market [2];

(12) Whereas it is necessary to set individual parametric values for substances which are important throughout the Community at a level strict enough to ensure that this Directive's purpose can be achieved;

(13) Whereas the parametric values are based on the scientific knowledge available and the precautionary principle has also been taken into account; whereas those values have been selected to ensure that water intended for human consumption can be consumed safely on a life-long basis, and thus represent a high level of health protection;

(14) Whereas a balance should be struck to prevent both microbiological and chemical risks; whereas, to that end, and in the light of a future review of the parametric values, the establishment of parametric values applicable to water intended for human consumption should be based on public-health considerations and on a method of assessing risk;

(15) Whereas there is at present insufficient evidence on which to base parametric values for endocrine-disrupting chemicals at Community level, yet there is increasing concern regarding the potential impact on humans and wildlife of the effects of substances harmful to health;

(16) Whereas in particular the standards in Annex I are generally based on the World Health Organisation's 'Guidelines for drinking water quality', and the opinion of the Commission's Scientific Advisory Committee to examine the toxicity and ecotoxicity of chemical compounds;

(17) Whereas Member States must set values for other additional parameters not included in Annex I where that is necessary to protect human health within their territories;

(18) Whereas Member States may set values for other additional parameters not included in Annex I where that is deemed necessary for the purpose of ensuring the quality of the production, distribution and inspection of water intended for human consumption;

(19) Whereas, when Member States deem it necessary to adopt standards more stringent than those set out in Annex I, Parts A and B, or standards for additional parameters not included in Annex I but necessary to protect human health, they must notify the Commission of those standards;

(20) Whereas Member States are bound, when introducing or maintaining more stringent protection measures, to respect the principles and rules of the Treaty, as they are interpreted by the Court of Justice;

(21) Whereas the parametric values are to be complied with at the point where water intended for human consumption is made available to the appropriate user;

(22) Whereas the quality of water intended for human consumption can be influenced by the domestic distribution system; whereas, furthermore, it is recognised that neither the domestic distribution system nor its maintenance may be the responsibility of the Member States;

(23) Whereas each Member State should establish monitoring programmes to check that water intended for human consumption meets the requirements of this Directive; whereas such monitoring programmes should be appropriate to local needs and should meet the minimum monitoring requirements laid down in this Directive;

(24) Whereas the methods used to analyse the quality of water intended for human consumption should be such as to ensure that the results obtained are reliable and comparable;

[1] OJ L 230, 19.8.1991, p. 1. Directive as last amended by Commission Directive 96/68/EC (OJ L 277, 30.10.1996, p. 25).

[2] OJ L 123, 24.4.1998, p. 1.

(25) Whereas, in the event of non-compliance with the standards imposed by this Directive the Member State concerned should investigate the cause and ensure that the necessary remedial action is taken as soon as possible to restore the quality of the water;

(26) Whereas it is important to prevent contaminated water causing a potential danger to human health; whereas the supply of such water should be prohibited or its use restricted;

(27) Whereas, in the event of non-compliance with a parameter that has an indicator function, the Member State concerned must consider whether that non-compliance poses any risk to human health; whereas it should take remedial action to restore the quality of the water where that is necessary to protect human health;

(28) Whereas, should such remedial action be necessary to restore the quality of water intended for human consumption, in accordance with Article 130r(2) of the Treaty, priority should be given to action which rectifies the problem at source;

(29) Whereas Member States should be authorised, under certain conditions, to grant derogations from this Directive; whereas, furthermore, it is necessary to establish a proper framework for such derogations, provided that they must not constitute a potential danger to human health and provided that the supply of water intended for human consumption in the area concerned cannot otherwise be maintained by any other reasonable means;

(30) Whereas, since the preparation or distribution of water intended for human consumption may involve the use of certain substances or materials, rules are required to govern the use thereof in order to avoid possible harmful effects on human health;

(31) Whereas scientific and technical progress may necessitate rapid adaptation of the technical requirements laid down in Annexes II and III; whereas, furthermore, in order to facilitate application of the measures required for that purpose, provision should be made for a procedure under which the Commission can adopt such adaptations with the assistance of a committee composed of representatives of the Member States;

(32) Whereas consumers should be adequately and appropriately informed of the quality of water intended for human consumption, of any derogations granted by the Member States and of any remedial action taken by the competent authorities; whereas, furthermore, consideration should be given both to the technical and statistical needs of the Commission, and to the rights of the individual to obtain adequate information concerning the quality of water intended for human consumption;

(33) Whereas, in exceptional circumstances and for geographically defined areas, it may be necessary to allow Member States a more extensive timescale for compliance with certain provisions of this Directive;

(34) Whereas this Directive should not affect the obligations of the Member States as to the time limit for transposition into national law, or as to application, as shown in Annex IV,

HAS ADOPTED THIS DIRECTIVE:

Article 1

Objective

1. This Directive concerns the quality of water intended for human consumption.

2. The objective of this Directive shall be to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean.

Article 2

Definitions

For the purposes of this Directive:

1. 'water intended for human consumption' shall mean:

   (a) all water either in its original state or after treatment, intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin and whether it is supplied from a distribution network, from a tanker, or in bottles or containers;

   (b) all water used in any food-production undertaking for the manufacture, processing, preservation or marketing of products or substances intended for human consumption unless the competent national authorities are satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form;

2. 'domestic distribution system' shall mean the pipework, fittings and appliances which are installed between the taps that are normally used for human consumption and the distribution network but only if they are not the responsibility of the water supplier, in its capacity as a water supplier, according to the relevant national law.

Article 3

Exemptions

1. This Directive shall not apply to:

(a) natural mineral waters recognised as such by the competent national authorities, in accordance with Council Directive 80/777/EEC of 15 July 1980 on the approximation of the laws of the Member States relating to the exploitation and marketing of natural mineral waters [1];

(b) waters which are medicinal products within the meaning of Council Directive 65/65/EEC of 26 January 1965 on the approximation of provisions laid down by law, regulation or administrative action relating to medicinal products [2].

2. Member States may exempt from the provisions of this Directive:

(a) water intended exclusively for those purposes for which the competent authorities are satisfied that the quality of the water has no influence, either directly or indirectly, on the health of the consumers concerned;

(b) water intended for human consumption from an individual supply providing less than 10 m^3 a day as an average or serving fewer than 50 persons, unless the water is supplied as part of a commercial or public activity.

3. Member States that have recourse to the exemptions provided for in paragraph 2(b) shall ensure that the population concerned is informed thereof and of any action that can be taken to protect human health from the adverse effects resulting from any contamination of water intended for human consumption. In addition, when a potential danger to human health arising out of the quality of such water is apparent, the population concerned shall promptly be given appropriate advice.

Article 4

General obligations

1. Without prejudice to their obligations under other Community provisions, Member States shall take the measures necessary to ensure that water intended for human consumption is wholesome and clean. For the purposes of the minimum requirements of this Directive, water intended for human consumption shall be wholesome and clean if it:

(a) is free from any micro-organisms and parasites and from any substances which, in numbers or concentrations, constitute a potential danger to human health, and

(b) meets the minimum requirements set out in Annex I, Parts A and B;

and if, in accordance with the relevant provisions of Articles 5 to 8 and 10 and in accordance with the Treaty, Member States take all other measures necessary to ensure that water intended for human consumption complies with the requirements of this Directive.

2. Member States shall ensure that the measures taken to implement this Directive in no circumstances have the effect of allowing, directly or indirectly, either any deterioration of the present quality of water intended for human consumption so far as that is relevant for the protection of human health or any increase in the pollution of waters used for the production of drinking water.

Article 5

Quality standards

1. Member States shall set values applicable to water intended for human consumption for the parameters set out in Annex I.

2. The values set in accordance with paragraph 1 shall not be less stringent than those set out in Annex I. As regards the parameters set out in Annex I, Part C, the values need be fixed only for monitoring purposes and for the fulfilment of the obligations imposed in Article 8.

3. A Member State shall set values for additional parameters not included in Annex I where the protection

(1) OJ L 229, 30.8.1980, p. 1. Directive as last amended by Directive 96/70/EC (OJ L 299, 23.11.1996, p. 26).

(2) OJ 22 9.2.1965, p. 369. Directive as last amended by Directive 93/39/EEC (OJ L 214, 24.8.1993, p. 22).

of human health within its national territory or part of it so requires. The values set should, as a minimum, satisfy the requirements of Article 4(1)(a).

Article 6

Point of compliance

1. The parametric values set in accordance with Article 5 shall be complied with:

(a) in the case of water supplied from a distribution network, at the point, within premises or an establishment, at which it emerges from the taps that are normally used for human consumption;

(b) in the case of water supplied from a tanker, at the point at which it emerges from the tanker;

(c) in the case of water put into bottles or containers intended for sale, at the point at which the water is put into the bottles or containers;

(d) in the case of water used in a food-production undertaking, at the point where the water is used in the undertaking.

2. In the case of water covered by paragraph 1(a), Member States shall be deemed to have fulfilled their obligations under this Article and under Articles 4 and 8(2) where it can be established that non-compliance with the parametric values set in accordance with Article 5 is due to the domestic distribution system or the maintenance thereof except in premises and establishments where water is supplied to the public, such as schools, hospitals and restaurants.

3. Where paragraph 2 applies and there is a risk that water covered by paragraph 1(a) would not comply with the parametric values established in accordance with Article 5, Member States shall nevertheless ensure that:

(a) appropriate measures are taken to reduce or eliminate the risk of non-compliance with the parametric values, such as advising property owners of any possible remedial action they could take, and/or

other measures, such as appropriate treatment techniques, are taken to change the nature or properties of the water before it is supplied so as to reduce or eliminate the risk of the water not complying with the parametric values after supply;

and

(b) the consumers concerned are duly informed and advised of any possible additional remedial action that they should take.

Article 7

Monitoring

1. Member States shall take all measures necessary to ensure that regular monitoring of the quality of water intended for human consumption is carried out, in order to check that the water available to consumers meets the requirements of this Directive and in particular the parametric values set in accordance with Article 5. Samples should be taken so that they are representative of the quality of the water consumed throughout the year. In addition, Member States shall take all measures necessary to ensure that, where disinfection forms part of the preparation or distribution of water intended for human consumption, the efficiency of the disinfection treatment applied is verified, and that any contamination from disinfection by-products is kept as low as possible without compromising the disinfection.

2. To meet the obligations imposed in paragraph 1, appropriate monitoring programmes shall be established by the competent authorities for all water intended for human consumption. Those monitoring programmes shall meet the minimum requirements set out in Annex II.

3. The sampling points shall be determined by the competent authorities and shall meet the relevant requirements set out in Annex II.

4. Community guidelines for the monitoring prescribed in this Article may be drawn up in accordance with the procedure laid down in Article 12.

5 (a) Member States shall comply with the specifications for the analyses of parameters set out in Annex III.

(b) Methods other than those specified in Annex III, Part 1, may be used, providing it can be demonstrated that the results obtained are at least as reliable as those produced by the methods specified. Member States which have recourse to alternative methods shall provide the Commission with all relevant information concerning such methods and their equivalence.

(c) For those parameters listed in Annex III, Parts 2 and 3, any method of analysis may be used provided that it meets the requirements set out therein.

6. Member States shall ensure that additional monitoring is carried out on a case-by-case basis of substances and micro-organisms for which no parametric value has been set in accordance with Article 5, if there is reason to suspect that they may be present in amounts or

numbers which constitute a potential danger to human health.

Article 8

Remedial action and restrictions in use

1. Member States shall ensure that any failure to meet the parametric values set in accordance with Article 5 is immediately investigated in order to identify the cause.

2. If, despite the measures taken to meet the obligations imposed in Article 4(1), water intended for human consumption does not meet the parametric values set in accordance with Article 5, and subject to Article 6(2), the Member State concerned shall ensure that the necessary remedial action is taken as soon as possible to restore its quality and shall give priority to their enforcement action, having regard *inter alia* to the extent to which the relevant parametric value has been exceeded and to the potential danger to human health.

3. Whether or not any failure to meet the parametric values has occurred, Member States shall ensure that any supply of water intended for human consumption which constitutes a potential danger to human health is prohibited or its use restricted or such other action is taken as is necessary to protect human health. In such cases consumers shall be informed promptly thereof and given the necessary advice.

4. The competent authorities or other relevant bodies shall decide what action under paragraph 3 should be taken, bearing in mind the risks to human health which would be caused by an interruption of the supply or a restriction in the use of water intended for human consumption.

5. Member States may establish guidelines to assist the competent authorities to fulfil their obligations under paragraph 4.

6. In the event of non-compliance with the parametric values or with the specifications set out in Annex I, Part C, Member States shall consider whether that non-compliance poses any risk to human health. They shall take remedial action to restore the quality of the water where that is necessary to protect human health.

7. Member States shall ensure that, where remedial action is taken, consumers are notified except where the competent authorities consider the non-compliance with the parametric value to be trivial.

Article 9

Derogations

1. Member States may provide for derogations from the parametric values set out in Annex I, Part B, or set in accordance with Article 5(3), up to a maximum value to be determined by them, provided no derogation constitutes a potential danger to human health and provided that the supply of water intended for human consumption in the area concerned cannot otherwise be maintained by any other reasonable means. Derogations shall be limited to as short a time as possible and shall not exceed three years, towards the end of which a review shall be conducted to determine whether sufficient progress has been made. Where a Member State intends to grant a second derogation, it shall communicate the review, along with the grounds for its decision on the second derogation, to the Commission. No such second derogation shall exceed three years.

2. In exceptional circumstances, a Member State may ask the Commission for a third derogation for a period not exceeding three years. The Commission shall take a decision on any such request within three months.

3. Any derogation granted in accordance with paragraphs 1 or 2 shall specify the following:

(a) the grounds for the derogation;

(b) the parameter concerned, previous relevant monitoring results, and the maximum permissible value under the derogation;

(c) the geographical area, the quantity of water supplied each day, the population concerned and whether or not any relevant food-production undertaking would be affected;

(d) an appropriate monitoring scheme, with an increased monitoring frequency where necessary;

(e) a summary of the plan for the necessary remedial action, including a timetable for the work and an estimate of the cost and provisions for reviewing;

(f) the required duration of the derogation.

4. If the competent authorities consider the non-compliance with the parametric value to be trivial, and if action taken in accordance with Article 8(2) is sufficient to remedy the problem within 30 days, the requirements of paragraph 3 need not be applied.

In that event, only the maximum permissible value for the parameter concerned and the time allowed to remedy the problem shall be set by the competent authorities or other relevant bodies.

5. Recourse may no longer be had to paragraph 4 if failure to comply with any one parametric value for a given water supply has occurred on more than 30 days on aggregate during the previous 12 months.

6. Any Member State which has recourse to the derogations provided for in this Article shall ensure that the population affected by any such derogation is promptly informed in an appropriate manner of the derogation and of the conditions governing it. In addition the Member State shall, where necessary, ensure that advice is given to particular population groups for which the derogation could present a special risk.

These obligations shall not apply in the circumstances described in paragraph 4 unless the competent authorities decide otherwise.

7. With the exception of derogations granted in accordance with paragraph 4 a Member State shall inform the Commission within two months of any derogation concerning an individual supply of water exceeding 1 000 m^3 a day as an average or serving more than 5 000 persons, including the information specified in paragraph 3.

8. This Article shall not apply to water intended for human consumption offered for sale in bottles or containers.

Article 10

Quality assurance of treatment, equipment and materials

Member States shall take all measures necessary to ensure that no substances or materials for new installations used in the preparation or distribution of water intended for human consumption or impurities associated with such substances or materials for new installations remain in water intended for human consumption in concentrations higher than is necessary for the purpose of their use and do not, either directly or indirectly, reduce the protection of human health provided for in this Directive; the interpretative document and technical specifications pursuant to Article 3 and Article 4 (1) of Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products [1] shall respect the requirements of this Directive.

Article 11

Review of Annexes

1. At least every five years, the Commission shall review Annex I in the light of scientific and technical progress and shall make proposals for amendments, where necessary, under the procedure laid down in Article 189c of the Treaty.

2. At least every five years, the Commission shall adapt Annexes II and III to scientific and technical progress. Such changes as are necessary shall be adopted in accordance with the procedure laid down in Article 12.

Article 12

Committee procedure

1. The Commission shall be assisted by a committee composed of representatives of the Member States and chaired by a Commission representative.

2. The Commission representative shall submit to the committee a draft of the measures to be taken. The committee shall deliver its opinion on the draft within a time limit which the chairman may lay down according to the urgency of the matter. The opinion shall be delivered by the majority laid down in Article 148(2) of the Treaty in the case of decisions which the Council is required to adopt on a proposal from the Commission. The votes of the representatives of the Member States within the committee shall be weighted in the manner set out in that Article. The chairman shall not vote.

3. The Commission shall adopt measures which shall apply immediately. However, if those measures are not in accordance with the committee's opinion, the Commission shall communicate them to the Council forthwith. In that event:

(a) the Commission shall defer application of the measures which it has adopted for a period of three months from the date of communication;

(b) the Council, acting by a qualified majority, may take a different decision within the time limit referred to in point (a).

Article 13

Information and reporting

1. Member States shall take the measures necessary to ensure that adequate and up-to-date information on the

(1) OJ L 40, 11.2.1989, p. 12. Directive as last amended by Directive 93/68/EEC (OJ L 220, 30.8.1993, p. 1).

quality of water intended for human consumption is available to consumers.

2. Without prejudice to Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment [1], each Member State shall publish a report every three years on the quality of water intended for human consumption with the objective of informing consumers. The first report shall cover the years 2002, 2003 and 2004. Each report shall include, as a minimum, all individual supplies of water exceeding 1 000 m^3 a day as an average or serving more than 5 000 persons and it shall cover three calendar years and be published within one calendar year of the end of the reporting period.

3. Member States shall send their reports to the Commission within two months of their publication.

4. The formats and the minimum information for the reports provided for in paragraph 2 shall be determined having special regard to the measures referred to in Article 3(2), Article 5(2) and (3), Article 7(2), Article 8, Article 9(6) and (7) and 15(1), and shall if necessary be amended in accordance with the procedure laid down in Article 12.

5. The Commission shall examine the Member States' reports and, every three years, publish a synthesis report on the quality of water intended for human consumption in the Community. That report shall be published within nine months of the receipt of the Member States' reports.

6. Together with the first report on this Directive as mentioned in paragraph 2, Member States shall also produce a report to be forwarded to the Commission on the measures they have taken or plan to take to fultil their obligations pursuant to Article 6(3) and Annex I, Part B, note 10. The Commission shall submit, as appropriate, a proposal on the format of this report in accordance with the procedure laid down in Article 12.

Article 14

Timescale for compliance

Member States shall take the measures necessary to ensure that the quality of water intended for human consumption complies with this Directive within five years of its entry into force, without prejudice to Notes 2, 4 and 10 in Annex I, Part B.

Article 15

Exceptional circumstances

1. A Member State may, in exceptional circumstances and for geographically defined areas, submit a special request to the Commission for a period longer than that laid down in Article 14. The additional period shall not exceed three years, towards the end of which a review shall be carried out and forwarded to the Commission which may, on the basis of that review, permit a second additional period of up to three years. This provision shall not apply to water intended for human consumption offered for sale in bottles or containers.

2. Any such request, grounds for which shall be given, shall set out the difficulties experienced and include, as a minimum, all the information specified in Article 9(3).

3. The Commission shall examine that request in accordance with the procedure laid down in Article 12.

4. Any Member State which has recourse to this Article shall ensure that the population affected by its request is promptly informed in an appropriate manner of the outcome of that request. In addition, the Member State shall, where necessary, ensure that advice is given to particular population groups for which the request could present a special risk.

Article 16

Repeal

1. Directive 80/778/EEC is hereby repealed with effect from five years after the entry into force of this Directive. Subject to paragraph 2, this repeal shall be without prejudice to Member States' obligations regarding deadlines for transposition into national law and for application as shown in Annex IV.

Any reference to the Directive repealed shall be construed as a reference to this Directive and shall be read in accordance with the correlation table set out in Annex V.

2. As soon as a Member State has brought into force the laws, regulations and administrative provisions necessary to comply with this Directive and has taken the measures provided for in Article 14, this Directive, not Directive 80/778/EEC, shall apply to the quality of water intended for human consumption in that Member State.

[1] OJ L 158, 23.6.1990, p. 56.

Article 17

Transposition into national law

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive within two years of its entry into force. They shall forthwith inform the Commission thereof.

When the Member States adopt those measures, these shall contain references to this Directive or shall be accompanied by such references on the occasion of their official publication. The methods of making such references shall be laid down by the Member States.

2. The Member States shall communicate to the Commission the texts of the provisions of national law which they adopt in the field covered by this Directive.

Article 18

Entry into force

This Directive shall enter into force on the 20th day following its publication in the *Official Journal of the European Communities*.

Article 19

Addressees

This Directive is addressed to the Member States.

Done at Brussels, 3 November 1998.

For the Council

The President

B. PRAMMER

ANNEX I

PARAMETERS AND PARAMETRIC VALUES

PART A

Microbiological parameters

Parameter	Parametric value (number/100 ml)
Escherichia coli (E. coli)	0
Enterococci	0

The following applies to water offered for sale in bottles or containers:

Parameter	Parametric value
Escherichia coli (E. coli)	0/250 ml
Enterococci	0/250 ml
Pseudomonas aeruginosa	0/250 ml
Colony count 22 °C	100/ml
Colony count 37 °C	20/ml

PART B

Chemical parameters

Parameter	Parametric value	Unit	Notes
Acrylamide	0,10	μg/l	Note 1
Antimony	5,0	μg/l	
Arsenic	10	μg/l	
Benzene	1,0	μg/l	
Benzo(a)pyrene	0,010	μg/l	
Boron	1,0	mg/l	
Bromate	10	μg/l	Note 2
Cadmium	5,0	μg/l	
Chromium	50	μg/l	
Copper	2,0	mg/l	Note 3
Cyanide	50	μg/l	
1,2-dichloroethane	3,0	μg/l	
Epichlorohydrin	0,10	μg/l	Note 1
Fluoride	1,5	mg/l	
Lead	10	μg/l	Notes 3 and 4
Mercury	1,0	μg/l	
Nickel	20	μg/l	Note 3
Nitrate	50	mg/l	Note 5
Nitrite	0,50	mg/l	Note 5
Pesticides	0,10	μg/l	Notes 6 and 7
Pesticides — Total	0,50	μg/l	Notes 6 and 8
Polycyclic aromatic hydrocarbons	0,10	μg/l	Sum of concentrations of specified compounds; Note 9
Selenium	10	μg/l	
Tetrachloroethene and Trichloroethene	10	μg/l	Sum of concentrations of specified parameters
Trihalomethanes — Total	100	μg/l	Sum of concentrations of specified compounds; Note 10
Vinyl chloride	0,50	μg/l	Note 1

Note 1: The parametric value refers to the residual monomer concentration in the water as calculated according to specifications of the maximum release from the corresponding polymer in contact with the water.

Note 2: Where possible, without compromising disinfection, Member States should strive for a lower value.

For the water referred to in Article 6(1)(a), (b) and (d), the value must be met, at the latest, 10 calendar years after the entry into force of the Directive. The parametric value for bromate from five years after the entry into force of this Directive until 10 years after its entry into force is 25 μg/l.

Note 3: The value applies to a sample of water intended for human consumption obtained by an adequate sampling method ([1]) at the tap and taken so as to be representative of a weekly average value ingested by consumers. Where appropriate the sampling and monitoring methods must be applied in a harmonised fashion to be drawn up in accordance with Article 7(4). Member States must take account of the occurrence of peak levels that may cause adverse effects on human health.

Note 4: For water referred to in Article 6(1)(a), (b) and (d), the value must be met, at the latest, 15 calendar years after the entry into force of this Directive. The parametric value for lead from five years after the entry into force of this Directive until 15 years after its entry into force is 25 μg/l.

Member States must ensure that all appropriate measures are taken to reduce the concentration of lead in water intended for human consumption as much as possible during the period needed to achieve compliance with the parametric value.

When implementing the measures to achieve compliance with that value Member States must progressively give priority where lead concentrations in water intended for human consumption are highest.

Note 5: Member States must ensure that the condition that [nitrate]/50 + [nitrite]/3 $\leq$ 1, the square brackets signifying the concentrations in mg/l for nitrate (NO_3) and nitrite (NO_2), is complied with and that the value of 0,10 mg/l for nitrites is complied with ex water treatment works.

Note 6: 'Pesticides' means:

- organic insecticides,
- organic herbicides,
- organic fungicides,
- organic nematocides,
- organic acaricides,
- organic algicides,
- organic rodenticides
- organic slimicides,
- related products (*inter alia*, growth regulators)

and their relevant metabolites, degradation and reaction products.

Only those pesticides which are likely to be present in a given supply need be monitored.

Note 7: The parametric value applies to each individual pesticide. In the case of aldrin, dieldrin, heptachlor and heptachlor epoxide the parametric value is 0,030 μg/l.

Note 8: 'Pesticides — Total' means the sum of all individual pesticides detected and quantified in the monitoring procedure.

Note 9: The specified compounds are:

- benzo(b)fluoranthene,
- benzo(k)fluoranthene,
- benzo(ghi)perylene,
- indeno(1,2,3-cd)pyrene.

Note 10: Where possible, without compromising disinfection, Member States should strive for a lower value.

The specified compounds are: chloroform, bromoform, dibromochloromethane, bromodichloromethane.

For the water referred to in Article 6(1)(a), (b) and (d), the value must be met, at the latest, 10 calendar years after the entry into force of this Directive. The parametric value for total THMs from five years after the entry into force of this Directive until 10 years after its entry into force is 150 μg/l.

([1]) To be added following the outcome of the study currently being carried out.

Member States must ensure that all appropriate measures are taken to reduce the concentration of THMs in water intended for human consumption as much as possible during the period needed to achieve compliance with the parametric value.

When implementing the measures to achieve this value, Member States must progressively give priority to those areas where THM concentrations in water intended for human consumption are highest.

PART C

Indicator parameters

Parameter	Parametric value	Unit	Notes
Aluminium	200	µg/l	
Ammonium	0,50	mg/l	
Chloride	250	mg/l	Note 1
Clostridium perfringens (including spores)	0	number/100 ml	Note 2
Colour	Acceptable to consumers and no abnormal change		
Conductivity	2 500	µS cm^{-1} at 20 °C	Note 1
Hydrogen ion concentration	≥ 6,5 and ≤ 9,5	pH units	Notes 1 and 3
Iron	200	µg/l	
Manganese	50	µg/l	
Odour	Acceptable to consumers and no abnormal change		
Oxidisability	5,0	mg/l O_2	Note 4
Sulphate	250	mg/l	Note 1
Sodium	200	mg/l	
Taste	Acceptable to consumers and no abnormal change		
Colony count 22°	No abnormal change		
Coliform bacteria	0	number/100 ml	Note 5
Total organic carbon (TOC)	No abnormal change		Note 6
Turbidity	Acceptable to consumers and no abnormal change		Note 7

RADIOACTIVITY

Parameter	Parametric value	Unit	Notes
Tritium	100	Bq/l	Notes 8 and 10
Total indicative dose	0,10	mSv/year	Notes 9 and 10

Note 1: The water should not be aggressive.

Note 2: This parameter need not be measured unless the water originates from or is influenced by surface water. In the event of non-compliance with this parametric value, the Member State concerned must investigate the supply to ensure that there is no potential danger to human health arising from the presence of pathogenic micro-organisms, e.g. cryptosporidium. Member States must include the results of all such investigations in the reports they must submit under Article 13(2).

Note 3: For still water put into bottles or containers, the minimum value may be reduced to 4,5 pH units.

For water put into bottles or containers which is naturally rich in or artificially enriched with carbon dioxide, the minimum value may be lower.

Note 4: This parameter need not be measured if the parameter TOC is analysed.

Note 5: For water put into bottles or containers the unit is number/250 ml.

Note 6: This parameter need not be measured for supplies of less than 10 000 m^3 a day.

Note 7: In the case of surface water treatment, Member States should strive for a parametric value not exceeding 1,0 NTU (nephelometric turbidity units) in the water ex treatment works.

Note 8: Monitoring frequencies to be set later in Annex II.

Note 9: Excluding tritium, potassium -40, radon and radon decay products; monitoring frequencies, monitoring methods and the most relevant locations for monitoring points to be set later in Annex II.

Note 10:

1. The proposals required by Note 8 on monitoring frequencies, and Note 9 on monitoring frequencies, monitoring methods and the most relevant locations for monitoring points in Annex II shall be adopted in accordance with the procedure laid down in Article 12. When elaborating these proposals the Commission shall take into account *inter alia* the relevant provisions under existing legislation or appropriate monitoring programmes including monitoring results as derived from them. The Commission shall submit these proposals at the latest within 18 months following the date referred to in Article 18 of the Directive.

2. A Member State is not required to monitor drinking water for tritium or radioactivity to establish total indicative dose where it is satisfied that, on the basis of other monitoring carried out, the levels of tritium of the calculated total indicative dose are well below the parametric value. In that case, it shall communicate the grounds for its decision to the Commission, including the results of this other monitoring carried out.

ANNEX II

MONITORING

TABLE A

Parameters to be analysed

1. *Check monitoring*

The purpose of check monitoring is regularly to provide information on the organoleptic and microbiological quality of the water supplied for human consumption as well as information on the effectiveness of drinking-water treatment (particularly of disinfection) where it is used, in order to determine whether or not water intended for human consumption complies with the relevant parametric values laid down in this Directive.

The following parameters must be subject to check monitoring. Member States may add other parameters to this list if they deem it appropriate.

Aluminium (Note 1)

Ammonium

Colour

Conductivity

Clostridium perfringens (including spores) (Note 2)

Escherichia coli (E. coli)

Hydrogen ion concentration

Iron (Note 1)

Nitrite (Note 3)

Odour

Pseudomonas aeruginosa (Note 4)

Taste

Colony count 22 °C and 37 °C (Note 4)

Coliform bacteria

Turbidity

Note 1: Necessary only when used as flocculant (*).

Note 2: Necessary only if the water originates from or is influenced by surface water (*).

Note 3: Necessary only when chloramination is used as a disinfectant (*).

Note 4: Necessary only in the case of water offered for sale in bottles or containers.

(*) In all other cases, the parameters are in the list for audit monitoring.

2. *Audit monitoring*

The purpose of audit monitoring is to provide the information necessary to determine whether or not all of the Directive's parametric values are being complied with. All parameters set in accordance with Article 5(2) and (3) must be subject to audit monitoring unless it can be established by the competent authorities, for a period of time to be determined by them, that a parameter is not likely to be present in a given supply in concentrations which could lead to the risk of a breach of the relevant parametric value. This paragraph does not apply to the parameters for radioactivity, which, subject to Notes 8, 9 and 10 in Annex I, Part C, will be monitored in accordance with monitoring requirements adopted under Article 12.

TABLE B1

Minimum frequency of sampling and analyses for water intended for human consumption supplied from a distribution network or from a tanker or used in a food-production undertaking

Member States must take samples at the points of compliance as defined in Article 6(1) to ensure that water intended for human consumption meets the requirements of the Directive. However, in the case of a distribution network, a Member State may take samples within the supply zone or at the treatment works for particular parameters if it can be demonstrated that there would be no adverse change to the measured value of the parameters concerned.

<table>
<tr><th>Volume of water distributed or produced each day within a supply zone
(Notes 1 and 2)
m^3</th><th>Check monitoring number of samples per year
(Notes 3, 4 and 5)</th><th>Audit monitoring number of samples per year
(Notes 3 and 5)</th></tr>
<tr><td>≤ 100</td><td>(Note 6)</td><td>(Note 6)</td></tr>
<tr><td>> 100 ≤ 1 000</td><td>4</td><td>1</td></tr>
<tr><td>> 1 000 ≤ 10 000</td><td rowspan="3">4
+ 3 for each 1 000 m^3/d and part thereof of the total volume</td><td>1
+ 1 for each 3 300 m^3/d and part thereof of the total volume</td></tr>
<tr><td>> 10 000 ≤ 100 000</td><td>3
+ 1 for each 10 000 m^3/d and part thereof of the total volume</td></tr>
<tr><td>> 100 000</td><td>10
+ 1 for each 25 000 m^3/d and part thereof of the total volume</td></tr>
</table>

Note 1: A supply zone is a geographically defined area within which water intended for human consumption comes from one or more sources and within which water quality may be considered as being approximately uniform.

Note 2: The volumes are calculated as averages taken over a calendar year. A Member State may use the number of inhabitants in a supply zone instead of the volume of water to determine the minimum frequency, assuming a water consumption of 200 l/day/capita.

Note 3: In the event of intermittent short-term supply the monitoring frequency of water distributed by tankers is to be decided by the Member State concerned.

Note 4: For the different parameters in Annex I, a Member State may reduce the number of samples specified in the table if:

(a) the values of the results obtained from samples taken during a period of at least two successive years are constant and significantly better than the limits laid down in Annex I, and

(b) no factor is likely to cause a deterioration of the quality of the water.

The lowest frequency applied must not be less than 50 % of the number of samples specified in the table except in the particular case of note 6.

Note 5: As far as possible, the number of samples should be distributed equally in time and location.

Note 6: The frequency is to be decided by the Member State concerned.

TABLE B2

Minimum frequency of sampling and analysis for water put into bottles or containers intended for sale

Volume of water produced for offering for sale in bottles or containers each day [1] m^3		Check monitoring number of samples per year	Audit monitoring number of samples per year
≤ 10		1	1
> 10	≤ 60	12	1
> 60		1 for each 5 m^3 and part thereof of the total volume	1 for each 100 m^3 and part thereof of the total volume

[1] The volumes are calculated as averages taken over a calendar year.

ANNEX III

SPECIFICATIONS FOR THE ANALYSIS OF PARAMETERS

Each Member State must ensure that any laboratory at which samples are analysed has a system of analytical quality control that is subject from time to time to checking by a person who is not under the control of the laboratory and who is approved by the competent authority for that purpose.

1. PARAMETERS FOR WHICH METHODS OF ANALYSIS ARE SPECIFIED

The following principles for methods of microbiological parameters are given either for reference whenever a CEN/ISO method is given or for guidance, pending the possible future adoption, in accordance with the procedure laid down in Article 12, of further CEN/ISO international methods for these parameters. Member States may use alternative methods, providing the provisions of Article 7(5) are met.

Coliform bacteria and *Escherichia coli (E. coli)* (ISO 9308-1)

Enterococci (ISO 7899-2)

Pseudomonas aeruginosa (prEN ISO 12780)

Enumeration of culturable microorganisms — Colony count 22 °C (prEN ISO 6222)

Enumeration of culturable microorganisms — Colony count 37 °C (prEN ISO 6222)

Clostridium perfringens (including spores)

Membrane filtration followed by anaerobic incubation of the membrane on m-CP agar (Note 1) at 44 ± 1 °C for 21 ± 3 hours. Count opaque yellow colonies that turn pink or red after exposure to ammonium hydroxide vapours for 20 to 30 seconds.

Note 1: The composition of m-CP agar is:

Basal medium

Tryptose	30 g
Yeast extract	20 g
Sucrose	5 g
L-cysteine hydrochloride	1 g
$MgSO_4 \cdot 7H_2O$	0,1 g
Bromocresol purple	40 mg
Agar	15 g
Water	1 000 ml

Dissolve the ingredients of the basal medium, adjust pH to 7,6 and autoclave at 121 °C for 15 minutes. Allow the medium to cool and add:

D-cycloserine	400 mg
Polymyxine-B sulphate	25 mg
Indoxyl-β-D-glucoside to be dissolved in 8 ml sterile water before addition	60 mg
Filter — sterilised 0,5% phenolphthalein diphosphate solution	20 ml
Filter — sterilised 4,5 % $FeCl_3 \cdot 6H_2O$	2 ml

2. PARAMETERS FOR WHICH PERFORMANCE CHARACTERISTICS ARE SPECIFIED

2.1. For the following parameters, the specified performance characteristics are that the method of analysis used must, as a minimum, be capable of measuring concentrations equal to the parametric value with a trueness, precision and limit of detection specified. Whatever the sensitivity of the method of analysis used, the result must be expressed using at least the same number of decimals as for the parametric value considered in Annex I, Parts B and C.

Parameters	Trueness % of parametric value (Note 1)	Precision % of parametric value (Note 2)	Limit of detection % of parametric value (Note 3)	Conditions	Notes
Acrylamide				To be controlled by product specification	
Aluminium	10	10	10		
Ammonium	10	10	10		
Antimony	25	25	25		
Arsenic	10	10	10		
Benzo(a)pyrene	25	25	25		
Benzene	25	25	25		
Boron	10	10	10		
Bromate	25	25	25		
Cadmium	10	10	10		
Chloride	10	10	10		
Chromium	10	10	10		
Conductivity	10	10	10		
Copper	10	10	10		
Cyanide	10	10	10		Note 4
1,2-dichloroethane	25	25	10		
Epichlorohydrin				To be controlled by product specification	
Fluoride	10	10	10		
Iron	10	10	10		
Lead	10	10	10		
Manganese	10	10	10		
Mercury	20	10	20		
Nickel	10	10	10		
Nitrate	10	10	10		
Nitrite	10	10	10		
Oxidisability	25	25	10		Note 5
Pesticides	25	25	25		Note 6
Polycyclic aromatic hydrocarbons	25	25	25		Note 7

Parameters	Trueness % of parametric value (Note 1)	Precision % of parametric value (Note 2)	Limit of detection % of parametric value (Note 3)	Conditions	Notes
Selenium	10	10	10		
Sodium	10	10	10		
Sulphate	10	10	10		
Tetrachloroethene	25	25	10		Note 8
Trichloroethene	25	25	10		Note 8
Trihalomethanes — Total	25	25	10		Note 7
Vinyl chloride				To be controlled by product specification	

2.2. For hydrogen ion concentration the specified performance characterisatics are that the method of analysis used must be capable of measuring concentrations equal to the parametric value with a trueness of 0,2 pH unit and a precision of 0,2 pH unit.

Note 1 (*): Trueness is the systematic error and is the difference between the mean value of the large number of repeated measurements and the true value.

Note 2 (*): Precision is the random error and is usually expressed as the standard deviation (within and between batch) of the spread of results about the mean. Acceptable precision is twice the relative standard deviation.

(*) These terms are further defined in ISO 5725.

Note 3: Limit of detection is either:

- three times the relative within batch standard deviation of a natural sample containing a low concentration of the parameter,

  or

- five times the relative within batch standard deviation of a blank sample.

Note 4: The method should determine total cyanide in all forms.

Note 5: Oxidation should be carried out for 10 minutes at 100 °C under acid conditions using permanganate.

Note 6: The performance characteristics apply to each individual pesticide and will depend on the pesticide concerned. The limit of detection may not be achievable for all pesticides at present, but Member States should strive to achieve this standard.

Note 7: The performance characteristics apply to the individual substances specified at 25 % of the parametric value in Annex I.

Note 8: The performance characteristics apply to the individual substances specified at 50 % of the parametric value in Annex I.

3. PARAMETERS FOR WHICH NO METHOD OF ANALYSIS IS SPECIFIED

Colour
Odour
Taste
Total organic carbon
Turbidity (Note 1)

Note 1: For turbidity monitoring in treated surface water the specified performance characteristics are that the method of analysis used must, as a minimum, be capable of measuring concentrations equal to the parametric value with a trueness of 25 %, precision of 25 % and a 25 % limit of detection.

ANNEX IV

DEADLINES FOR TRANSPOSITION INTO NATIONAL LAW AND FOR APPLICATION

Directive 80/778/EEC Transposition 17.7.1982 Application 17.7.1985 All Member States except Spain, Portugal and new *Länder* of Germany	Directive 81/858/EEC (Adaptation due to accession of Greece)	Act of Accession of Spain and Portugal Spain: transposition 1.1.1986 application 1.1.1986 Portugal: transposition 1.1.1986 application 1.1.1989	Directive 90/656/EEC for new *Länder* of Germany	Act of Accession of Austria, Finland and Sweden Austria: transposition 1.1.1995 application 1.1.1995 Finland: transposition 1.1.1995 application 1.1.1995 Sweden: transposition 1.1.1995 application 1.1.1995	Directive 91/692/EEC
Articles 1 to 14			Application 31.12.1995		
Article 15	Amended with effect from 1.1.1981	Amended with effect from 1.1.1986		Amended with effect from 1.1.1995	
Article 16					
Article 17					Article 17(a) inserted
Article 18					
Article 19		Amended	Amended		
Article 20					
Article 21					

ANNEX V

CORRELATION TABLE

This Directive	Directive 80/778/EEC
Article 1(1)	Article 1(1)
Article 1(2)	—
Article 2(1) (a) and (b)	Article 2
Article 2(2)	—
Article 3(1) (a) and (b)	Article 4(1)
Article 3(2) (a) and (b)	—
Article 3(3)	—
Article 4(1)	Article 7(6)
Article 4(2)	Article 11
Article 5(1)	Article 7(1)
Article 5(2) first sentence	Article 7(3)
Article 5(2) second sentence	—
Article 5(3)	—
Article 6(1)	Article 12(2)
Article 6(2) to (3)	—
Article 7(1)	Article 12(1)
Article 7(2)	—
Article 7(3)	Article 12(3)
Article 7(4)	—
Article 7(5)	Article 12(5)
Article 7(6)	—
Article 8	—
Article 9(1)	Article 9(1) and Article 10(1)
Article 9(2) to (6)	—
Article 9(7)	Article 9(2) and Article 10(3)
Article 9(8)	—
Article 10	Article 8

This Directive	Directive 80/778/EEC
Article 11(1)	—
Article 11(2)	Article 13
Article 12(1)	Article 14
Article 12(2) and (3)	Article 15
Article 13(1)	—
Article 13(2) to (5)	Article 17(a) (inserted by Directive 91/692/EEC)
Article 14	Article 19
Article 15	Article 20
Article 16	—
Article 17	Article 18
Article 18	—
Article 19	Article 21

Monthly Report

Name and number of FB:____

Contact person:____

1. Short description of monthly actions:_________________________________
   Max 100 characters
2. Installed Equipment:____
3. Investments:____
4. Parameters monitoring:____
5. System/Method employed:____
6. Obtained monitoring data:____
7. Encountered difficulties:____
   Max 100 characters
8. Annex: (tendering, datasheets, etc.)__________________________________

Water Loss Worksheet

A. Water Utility General Information

1. Water Utility Name: ____

2. Contact: Name ____

   Telephone# ___________________ Email Address _________________________________

3. Reporting Period: From _______/_______/________ to _______/_______/________

4. Source Water Utilization, percentage: Surface Water ________% Groundwater__________%

5. Population Served:

   a. Retail Population Served ________________

   b. Wholesale Population Served ________________

6. Utility's Length of Main Lines, km _________________

7. Number of Wholesale Connections Served _________________

8. Number of Retail Service Connections Served _________________

9. Service Connection Density _________________
   (Number of retail service connections/km of main lines)

10. Average Yearly System Operating Pressure (psi) _________________

11. Volume Units of Measure (m^3): _________________

B. System Input Volume

12. Water Volume from own Sources _________________

13. Wholesale Water Imported _________________

14. Wholesale Water Exported _________________

15. **System Input Volume** _________________
    (Corrected input volume, plus imported water, minus exported water)

C. Authorized Consumption

16. Billed Metered ________________

17. Billed Unmetered ________________

18. Unbilled Metered ________________

19. Unbilled Unmetered ________________

20. Total Authorized Consumption ________________

D. Water Losses

21. Water Losses ________________
(Line 15 minus Line 20)

E. Apparent Losses

22. Systematic Data Handling Discrepancy ________________

23. Unauthorized Consumption ________________

24. Total Apparent Losses ________________

F. Real Losses

25. Reported Breaks and Leaks ________________
(Estimated volume of leaks and breaks repaired during the audit period)

26. Unreported Loss ________________
(Includes all unknown water loss)

27. Total Real Losses ________________
(Line 25, plus Line 26)

28. Water Losses (Apparent + Real) ________________
(Line 24 plus Line 27) = Line 21

29. Non-revenue Water
(Water Losses + Unbilled Authorized Consumption) ________________
(Line 28, plus Line 18, plus Line 19)

G. Technical Performance Indicator for Apparent Loss

30.Apparent Losses Normalized
(Apparent Loss Volume/# of Retail Service
Connections/365) _______________

H. Technical Performance Indicators for Real Loss

31. Real Loss Volume *(Line 27)* _______________

32. Unavoidable Annual Real Losses, volume (calculated) _______________

33. Infrastructure Leakage Index (calculated) _______________
(Equals real loss volume divided by unavoidable annual real losses)

34. Real Losses Normalized
(Real Loss Volume/# of Service Connections/365) _______________
(This indicator applies if service connection density is greater than 32/km)

35. Real Losses Normalized
(Real Loss Volume/km of Main Lines/365) _______________
(This indicator applies if service connection density is less than 32/km)

I. Financial Performance Indicators

36. Total Apparent Losses *(Line 24)* _______________

37. Retail Price of Water _______________

38. Cost of Apparent Losses _______________
(Apparent loss volume multiplied by retail cost of water, Line 36 x Line 37)

39. Total Real Losses *(Line 27)* _______________

40. Variable Production Cost of Water* _______________
*(*Note: In case of water shortage, real losses might be valued at the retail price of water instead of the variable production cost.)*

41. Cost of Real Losses _______________
(Real loss multiplied by variable production cost of water, Line 39 x Line 40)

42. Total Cost Impact of Apparent and Real Losses _______________

Water Loss Worksheet Instructions

(All numbers used in this worksheet are for example purposes only)

The following instructions can be used in completing the Water Loss Worksheet. The instructions are labeled by line number shown on the worksheet. The Water Loss Worksheet requests that the water utility enter general information and water supply, consumption, and loss quantities.

A. Water Utility Information

1. **Water Utility Name:** List the formal name of the water utility for which the water audit exists.
2. **Contact:** List the name of the primary contact person responsible for completing the water audit for the water utility, the telephone number, and email address.
3. **Reporting Period:** Enter calendar year or fiscal year dates for the reporting period.
4. **Source Water Utilization:** Enter percentages to represent the proportions of surface water and groundwater withdrawn for source water supply. Remember that the total of the two percentages must equal 100%.
5. **Population Served:** List separately the retail and wholesale populations served. You may multiply the number of connections by three if needed to estimate the retail population.
6. **Utility's Length of Main Lines, km:** List the total length of pipeline in the water distribution system in km.
7. **Number of Wholesale Connections Served:** List the number of wholesale interconnections supplying water to other water utilities.
8. **Number of Retail Service Connections Served:** List the number of retail customer service connections served by the utility's water distribution system.
9. **Service Connection Density:** Calculate the service connection density by dividing the number of retail customer service connections by the length of miles of pipeline in the water distribution system.
10. **Average Yearly System Operating Pressure:** List the average pressure across the entire water distribution systems for the audit period. If a hydraulic model of the network exists, the average pressure can be calculated by the model; otherwise, an estimate can be used.
11. **Volume Units of Measure:** Select the volume units of measure for the water audit. The units must be consistent throughout the entire water audit. If choosing cubic meters for system input (from production meters), then authorized consumption (billed and unbilled) and all other entries must also be entered in cubic meters. This typically requires a conversion for billed metered consumption.

B. **System Input Volume:** The total water supplied to the infrastructure. It is the total of all production meter readings for the entire year.

12. **Water Volume from own Sources:** Includes all water taken as source water from permitted sources, such as rivers, lakes, streams, and wells.
13. **Wholesale Water Imported:** Amount of purchased wholesale water transferred into the utility's water distribution system from other water suppliers.
14. **Wholesale Water Exported:** Amount of wholesale water transferred out of the utility's distribution system. It may be put into the system initially but is only in the system for a brief time for conveyance reasons.
15. **System Input Volume:** Calculated as the corrected input volume plus water imported minus water exported (Line 14, plus Line 15, minus Line 16).

C. **Authorized Consumption:** All water that has been authorized for use or consumption by the utility or its customers. Remember to convert these volumes into the same units as the water delivery volume. Note: Any type of legitimate consumption should be classified in one of the four components of authorized consumption.

16. **Billed Metered:** All retail water sold and metered.
17. **Billed Unmetered:** All water sold but not metered.
18. **Unbilled Metered:** All water metered but not billed, such as back flushing water, parks, golf courses, and municipal government offices.
19. **Unbilled Unmetered:** All water not billed or metered, such as flushing fire hydrants.
20. **Total Authorized Consumption:** The total of the above four components, automatically calculated in the online worksheet.

D. **Water Losses:** Water delivered to the distribution system that does not appear as authorized consumption.

21. Calculated as the difference of the system input volume and total authorized consumption (Line 15 minus Line 20)

E. Apparent Losses: Water that has been consumed but not properly measured or billed. These losses represent under-registered or under-billed water that occurs via customer meter inaccuracy, systematic data handling error in the customer billing system, and unauthorized consumption:

22. **Systematic Data Handling Discrepancy:** List the estimated volume of water recorded by customer meters but distorted by meter reading or billing system error.
23. **Unauthorized Consumption (theft):** Estimate amount of water loss due to theft. Include an estimate of water taken illegally from fire hydrants, as well as water loss at the customer service connection. Theft at the customer connection can include tampering with meters or meter reading equipment, in addition to illegal taps and other similar occurrences.
24. **Total Apparent Losses:** This value is calculated automatically online as the sum of customer meter accuracy loss, systematic data handling error, and unauthorized consumption.

F. Real Losses: These are physical losses from the pressurized water distribution system, including water mains and all appurtenances (for example, valves and hydrants) and customer service connection piping. Real losses represent water that is lost from the distribution system prior to reaching the customer destination.

25. **Reported Breaks and Leaks:** Reported breaks and leaks are brought to the attention of the water utility by customers, public safety officials, other utilities, or other members of the general public. Usually these visible water main breaks are very disruptive and water utilities respond quickly to these events, so the run duration of the break or leak is relatively short. Estimate the total volume of water loss during the water audit period from reported breaks and leaks that were repaired during the year. Leakage flow rates must be estimated for various types of breaks and leaks, as well as the approximate duration of the breaks or leaks prior to repair.
26. **Unreported Loss:** This is a “catch-all” volume, meaning that this volume of real losses is the quantity that remains after authorized consumption, apparent losses, and reported leakage have been subtracted from the system input volume. In every water distribution system, even those employing effective active leakage control programs, there exists some amount of undetected leakage. Some of this loss is comprised of unreported leakage that has not yet been detected in leak surveys. It also includes a subcomponent known as background leakage, which is the collective weeps and seeps at pipe joints and on customer service connections that cannot be detected with acoustic sounding devices. Any degree of error in quantifying metered and estimated volumes in the water audit results in error in this component. As the validation of the water audit improves over time, so will the level of validation of the unreported loss volume.

27. **Total Real Losses:** This value is calculated automatically online as the sum of reported breaks and leaks and unreported loss.
28. **Water Losses:** Calculated as the sum of apparent losses and real losses. This value should equal the value of Line 21. This line is included as a balancing check.
29. **Non-revenue Water:** Calculated as the sum of apparent losses, plus real losses, plus unbilled metered consumption and unbilled unmetered consumption. This is the water that does not contribute to the water utility billings.

G. Technical Performance Indicator for Apparent Loss: Performance indicators are quantitative measures of key aspects within the utility. Using these indicators, the utility will have a history to track its performance from year to year. One performance indicator exists for apparent loss.

30. **Apparent Losses Normalized:** Calculated as the volume of apparent loss, divided by the number of retail customer service connections, divided by 365 days. This performance indicator allows for reliable performance tracking in the water utility's efforts to reduce apparent losses.

H. Technical Performance Indicator for Real Loss: Several performance indicators exist for real loss.

31. **Real Loss Volume:** This is the quantity from Line 27.
32. **Unavoidable Annual Real Losses:** This is a theoretical value of the technical low level of leakage that might be attained in a given water utility, based upon several system specific parameters.
33. **Infrastructure Leakage Index:** This performance indicator is calculated as the ratio of real losses over the unavoidable annual real losses. The index measures the water utility's leakage management effectiveness and is an excellent performance indicator for comparing performance among water utilities. The lower the value of the infrastructure leakage index, the closer the utility is operating to the theoretical low level of the unavoidable annual real loss.
34. **Real Losses Normalized:** Calculated as the real loss volume, divided by the number of retail service connections, divided by 365. Use this calculation if the service connection density is greater than, or equal to, 32 per km. This indicator allows for reliable performance tracking in the water utility's efforts to reduce real losses.
35. **Real Losses Normalized:** Calculated as the real loss volume, divided by the number of km of pipeline, divided by 365. Use this calculation if the service connection density is less than 32 per km. This indicator allows for reliable performance tracking in the water utility's efforts to reduce real losses.

I. Financial Performance Indicators

36. **Total Apparent Losses:** List the volume from line 24.
37. **Retail Price of Water:** Water utility rate structures usually feature multiple tiers of pricing based upon volume consumed. It is best to use a single composite price rate to represent the retail cost of water, which is used to place a value on the apparent losses. The largest number of accounts in most utilities is residential accounts; therefore, the residential pricing tier may be used in place of weighted calculations to determine a composite rate.
38. **Cost of Apparent Losses:** Calculated by multiplying the apparent loss volume by the retail price of water. This represents the potential amount of missed revenue due to apparent losses.
39. **Total Real Losses:** List the volume from line 27.
40. **Variable Production Cost of Water:** Marginal production cost including variable costs, which are typically the costs of raw water, energy, and chemicals. If applicable, the cost of raw water should include the price of take or pay contracts. These costs are applied to determine the cost impact of real losses. In cases of water shortage, real losses might be valued at the retail price of water instead of the variable production cost.
41. **Cost of Real Losses:** Calculated by multiplying the real loss volume by the variable production cost of water. These costs represent the additional operating costs incurred by the water utility due to the real losses (in other words, leakage).
42. **Total Cost Impact of Apparent and Real Losses:** Calculated by adding lines 38 and 41. This amount indicates the cost inefficiency encountered by the water utility for losses. This cost value can be objectively weighed against potential loss control programs to determine the cost effectiveness of such programs.

Guidelines for Drinking-water Quality

FOURTH EDITION

World Health Organization

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Contents

Preface

Access to safe drinking-water is essential to health, a basic human right and a component of effective policy for health protection.

The importance of water, sanitation and hygiene for health and development has been reflected in the outcomes of a series of international policy forums. These have included health-oriented conferences such as the International Conference on Primary Health Care, held in Alma-Ata, Kazakhstan (former Soviet Union), in 1978. They have also included water-oriented conferences such as the 1977 World Water Conference in Mar del Plata, Argentina, which launched the water supply and sanitation decade of 1981–1990, as well as the Millennium Development Goals adopted by the General Assembly of the United Nations (UN) in 2000 and the outcome of the Johannesburg World Summit for Sustainable Development in 2002. The UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action, "Water for Life". Most recently, the UN General Assembly declared safe and clean drinking-water and sanitation a human right essential to the full enjoyment of life and all other human rights.

Access to safe drinking-water is important as a health and development issue at national, regional and local levels. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, as the reductions in adverse health effects and health-care costs outweigh the costs of undertaking the interventions. This is true for investments ranging from major water supply infrastructure through to water treatment in the home. Experience has also shown that interventions in improving access to safe water favour the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies.

The World Health Organization (WHO) published three editions of the *Guidelines for drinking-water quality* in 1983–1984, 1993–1997 and 2004, as successors to previous WHO *International standards for drinking water*, published in 1958, 1963 and 1971. From 1995, the Guidelines have been kept up to date through a process of rolling revision, which leads to the regular publication of addenda that may add to or supersede information in previous volumes as well as expert reviews on key issues preparatory to the development of the Guidelines.

Leading the process of the development of the fourth edition was the Water, Sanitation, Hygiene and Health Unit within WHO Headquarters, with the Programme on

Chemical Safety providing input on chemical hazards and the Radiation and Environmental Health Unit providing input on radiological hazards. All six WHO Regional Offices participated in the process, in consultation with Member States.

This edition of the *Guidelines for drinking-water quality* integrates the third edition, which was published in 2004, with both the first addendum to the third edition, published in 2006, and the second addendum to the third edition, published in 2008. It supersedes previous editions of the Guidelines and previous International Standards.

This edition of the Guidelines further develops concepts, approaches and information introduced in previous editions, including the comprehensive preventive risk management approach for ensuring drinking-water quality that was introduced in the third edition. It considers:

- drinking-water safety, including minimum procedures and specific guideline values and how these are intended to be used;
- approaches used in deriving the Guidelines, including guideline values;
- microbial hazards, which continue to be the primary concern in both developing and developed countries. Experience has shown the value of a systematic approach to securing microbial safety. This edition builds on the preventive principles introduced in the third edition on ensuring the microbial safety of drinking-water through a multiple-barrier approach, highlighting the importance of source water protection;
- climate change, which results in changing water temperature and rainfall patterns, severe and prolonged drought or increased flooding, and its implications for water quality and water scarcity, recognizing the importance of managing these impacts as part of water management strategies;
- chemical contaminants in drinking-water, including information on chemicals not considered previously, such as pesticides used for vector control in drinking-water; revisions of existing chemical fact sheets, taking account of new scientific information; and, in some cases, reduced coverage in the Guidelines where new information suggests a lesser priority;
- those key chemicals responsible for large-scale health effects through drinking-water exposure, including arsenic, fluoride, lead, nitrate, selenium and uranium, providing guidance on identifying local priorities and on management;
- the important roles of many different stakeholders in ensuring drinking-water safety. This edition furthers the discussion introduced in the third edition of the roles and responsibilities of key stakeholders in ensuring drinking-water safety;
- guidance in situations other than traditional community supplies or managed utilities, such as rainwater harvesting and other non-piped supplies or dual piped systems.

This edition of the Guidelines is accompanied by a series of supporting publications. These include internationally peer-reviewed risk assessments for specific chemicals (see list of chapter 12 background documents in Annex 2) and other publications explaining the scientific basis of the development of the Guidelines and providing guidance on good practice in their implementation (see Annex 1). The *Guidelines* *for drinking-water quality Volume 3—Surveillance and control of community supplies* (1997) provides guidance on good practice in surveillance, monitoring and assessment of drinking-water quality in community supplies.

The Guidelines are addressed primarily to water and health regulators, policy-makers and their advisors, to assist in the development of national standards. The Guidelines and associated documents are also used by many others as a source of information on water quality and health and on effective management approaches.

The Guidelines are recognized as representing the position of the UN system on issues of drinking-water quality and health by "UN-Water", the body that coordinates among the 24 UN agencies and programmes concerned with water issues.

ANNEX 3

Chemical summary tables

Table A3.1 Chemicals excluded from guideline value derivation

Chemical	Reason for exclusion
Amitraz	Degrades rapidly in the environment and is not expected to occur at measurable concentrations in drinking-water supplies
Chlorobenzilate	Unlikely to occur in drinking-water
Chlorothalonil	Unlikely to occur in drinking-water
Cypermethrin	Unlikely to occur in drinking-water
Deltamethrin	Unlikely to occur in drinking-water
Diazinon	Unlikely to occur in drinking-water
Dinoseb	Unlikely to occur in drinking-water
Ethylene thiourea	Unlikely to occur in drinking-water
Fenamiphos	Unlikely to occur in drinking-water
Formothion	Unlikely to occur in drinking-water
Hexachlorocyclohexanes (mixed isomers)	Unlikely to occur in drinking-water
MCPB[a]	Unlikely to occur in drinking-water
Methamidophos	Unlikely to occur in drinking-water
Methomyl	Unlikely to occur in drinking-water
Mirex	Unlikely to occur in drinking-water
Monocrotophos	Has been withdrawn from use in many countries and is unlikely to occur in drinking-water
Oxamyl	Unlikely to occur in drinking-water
Phorate	Unlikely to occur in drinking-water
Propoxur	Unlikely to occur in drinking-water
Pyridate	Not persistent and only rarely found in drinking-water
Quintozene	Unlikely to occur in drinking-water
Toxaphene	Unlikely to occur in drinking-water
Triazophos	Unlikely to occur in drinking-water
Tributyltin oxide	Unlikely to occur in drinking-water
Trichlorfon	Unlikely to occur in drinking-water

[a] 4-(4-chloro-o-tolyloxy)butyric acid.

Table A3.2 Chemicals for which guideline values have not been established

Chemical	Reason for not establishing a guideline value
Aluminium	A health-based value of 0.9 mg/l could be derived, but this value exceeds practicable levels based on optimization of the coagulation process in drinking-water plants using aluminium-based coagulants: 0.1 mg/l or less in large water treatment facilities and 0.2 mg/l or less in small facilities
Ammonia	Occurs in drinking-water at concentrations well below those of health concern
Asbestos	No consistent evidence that ingested asbestos is hazardous to health
Bentazone	Occurs in drinking-water at concentrations well below those of health concern
Beryllium	Rarely found in drinking-water at concentrations of health concern
Bromide	Occurs in drinking-water at concentrations well below those of health concern
Bromochloroacetate	Available data inadequate to permit derivation of health-based guideline value
Bromochloroacetonitrile	Available data inadequate to permit derivation of health-based guideline value
Bacillus thuringiensis israelensis (Bti)	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Carbaryl	Occurs in drinking-water at concentrations well below those of health concern
Chloral hydrate	Occurs in drinking-water at concentrations well below those of health concern
Chloride	Not of health concern at levels found in drinking-water[a]
Chlorine dioxide	Rapidly breaks down to chlorite, and chlorite provisional guideline value is adequately protective for potential toxicity from chlorine dioxide
Chloroacetones	Available data inadequate to permit derivation of health-based guideline values for any of the chloroacetones
2-Chlorophenol	Available data inadequate to permit derivation of health-based guideline value
Chloropicrin	Available data inadequate to permit derivation of health-based guideline value
Cyanide	Occurs in drinking-water at concentrations well below those of health concern, except in emergency situations following a spill to a water source
Cyanogen chloride	Occurs in drinking-water at concentrations well below those of health concern
Dialkyltins	Available data inadequate to permit derivation of health-based guideline values for any of the dialkyltins
Dibromoacetate	Available data inadequate to permit derivation of health-based guideline value

Table A3.2 (continued)

Chemical	Reason for not establishing a guideline value
Dichloramine	Available data inadequate to permit derivation of health-based guideline value
1,3-Dichlorobenzene	Available data inadequate to permit derivation of health-based guideline value
1,1-Dichloroethane	Available data inadequate to permit derivation of health-based guideline value
1,1-Dichloroethene	Occurs in drinking-water at concentrations well below those of health concern
2,4-Dichlorophenol	Available data inadequate to permit derivation of health-based guideline value
1,3-Dichloropropane	Available data inadequate to permit derivation of health-based guideline value
Di(2-ethylhexyl)adipate	Occurs in drinking-water at concentrations well below those of health concern
Diflubenzuron	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Diquat	May be used as an aquatic herbicide for the control of free-floating and submerged aquatic weeds in ponds, lakes and irrigation ditches, but rarely found in drinking-water
Endosulfan	Occurs in drinking-water at concentrations well below those of health concern
Fenitrothion	Occurs in drinking-water at concentrations well below those of health concern
Fluoranthene	Occurs in drinking-water at concentrations well below those of health concern
Formaldehyde	Occurs in drinking-water at concentrations well below those of health concern
Glyphosate and AMPA[b]	Occur in drinking-water at concentrations well below those of health concern
Hardness	Not of health concern at levels found in drinking-water[a]
Heptachlor and heptachlor epoxide	Occur in drinking-water at concentrations well below those of health concern
Hexachlorobenzene	Occurs in drinking-water at concentrations well below those of health concern
Hydrogen sulfide	Not of health concern at levels found in drinking-water[a]
Inorganic tin	Occurs in drinking-water at concentrations well below those of health concern
Iodine	Available data inadequate to permit derivation of health-based guideline value, and lifetime exposure to iodine through water disinfection is unlikely
Iron	Not of health concern at levels causing acceptability problems in drinking-water[a]
Malathion	Occurs in drinking-water at concentrations well below those of health concern

Table A3.2 (continued)

Chemical	Reason for not establishing a guideline value
Manganese	Not of health concern at levels causing acceptability problems in drinking-water[a]
Methoprene	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Methyl parathion	Occurs in drinking-water at concentrations well below those of health concern
Methyl *tertiary*-butyl ether (MTBE)	Any guideline that would be derived would be significantly higher than concentrations at which MTBE would be detected by odour
Molybdenum	Occurs in drinking-water at concentrations well below those of health concern
Monobromoacetate	Available data inadequate to permit derivation of health-based guideline value
Monochlorobenzene	Occurs in drinking-water at concentrations well below those of health concern, and health-based value would far exceed lowest reported taste and odour threshold
MX	Occurs in drinking-water at concentrations well below those of health concern
Nitrobenzene	Rarely found in drinking-water at concentrations of health concern
Novaluron	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Parathion	Occurs in drinking-water at concentrations well below those of health concern
Permethrin	Not recommended for direct addition to drinking-water as part of WHO's policy to exclude the use of any pyrethroids for larviciding of mosquito vectors of human disease
Petroleum products	Taste and odour will in most cases be detectable at concentrations below those of health concern, particularly with short-term exposure
pH	Not of health concern at levels found in drinking-water[c]
2-Phenylphenol and its sodium salt	Occurs in drinking-water at concentrations well below those of health concern
Pirimiphos-methyl	Not recommended for direct application to drinking-water unless no other effective and safe treatments are available
Potassium	Occurs in drinking-water at concentrations well below those of health concern
Propanil	Readily transformed into metabolites that are more toxic; a guideline value for the parent compound is considered inappropriate, and there are inadequate data to enable the derivation of guideline values for the metabolites
Pyriproxyfen	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Silver	Available data inadequate to permit derivation of health-based guideline value
Sodium	Not of health concern at levels found in drinking-water[a]

Table A3.2 (continued)

Chemical	Reason for not establishing a guideline value
Spinosad	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Sulfate	Not of health concern at levels found in drinking-water[a]
Temephos	Not considered appropriate to set guideline values for pesticides used for vector control in drinking-water
Total dissolved solids	Not of health concern at levels found in drinking-water[a]
Trichloramine	Available data inadequate to permit derivation of health-based guideline value
Trichloroacetonitrile	Available data inadequate to permit derivation of health-based guideline value
Trichlorobenzenes (total)	Occur in drinking-water at concentrations well below those of health concern, and health-based value would exceed lowest reported odour threshold
1,1,1-Trichloroethane	Occurs in drinking-water at concentrations well below those of health concern
Zinc	Not of health concern at levels found in drinking-water[a]

[a] May affect acceptability of drinking-water (see chapter 10).
[b] Aminomethylphosphonic acid.
[c] An important operational water quality parameter.

Table A3.3 Guideline values for chemicals that are of health significance in drinking-water

	Guideline value		
Chemical	mg/l	µg/l	Remarks
Acrylamide	0.000 5[a]	0.5[a]	
Alachlor	0.02[a]	20[a]	
Aldicarb	0.01	10	Applies to aldicarb sulfoxide and aldicarb sulfone
Aldrin and dieldrin	0.000 03	0.03	For combined aldrin plus dieldrin
Antimony	0.02	20	
Arsenic	0.01 (A,T)	10 (A,T)	
Atrazine and its chloro-*s*-triazine metabolites	0.1	100	
Barium	0.7	700	
Benzene	0.01[a]	10[a]	
Benzo[*a*]pyrene	0.000 7[a]	0.7[a]	
Boron	2.4	2 400	
Bromate	0.01[a] (A,T)	10[a] (A,T)	
Bromodichloromethane	0.06[a]	60[a]	
Bromoform	0.1	100	
Cadmium	0.003	3	
Carbofuran	0.007	7	
Carbon tetrachloride	0.004	4	

Table A3.3 (continued)

Chemical	Guideline value mg/l	Guideline value µg/l	Remarks
Chlorate	0.7 (D)	700 (D)	
Chlordane	0.000 2	0.2	
Chlorine	5 (C)	5 000 (C)	For effective disinfection, there should be a residual concentration of free chlorine of ≥ 0.5 mg/l after at least 30 min contact time at pH < 8.0. A chlorine residual should be maintained throughout the distribution system. At the point of delivery, the minimum residual concentration of free chlorine should be 0.2 mg/l.
Chlorite	0.7 (D)	700 (D)	
Chloroform	0.3	300	
Chlorotoluron	0.03	30	
Chlorpyrifos	0.03	30	
Chromium	0.05 (P)	50 (P)	For total chromium
Copper	2	2 000	Staining of laundry and sanitary ware may occur below guideline value
Cyanazine	0.000 6	0.6	
2,4-D[b]	0.03	30	Applies to free acid
2,4-DB[c]	0.09	90	
DDT[d] and metabolites	0.001	1	
Dibromoacetonitrile	0.07	70	
Dibromochloromethane	0.1	100	
1,2-Dibromo-3-chloropropane	0.001[a]	1[a]	
1,2-Dibromoethane	0.000 4[a] (P)	0.4[a] (P)	
Dichloroacetate	0.05[a] (D)	50[a] (D)	
Dichloroacetonitrile	0.02 (P)	20 (P)	
1,2-Dichlorobenzene	1 (C)	1 000 (C)	
1,4-Dichlorobenzene	0.3 (C)	300 (C)	
1,2-Dichloroethane	0.03[a]	30[a]	
1,2-Dichloroethene	0.05	50	
Dichloromethane	0.02	20	
1,2-Dichloropropane	0.04 (P)	40 (P)	
1,3-Dichloropropene	0.02[a]	20[a]	
Dichlorprop	0.1	100	
Di(2-ethylhexyl)phthalate	0.008	8	
Dimethoate	0.006	6	
1,4-Dioxane	0.05[a]	50[a]	Derived using tolerable daily intake approach as well as linearized multistage modelling

Table A3.3 (continued)

	Guideline value		
Chemical	**mg/l**	**µg/l**	**Remarks**
Edetic acid	0.6	600	Applies to the free acid
Endrin	0.000 6	0.6	
Epichlorohydrin	0.000 4 (P)	0.4 (P)	
Ethylbenzene	0.3 (C)	300 (C)	
Fenoprop	0.009	9	
Fluoride	1.5	1 500	Volume of water consumed and intake from other sources should be considered when setting national standards
Hexachlorobutadiene	0.000 6	0.6	
Hydroxyatrazine	0.2	200	Atrazine metabolite
Isoproturon	0.009	9	
Lead	0.01 (A,T)	10 (A,T)	
Lindane	0.002	2	
MCPA[e]	0.002	2	
Mecoprop	0.01	10	
Mercury	0.006	6	For inorganic mercury
Methoxychlor	0.02	20	
Metolachlor	0.01	10	
Microcystin-LR	0.001 (P)	1 (P)	For total microcystin-LR (free plus cell-bound)
Molinate	0.006	6	
Monochloramine	3	3 000	
Monochloroacetate	0.02	20	
Nickel	0.07	70	
Nitrate (as NO_3^-)	50	50 000	Short-term exposure
Nitrilotriacetic acid	0.2	200	
Nitrite (as NO_2^-)	3	3 000	Short-term exposure
N-Nitrosodimethylamine	0.000 1	0.1	
Pendimethalin	0.02	20	
Pentachlorophenol	0.009[a] (P)	9[a] (P)	
Selenium	0.04 (P)	40 (P)	
Simazine	0.002	2	
Sodium dichloroisocyanurate	50	50 000	As sodium dichloroisocyanurate
	40	40 000	As cyanuric acid
Styrene	0.02 (C)	20 (C)	
2,4,5-T[f]	0.009	9	
Terbuthylazine	0.007	7	
Tetrachloroethene	0.04	40	

Chemical	Guideline value		Remarks
	mg/l	µg/l	
Simazine	0.002	2	
Sodium dichloroisocyanurate	50	50 000	As sodium dichloroisocyanurate
	40	40 000	As cyanuric acid
Styrene	0.02 (C)	20 (C)	
2,4,5-T[f]	0.009	9	
Terbuthylazine	0.007	7	
Tetrachloroethene	0.04	40	
Toluene	0.7 (C)	700 (C)	
Trichloroacetate	0.2	200	
Trichloroethene	0.02 (P)	20 (P)	
2,4,6-Trichlorophenol	0.2[a] (C)	200[a] (C)	
Trifluralin	0.02	20	
Trihalomethanes			The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
Uranium	0.03 (P)	30 (P)	Only chemical aspects of uranium addressed
Vinyl chloride	0.0003[a]	0.3[a]	
Xylenes	0.5 (C)	500 (C)	

A, provisional guideline value because calculated guideline value is below the achievable quantification level; C, concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, leading to consumer complaints; D, provisional guideline value because disinfection is likely to result in the guideline value being exceeded; P, provisional guideline value because of uncertainties in the health database; T, provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.

[a] For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an upper-bound excess lifetime cancer risk of 10^{-5} (one additional case of cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with upper-bound estimated excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

[b] 2,4-Dichlorophenoxyacetic acid.

[c] 2,4-Dichlorophenoxybutyric acid.

[d] Dichlorodiphenyltrichlorethane.

[e] 4-(2-Methyl-4-chlorophenoxy)acetic acid.