REPUBLIC OF MOLDOVA

APA CANAL CHISINAU

CHISINAU WATER SUPPLY & SEWAGE TREATMENT - FEASIBILITY STUDY

NETWORK OPERATION RECOMMENDATIONS - FINAL

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LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Apa Canal Chisinau
CSD	Customer Service Department
CST	Central Storehouse
DW	Drinking Water
HDPE	High-Density Polyethylene
IR	Inception Report
LLI	Linear Leakage Index
LRI	Linear Repair Index
TLIP	Long Term Investment Programme
MDL	Moldovan Leu
ND	Nominal Diameter
PIP	Priority Investment Programme
ToR	Terms of Reference
WW	Waste Water
WWTP	Wastewater Treatment Plant

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1. INTRODUCTION

1.1. Overall Objective of Phase A8

A requirement of the Terms of Reference for the contract is Phase A.8 "*Assessment of and Proposal for Emergency Repair Requirements" within which "The Consultant shall carry out an Assessment of Emergency Repair Requirements and propose a short-term strategy for an Emergency Repair Programme to ensure operation of water supply and sewage collection for 12-24 months until start of Phase I of the investment programme*."0

In order to meet the requirements of the ToR, the following tasks have been performed:

1. provide ACC with an Emergency Response Plan;
2. prepare an Audit of the existing ACC emergency procedures;
3. prepare a list of fittings and hydraulic equipment to be used for emergency repair for the next 6-12 months;
4. draw up an initial list of priority "emergency" investments to that should be done to ensure the operation of the water supply and wastewater collection systems.

1.2. Objective of the Report

The above mentioned points 1, 2 and 4 have been covered in a separate report, submitted in draft version on November 2011.

The present report completes the first one by presenting an assessment of the current practices within ACC in terms of networks management. It goes even further as it also provides recommendations for best practices, equipment need, and storage of repair pieces.

This task has been performed based on our knowledge of the existing system, on the inventory of breaks, bursts, leaks, … and in conjunction with ACC operational staff who know the critical mains and sewers. Indeed, several meetings have been held with ACC operational staff, and from their experience of emergencies, the vulnerable elements within the existing systems/structures and the way to deal with emergencies were identified. A list of fittings and hydraulic equipment to be used for emergency repair must be prepared. It corresponds more or less to the stock that should be available in the storehouse of ACC. Rough cost estimates have been assessed and are provided.

2. GENERAL ORGANISATION OF OPERATION DELIVERY

An assessment of the general organisation of network management is provided in the following chapter. It is also based of the Organisation Analysis Report presented in the IR.

2.1. General Organisation

2.1.1. Overview

All the operations on the water supply and wastewater collection systems are entrusted to the Technical and Production Directorate (TPD) of ACC. The current organisational chart is provided below with comments.

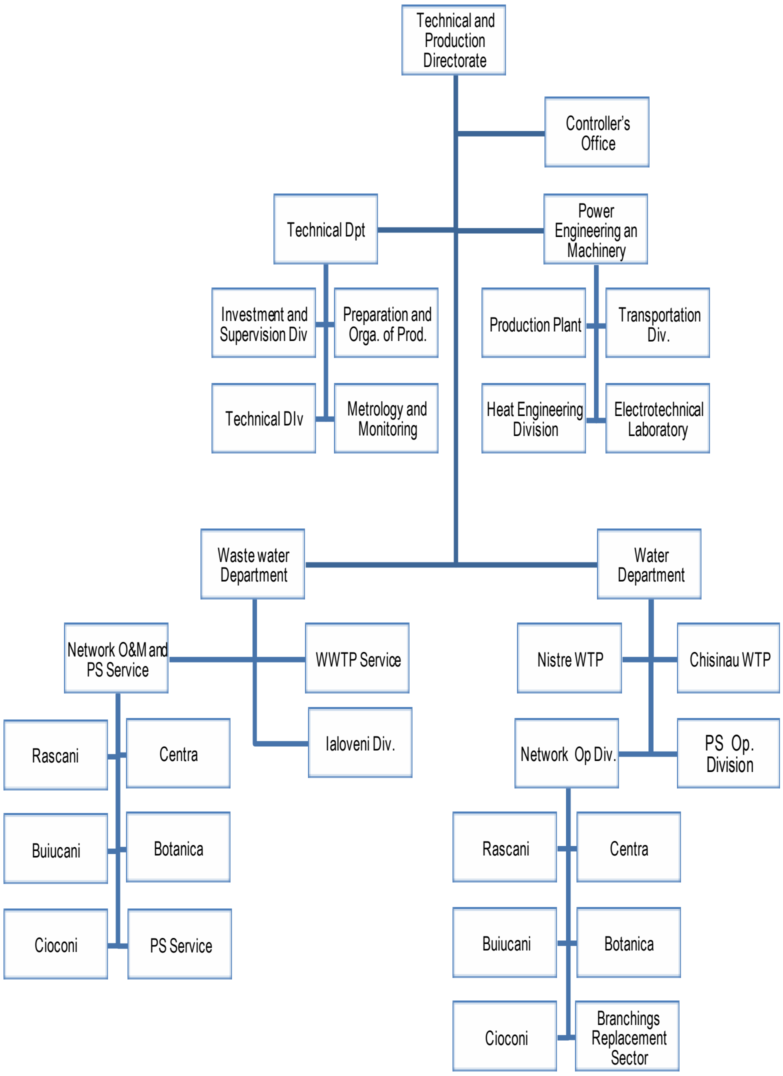


Figure 1: Organizational chart of Technical and Production Directorate

This organization chart shows a classic organization by function by opposition with an organization by division where every division hosts each functions. This type of organization is classic in Eastern Europe countries and can be summarized in three words: centralization, verticality and organized in silos.

Remark: It is worth noting there that the only exception to this scheme is the Ialoveni Division hosted by the Waste water Department. There the Director[1] is in charge of operations in both drinking water and waste water.

2.1.2. GEOGRAPHICAL ORGANISATION AND AREA OF ACTIVITY

Departments within the TPD are spread out in Chisinau. Offices are mainly implemented on plots with technical installations (pumping station, DWTP or WWTP).

The area of activity of ACC is larger than Chisinau city itself it covers several villages and small cities around Chisinau.

The following figures show the location of each Department within Chisinau and its vicinity and the area of activity of ACC:

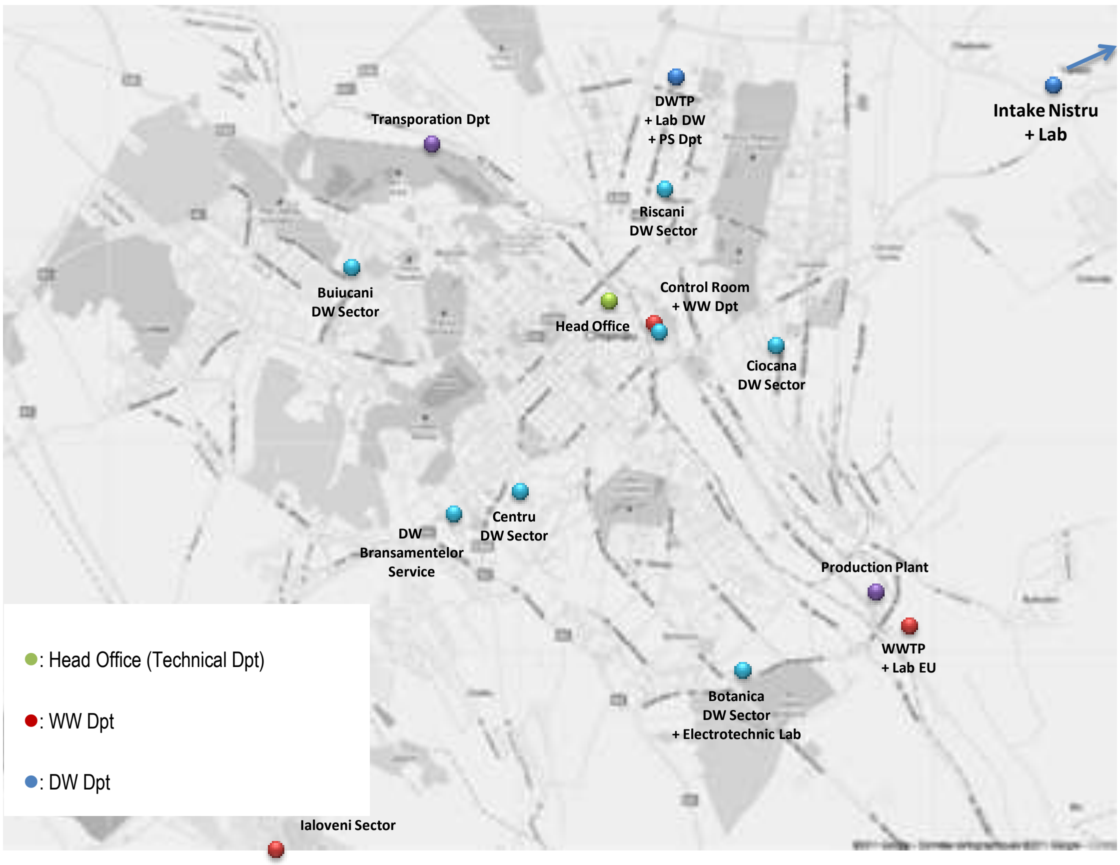


Figure 2: Locations of Departments within Chisinau

[1] This function is ensured directly by the Director of the Waste water Department.

As shown on the figure above, the only teams spread in Chisinau are the ones in charge of operations on the water network. In opposition to this, even if they are organised by sector, the teams in charge of waste water network are located in the same building in the centre of Chisinau.

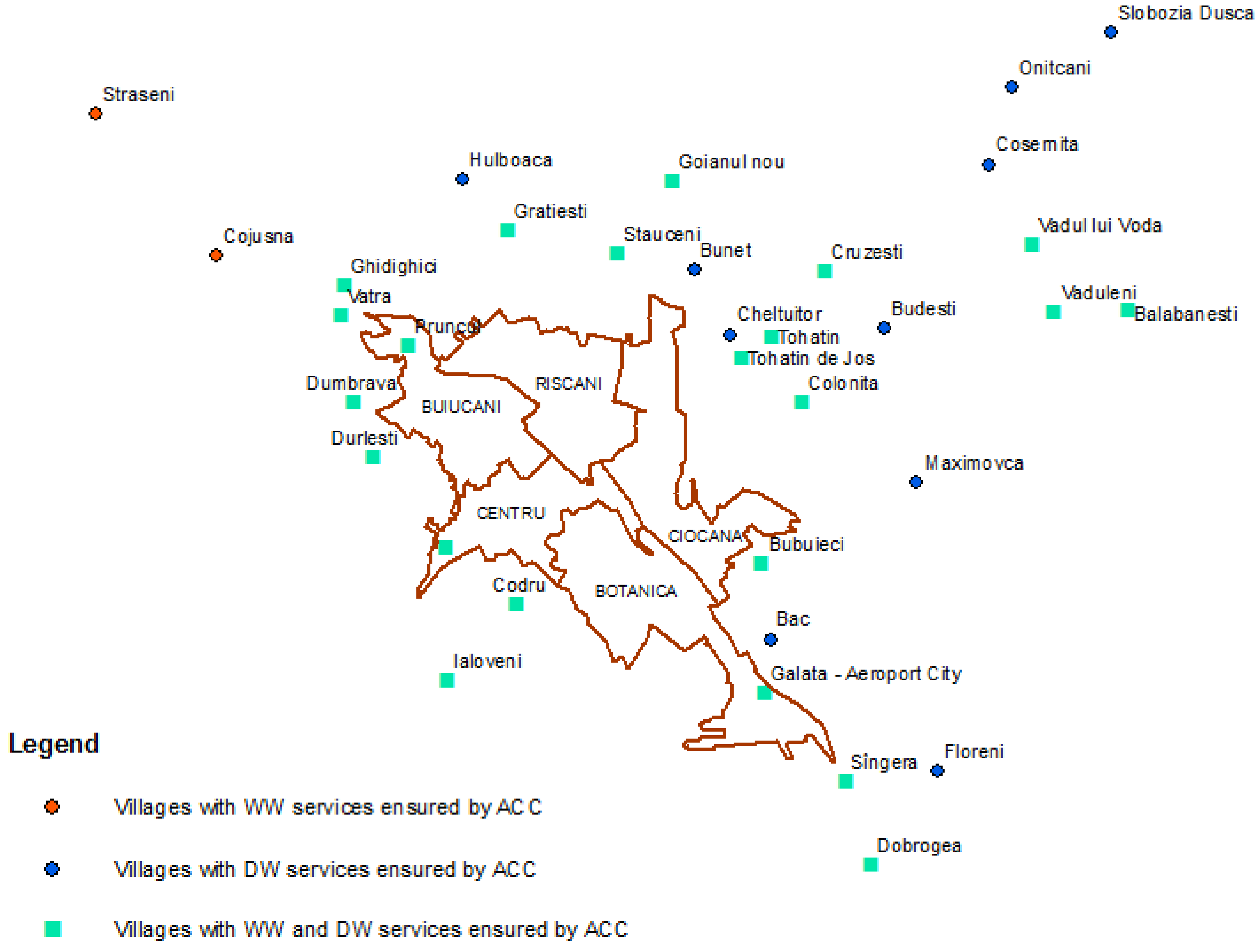


Figure 3: Perimeter of activity of ACC

Except Ialoveni, every village is entrusted to the nearest sector.

2.1.3. SERVICES ACTIVITIES

Activities and responsibilities are set for each service within the Quality Management documents. The following table summarized activities and responsibilities of each service within ACC:

Table 1: Services activities and staff (2010)

Department and Service	Main Activity(ies)	Staff	Type of staff
Technical Dpt		**47**	**-**
Investment and Supervision Div	Monitor subcontracted works Work with the Municipality on its investment budget Prepare investment plans on the network (Ø>200mm => investment = CAPEX /w depreciation)	8	Engineer Economist
Preparation and Orga. of Prod.	Plan common repairs on the network (Ø<200mm => common repairs = OPEX) according to sectors and clients claims	10	Engineer
Technical Div	Work on technical conditions for new projects (service lines, extension.…)	17	Engineer

Department and Service	Main Activity(ies)	Staff	Type of staff
	Perform fixed asset inventory and registration Manage technical library		
Metrology and Monitoring	Ensure accuracy and maintenance of metrology devices	12	Engineer Locksmith Storekeeper Economist
Water Department		**592**	
Nistre WTP	Operate intake and WTP	161	Engineer Economist Worker[2] Driver Dispatcher
Chisinau WTP	Operate WTP	65	Engineer Economist Dispatcher
Network Op Div.	-	208	Engineer Economist Dispatcher
• Sector (x5)	Operate and maintain valves Repair identified leaks Ensure the relation with the Municipality	-	Team Leader[3] Worker Operator
• Service Line Division	Execute internal works within the investment plant in every sector Execute works on service lines in every sector	-	Team Leader Worker
PS Op. Division • Borehole pumps Service • Big pumps Service • “Hydrofore” service	Monitor (manually) pumps functioning Send monitored data to Controller’s Office (every hour) Operate pumps (start, stop, switch, etc.) Ensure common maintenance and upkeep Ensure planned maintenance every 6 months Manage reservoirs Clean reservoirs once a year	158	Engineer Economist Technician Storekeeper
Waste water Department		**320**	
Network O&M and PS Service	-	142	Engineer Economist
• Sector (x5)	Deal with blockages (manually and with specialized machinery) Execute repairs on the network Ensure the relation with the Municipality	-	Team Leader Worker
• PS Div.	Monitor (manually) pumps functioning Send monitored data to Controller’s Office (every hour) Operate pumps (start, stop, switch, etc.) Ensure common maintenance and upkeep Ensure planned maintenance every 6 months Execute small works on pipes	-	Electrician Engineer Electrician
WWTP Service	Operate WWTP	134	Engineer Economist Head of Process Operator
Ialoveni Div.	Operate waste water and drinking water system Ensure the relation with the Municipality	44	Engineer Team Leader Dispatcher
Customer Service Department		**75**	
(Controllers Office)	Receive and manage technical claims from customers Collect all data from staff on installations Coordinate operations on pumping stations Plan operations on pumping stations Collect data from teams about repairs on networks Perform the first diagnosis on networks (WW and DW) Operate valves for some water cuts		Engineer Dispatcher Operator Electrician Welder Locksmith

[2] The term used for worker is Brigadier

[3] The term used for team leader is Master

Department and Service	Main Activity(ies)	Staff	Type of staff
	Eliminate (manually) small blockage on WW network Inform and coordinate on field teams for network repair Coordinate and allocate plants to on-field team Perform leak detection planned campaigns (3 persons)		
Power Engineering an Machinery	-	**448**	Engineer
Production Plant	-	194	Engineer Economist
• Repair and Construction Service	Ensure civil engineering operations Work on network pipes (up to 30 m and/or 400 mm)	69	Head of site
• Electromechanic Service	Perform heavy maintenance on pumps (on site or at workshop such as recoiling)	29	Engineer
• Mechanism Service	*Manage heavy machineries (e.g. excavator) pool* *Operate heavy machineries (e.g. excavator) on field*	82	Engineer Dispatcher
Transportation Div.	*Manage vehicles pool* *Drive vehicles* *Repair vehicles*	194	Engineer Economist Mechanic Dispatcher Storekeeper Technician Driver
Heat Engineering Division	Operate 3 heating systems	48	Engineer Economist Dispatcher
Electrotechnical Laboratory	Repair and control cathodic protection of network Operate electrical installation	12	Engineer Technician

<u>Remark:</u> it has to be noticed the presence of the Heat Engineering Division which is not part of the core business of ACC. It is worth reminding that this activity was given to ACC for the payment of an old debt. However, this activity was said to be not profitable.

2.1.4. SHORTCOMING

Concerning organisation, there are PROS and CONS in each main types of organization (by function and by division). They are illustrated in the following table:

Table 2: PROS and CONS for each type of organization

	Type of division	PROS	CONS
Structure by function <u>as ACC</u>	Specialized by function	• Clarity • Concentration of resources • Economy of scale • Development of specialized skills	• Highly centralized • Difficult transversal coordination and communication • Relative inertia
Structure with division	Divided according to: • Strategic business unit • Products • Market • Geographical area	• Decentralized structures • Efficient coordination within each activity • Easily adaptable structure	• Scattered resources • Diseconomy of scale • Difficult development of specialized skills

Concerning ACC, its vertical and activity oriented organization shows the classical limits of the above table:

- There are few transversal communications even in teams working in the same sectors. This situation is intensified by the fact that WW and DW teams are not in the same building for one sector.
- The strong centralization of ACC is illustrated by a very powerful Customer Service Department, also called "Dispecerat", that can be seen as the "brain" of the operations on the network. The knowledge and management are done here, which leaves the operational teams with very few responsibilities.
- The concentration of resources and the economy of scale are real in ACC. However, it is hard to see if it is a constraint or a will.

Experience shows that there is no universal ideal structure for one type of business or activity. Things are far more complex. And, in many ways, in terms network operations, ACC does respond very effectively to its main issues: deal with bursts on DW network and clean out blockages on WW network.

Theoretically, an organisation can be seen either (1) as a response to the constraints of the environment or (2) as a construction to deliver a product or a service. ACC better fits with the (1).

2.1.5. RECOMMENDATIONS

In terms of organisation, short terms adjustments can be made to achieve specific goals without modifying the principles of current organization. Suggestions of evolution to achieve each goal are suggested below:

- Organisation principles are maintained:
  - Subdivision in sectors should be kept at the bottom of the organization to deal with emergencies.
  - Separation between DW and WW department should be maintained
- First consolidation of sectors into three bigger branches could be studied:
  - Sector 1: Riscani + Ciocana + villages (east of Chisinau)
  - Sector 2: Centru + Buiucani + villages (north west of Chisinau)
  - Sector 3: Botanica + (Ialoveni) + villages (south of Chisinau)
- New preventives operations must be organised at a central level and should become the added value of each service (drinking water and waste water):
  - Leakage detection teams (from CSD to DW network operations division)
  - Replacement of connections and small diameters pipes
  - Preventive cleaning of waste water network
  - Video-inspection of black spots on the waste water network
- Limited reallocation of operational staffs from one service to another

A full reorganisation involving major changes in the fundamental principles of the current organisation should be triggered at a further horizon. It should be "powerful" enough to get the adhesion of the managers and staffs as a shift in organisation is generally accompanied with human resources changes (staff reallocation, new skills development, etc.), implementation of a new MIS, investment in new equipment, etc. that require the adhesion of the whole company.

2.2. THE CENTRAL DISPATCHING SERVICE (CSD)

2.2.1. OVERVIEW

The Central Dispatching Servce receives all customers' calls for technical issues. It is composed by an office team and an on-field team, operating 24 hours – 7 days a week.

Table 3: Teams organization for operations on DW network

Department and Service	Teams organization	Staff	Key figures
Central Dispatching Service	-	**75**	-
Office team	8am-8pm: 3 operators (2 DW + 1 WW), 2 dispatchers (1 DW + 1WW) and 1 engineer 8pm-8am: 1 dispatcher and 1 engineer Total: 3 teams	-	-
On field team	8am-8pm: 4 teams (2 DW + 2 WW) x 2 staffs (1 driver + 1 technician) 8pm-8am: 3 teams (2 DW + 1 WW) x 2 staffs (1 driver + 1 technician) 8am-8pm: 1 team collecting information for the electronic map The regime duty team Total: 9 teams x 2 staffs FTE (16 teams in total)	-	1,700 km DW 14,000 bursts DW 950 km WW 28,900 inter. WW

The office team:

- Receive and manage technical claims from customers
- Collect all data from staff on installations
- Coordinate operations on pumping stations
- Plan operations on pumping stations
- Collect data from teams about repairs on networks

The on-field team:

- Perform the first diagnosis on networks (WW and DW)
- Operate valves for some water cuts
- Eliminate (manually) small blockage on WW network
- Inform and coordinate on field teams for network repair
- Coordinate and allocate plants to on-field team

- Perform leak detection planned campaigns (1 1 team). In practice, the leak detection is nearly fully used to assist Operation in locating hidden leaks, and not to perform preventive and planned leak detection.

2.2.2. PROCEDURE TO DEAL WITH NETWORK EMERGENCIES

So, all emergencies that occur in the DW and WW networks of Chisinau are flagged and resolved / managed / coordinated through the Central Dispatching Service (CSD).

In case of emergency on the DW network, the intervention team from the CSD (on-field team) will go on site, check the address, and identify the nature of the problem (type of leakage). For each work of intervention, a worksheet is prepared mentioning the material and equipments required for the intervention. The CSD intervention team can also help the sector repair team by performing the water cut when required.

If an excavation is necessary, the CSD office will contact the other networks authorities for permission. If the excavation is in the street, the public transport authority and the traffic police will also be contacted. Any permission will cost ACC. The permission is given only for a short period. Depending on the localisation and if required, the intervention can be arranged on night in order to limit the impact on the traffic.

In case of waste water emergency, the intervention team from the CSD try to unclog the pipe with manual tools and if it cannot be done like this, the Sector team is called.

All information is communicated to the CSD office. When the repair or the unclogging is performed, the on-field team and/or the sector team will communicate by phone the information related to the work (address, type of intervention, material, diameter, works performed, date and hour of water cut and reconnection, date and hour of end of intervention).

It has to be noted that some interventions are raised directly by the Operationnals Sectors. From the example of list of interventions obtained from the CSD, we can deduce that most of those are on fire plugs.

2.2.3. SHORTCOMINGS AND RECOMMENDATIONS

The process used within ACC to deal with network emergencies allows a good track of all interventions. As operators are partly paid in function of the number of interventions completed, we can suppose that all interventions are well tracked, and that the productivity is satisfactory. But this practice could impact the quality of the works.

We recommend to complete the records by adding the two following information:

- the hydraulic entity the event belongs to. This will help to better assess the network efficiency and linear leakage index by area;
- Indication if the leak occurs on previous repair. There is currently no quantification of this phenomenon, but from several interviews, from the field visits and from the findings of the current systematic leak detection, it seems that a significant part of the leakages are from previous un-effective repairs.

It is also recommended that the future GIS will be deployed within the CSD for the use of the on-field team (it is currently an issue as the existing maps are not reliable). The GIS will be updated with the feed-back of information from the on-field teams and from the Sectors teams and all emergencies events will be mapped out.

We recommend the CSD to:

- inform back the customer when the problem is resolved;
- play a role of control of the effectiveness of the repairs. This will counter-balance the propensity of “quick” repairs lead by the payroll system.

As described before, we also recommend transferring the leak detection team from the CSD to the DW network operations division.

3. DRINKING WATER NETWORK OPERATIONS

3.1. NETWORK EFFICIENCY

The assessment of the current situation based on ACC data showed that the network's efficiency is thought to be around 61% and the linear leakage index around 47 m^3/day/km for the drinking water network.

This value is very high and shows that the network is in poor condition. In France, Veolia ranks urban network within the "Very Poor" category when the linear leakage index is higher than 16 m^3/day/km.

The measurement campaign performed on the drinking water network last summer confirms these values.

Such bad efficiencies are mainly due to the high brittleness of the network and its service connections: over the last 5 years, an average of 12,810 leaks were found and repaired every year. Around 68% occur on mains and 32% on service connections.

The most brittle pipes are pipes made of steel. The age of steel pipes is high.

32% of the repairs (around 4,100) are due to leakages on the service connections (around 120,000 units). The ratio of repair per connection is very high: 3.5 repairs / 100 connections. In France, performance indicators show that the ratio of repair per connection is around 1 repair / 100 connections. It means that i**n Chisinau the rate of interventions is 3.5 times higher.**

The main reasons of the brittleness of the network are:

1. **Corrosivity of soil:** clay soils are corrosive; they destroy concrete and metal in civil works, pipes, fittings etc... In consequence, steel pipes unprotected against corrosion are very fragile. Leakages due to corrosion pits are very common in Chisinau.
2. **Interruption of the water supply** during electrical shortages or sudden pumping events (such phenomena have been observed during the measurement campaign) generates water hammers and depressurisation of the network. It also leads to pipe bursts and pollution infiltration (lower water quality and public health hazards).
3. **Pipe repair practices:** wood cones are plugged into the pipe to obstruct the leaking surface and backfill compaction is not carried out. It is estimated that the recurrence rate of repaired leaks that re-appear during the year is around 30%.

3.2. ORGANISATION

3.2.1. STAFF

Department and Service	Teams organization	Staff	Key figures
Water Department	-	**592**	**-**
Network Op Div.	-	208	-
• Sector (x5)	8am-8pm: 2 teams / sector x 6 staffs (1 team leader + 1 welder + 4 technicians) 2 days on, 2 days off Total: 5 sectors x 4 – 5 teams x 6 staffs	189	1,850 km DW 14,000 bursts
• Service Line Division	2 teams x 5 staffs (1 team leader + 1 welder + 3 technicians)	11	1,850 km DW

In general, a team consists in 6 persons with different skills. The typical team is composed of:

- 1 foreman (team leader);
- 4 locksmiths;
- 1 welder
- + the drivers of the equipments (2)

The teams are working in shift, but if necessary, the program may be extended following an order. Indeed, in case of a large incident, the teams work around the clock in two shifts of 12 hours until the problem is fixed. Furthermore, if the current equipment is not sufficient to deal with the accident, an order is given to send on site additional equipment.

3.2.2. ACTIVITY

The length of networks managed and served by ACC is summarized below:

Table 4: Length of network operated by ACC in 2010

Ø	Ciment	Cast iron	Steel	PE	Total	%
≤50				22	**22**	**1%**
53-100	1.52	126	290	82	**498**	**27%**
108-150	0.04	90	73	105	**268**	**15%**
159-200	2	73	49	76	**200**	**11%**
219-300	1.44	263	91	34	**388**	**21%**
315-450	0.14	56	31	25	**112**	**6%**
500-700	6	86	106	6	**204**	**11%**
800-1400	32	5	119		**156**	**8%**
Total	**40**	**699**	**759**	**350**	**1844**	**100%**
%	**2%**	**38%**	**41%**	**19%**	**100%**	

- ACC DW network is still mainly composed of steel (41%) and cast iron (38%), despite some investments done in PE (19%)
- There is no distinction between cast iron and ductile iron as ductile iron is used for rehabilitation purposes since 2000 and no leaks have occurred on ductile iron pipelines. However these two materials should be distinguished as their age and performance are totally different.

Table 5: Repairs on DW network per material and diameter in 2010

Ø	Ciment	Cast iron	Steel	PE	Total	%
≤50[4]	6	151	2,409	110	**2,676**	**19%**
53-100	6	523	3,450	86	**4,065**	**29%**
108-150	3	471	2,045	16	**2,535**	**18%**
159-200	3	329	1,392	5	**1,729**	**12%**
219-300	2	364	1,574	3	**1,943**	**14%**
315-450		80	464	1	**545**	**4%**
500-700		43	377		**420**	**3%**
800-1400			111		**111**	**1%**
Total	**20**	**1,961**	**11,822**	**221**	**14,024**	**100%**
%	**0.1%**	**14%**	**84%**	**2%**	**100%**	

Note, there are repairs done on diameters <50mm other than PE pipe, although no such pipes are indicated in the existing database. We suppose that such repairs are done on service lines.

- There is an annual average of 4 leaks per day per repair team;
- At CSD, each DW team (4 teams) does on annual average 9.6 first diagnoses per full day, so 2.5 hours per diagnosis.
- 66% of events occur on Ø ≤ 150 mm pipes, 92% on Ø ≤ 300 mm pipes
- 84% of leaks occur on steel pipes, and 14% on iron pipes

Table 6: Total repairs on DW network per material and year

Material	2006	2007	2008	2009	2010	Total
ciment	12	13	17	28	20	90
cast iron	2,346	2,240	2,732	2,712	1,961	11,991
steel	8,231	9,922	10,951	9,992	11,822	50,918
PE	133	189	215	292	221	1,050
Total	**10,722**	**12,364**	**13,915**	**13,024**	**14,024**	**64,049**

- The number of operations progressively increases over the years, especially on steel pipes, despite the renewal of some of them each year;

Table 7: Linear Repair Index (# bursts/km/year) per material and diameter in 2010

Ø	Ciment	Cast iron	Steel	PE	Total
≤50				5,00	
53-100		4,15	11,90	1,05	**8,16**
108-150		5,23	28,01	0,15	**9,46**
159-200	1,50	4,51	28,41	0,07	**8,65**
219-300		1,38	17,30	0,09	**5,01**
315-450		1,43	14,97	0,04	**4,87**
500-700	0,00	0,50	3,56	0,00	**2,06**
800-1400	0,00	0,00	0,93		**0,71**
Total	**0,50**	**2,81**	**15,58**	**0,63**	**7,61**

- The LRIs on pipe <50mm except PE are not calculated as no indication of length of these pipes exist.
- There are 7.6 bursts / km / year on average, compared with 6 bursts / km / year for Bucharest and 0.5 bursts / km / year in Western countries.
- Steel pipes present the worse LRI, especially on small diameters up to Ø400mm
- The LRIs on iron pipes must be underestimated as the bursts must be on old cast iron pipes, but the length of pipes include the new ductile iron pipes.

3.2.3. RECOMMENDATIONS FOR A REPAIR TEAM SIZE

The number of staff per repair team is extremely high. From experience in France, we would recommend a team of 2 or 3 people, including driver, instead of currently 8 in average in Chisinau.

Therefore, we recommend ACC to decrease the size of each team with only 3 persons per team:

- one driver skilled in public works machinery
- one unskilled worker
- one skilled worker who can be in charge of supervising the operation

The driver will conduct a lorry or a mini-excavator on a trailer, and the 2 technicians will proceed with the water cut and with the repair. The driver will help when required (to give some tools or equipment, and to coordinate the safety from the road level).

The personal in excess should be re-affected to other functions, such as:

- 1 or 2 technician per sector performing preventive maintenance on the DW network: operating valves (with all the precaution required), cleaning air valves, controlling and adjusting any pressure reducing valve. This preventive maintenance on the network aims to decrease the number of problems on the network.

- Create a new repair team on each sector in order to deal with an increasing number of repairs following the implementation of a preventive maintenance and a pro-active leakage detection strategy. This number of repair teams should be reduced in the future with the reduction of leaks number following the replacement of the worse pipes and service lines (with no replacement of people leaving for retirement).
- Create 2 new teams in the Service Line Division in order to increase the intensity of replacement of old steel service lines, in a systematic way when a leak occur on them (except on the mains to be replaced within the next 2 years).
- Create a new team of pro-active leakage detection (the one currently existing is mainly used to detect the hidden leaks, ordered by the sector teams, in order to determine the exact location of the leaks).

Another recommendation is also to attach the leak detection teams to the DW network Operations Service. The leak detection is a function supporting the sectors, not the Customer Service Department. Each team should be composed of 1 technician and 1 servant.

Finally, we would also recommend organising the day shifts with 8 hours working per day during 5 days.

3.3. Equipment

3.3.1. Assessment of the Current Situation

The overall fleet of vehicles is old and not very efficient. Their productivity is low compared with modern vehicles. Their maintenance costs are high due in particular to a very high consumption of fuel.

Table 8: List of major equipment and associated characteristics

Type	N°	Average age
Bulldozer	3	22
Excavator	15	17
Loader	1	6
Scrapper	1	12
Tractor	10	15
Trailer	5	16
Total	**35**	**16**

Figure 4: Tractor

Figure 5: Heavy excavator

Table 9: Trucks within sectors and associated characteristics

Sector	N°	Average Age
Botanica	3	18
Buiucani	4	21
Centru	2	15
Ciocana	4	22
Riscani	3	17
Service Line Division	2	22
Total	**18**	**20**

Figure 6: Examples of ACC Truck at Botanica sector (exterior and interior)

The old trucks, equipped with a welding infrastructure, have a very high fuel consumption rate of 40l / 100 km.

Table 10: Equipment at Central Dispatch Service for leak detection purposes

Machine name	Type	Producer
Acoustic leak detector	Aqua – M 100 D	F.A.S.T. GmbH
Acoustic leak detector with correlation	Micro Call +	Palmer Environmental
Pressure recorder	Spectralog 1Pi	Biwater Industries Limited
Ultrasonic flowmeter Fluxus	ADM 6515	Katronik
Laboratory with the camera to inspect pipes and fountains	RAX 11.7	Ibak Helmut Hunger GmbH&Co
Pipe detector		
Metal detector	Ferotec 300	Hermann Sewerin GmbH

3.3.2. Recommendations for the Repair / Service Line Teams

Considering the age of the current equipment within ACC, and their inadequacy to a performing service, we recommend a massive investment in new equipment. If this investment is done along with the reorganisation and the implementation of new techniques, it will facilitate a smooth implementation of these changes.

According to best practices, for each team, the following equipment is necessary:

- Transportation
  - ➢ Small Truck 5-10T that should possess a locked compartment for the storage of the tools and equipment (for team transportation, equipment storage and raw material transportation) (30,000€ x1)

- Trailer for mini excavator (4,000€ x1)

- Public works machinery and equipment
  - Mini-excavator 3T with several type of buckets and hammer (25,000€ x1)

  - Generator (2,000€ x1)

  - Compressor (2,000€ x1)
  - Ram down machinery (2,000€ x1) (/w heat motor)

- Automated tools
  - Sawing machinery (1,500€ x1) (/w heat motor)
  - Jack hammer (200€ x1) (working /w generator)
  - Drill (100€ x1) (working /w generator)
  - Drill for connection on pipe (2,000€ x1) (working /w generator)
- Manual tools

- General tool box (with spanners of 19 and 24 among others…) (100€ x1)
- Specific spanners and tools for cleaning (for valve, meter box, manhole…) (100€ x1)
- Specific tools to work on HDPE pipes (plastic pipe saw, scissors shears on small diameters, rotary cutters for large diameters) (300€ x1)

- Wheel barrow, shovel, pickaxe, hammer, broom … (200€ x1)

- Safety equipment
  - Badges for identification (x3)
  - Individual safety equipment (Safety helmet, shoes, gloves, fluorescent jacket, noise protection headphone, etc.) (100€ x3)
  - Collective safety equipment (earthworks safety revetment, movable barrier, roadwork road sign, etc.) (100€ x1)
  - Gas detector for intervention in confined space (100€ x1)
- Spare parts
  - Stainless Steel Pipe Repair Clamps for the circumferential breaks
  - Couplings large tolerance for the longitudinal splits
  - Pipes, valves, etc.
  - Sand

The overall investment required for 1 team is around 70 K€, therefore an overall investment for ACC of 5 sectors x 3 teams + the Service Line Division x 4 teams = 19 teams x 70K€ = 1,330 K€

On top of this, it will still be necessary to have heavier excavators and trucks held centrally, for the interventions on big pipes in inclined natural land, such as:

- 1 JCB (backhoe loader) – 1 x 60,000€
- 1 Excavator on wheel 14T – 1 x 100,000€
- 1 Dump truck 4X6 26T – 1 x 100,000€

The total investment in new equipment for the DW network operation service is detailed in the table below:

Table 11: Cost estimates of the necessary equipment to operate the DW network

Item		Quantity	Unit Cost k EUR	Total cost k EUR
Transportation	Small Truck 5-10T	19	30.0	570
	Trailer for mini excavator	19	4.0	76
Public works machinery and equipment	Mini-excavator 3T	19	25.0	475
	Generator	19	2.0	38
	Compressor	19	2.0	38
	Ram down machinery	19	2.0	38
Automated tools	Sawing machinery	19	1.5	28.5
	Jack hammer	19	0.2	3.8
	Drill	19	0.1	1.9
	Drill for connection on pipe	19	2.0	38
Manual tools	General tool box	19	0.1	1.9
	Specific spanners and tools for cleaning	19	0.1	1.9
	Specific tools to work on HDPE pipes	19	0.3	5.7
	Wheel barrow, shovel, pickaxe, hammer, broom, …	19	0.2	3.8
Safety equipment	Individual safety equipment	57	0.1	5.7
	Collective safety equipment	19	0.1	1.9
	Gas detector	19	0.1	1.9
Spare parts	Stainless Steel Pipe Repair, Clamps, Couplings, etc.	Ens.	10.0	10.0
JCB (backhoe loader)		1	60.0	60
Excavator on wheel 14T		1	100.0	100
Dump truck 4X6 26T		1	100.0	100
TOTAL				**1,600**

3.3.3. Recommendations for the Leak Detection Team

For a leakage detection team, the following equipments are necessary:

- Transportation
  - Light commercial vehicle (1 x 6,000€)
- Public works machinery and equipment
  - Generator (1 x 12,000€)

- Automated tools
  - ➢ Leak detection acoustic equipment (with ground microphones, batteries, high quality headphones, etc…) (1 x15,000€)
  - ➢ Leak detection acoustic equipment with correlation (1 x 19,000€)
  - ➢ Portable ultrasonic flow meter (1 x 6,000€)
  - ➢ GPS for GIS purpose (1 x 4,000€)
  - ➢ Pipe detector (with probe for non metallic pipe detection) (1 x 2,500€)
  - ➢ Magnetometer (1 xs 1,000€)
  - ➢ Drill (1 x 500€) (working /w generator)
  - ➢ Dewatering pump (1 x 500€)
- Manual tools (400€)
  - ➢ Small specific tools (brush, etc.)
  - ➢ Tool box (hammer, screwdriver, tape measure, spanners…)
  - ➢ Specific tools to work on HDPE pipes
  - ➢ Specific spanners and tools for cleaning (for valve, meter box, manhole…)
  - ➢ Portable light
- Safety equipment (100€)
  - ➢ Badges for identification (x2)
  - ➢ Individual safety equipment (safety shoes and gloves and fluorescent jacket) (x2)
  - ➢ Collective safety equipment (roadwork road sign) (x1)
- Office equipment
  - ➢ PC for GIS and data analysis (1 x 1,000€)

The total investment in new equipment for 2 Leak Detection Teams is detailed in the table below:

Table 12: Cost estimates of the necessary equipment for 2 leak detection teams

Item		Quantity	Unit Cost k EUR	Total cost k EUR
Transportation	Light commercial vehicle	2	6.0	12
Public works machinery and equipment	Generator	2	2.0	4
Automated tools	Leak detection acoustic equipment	2	5	10
	Leak detection acoustic equipment with correlation	2	9	18
	Portable ultrasonic flow meter	2	6	12

Item		Quantity	Unit Cost k EUR	Total cost k EUR
	Drill	2	0.5	1
	GPS for GIS purpose	2	4	8
	Pipe detector	2	2.5	5
	Magnetometer	2	1	2
	Dewatering pump	2	0.5	1
Manual tools	General tool box	2	0.4	0.8
Safety equipment	Individual safety equipment	4	0.05	0.2
Office equipment (PC for GIS and data analysis)		1	1	1
Miscellaneous		10%	75	7.5
TOTAL				**82.5**

3.4. TECHNIQUES OF REPAIR

3.4.1. ASSESSMENT OF THE CURRENT SITUATION

After having visited the Central Store House and the Riscani Sector, we can conclude that no Water Pipe Repair Parts are used within ACC. Only a few pipe coupling for Ø250mm where found in the CSH, and we discovered later from discussion that they are the remaining parts left at the end of a big ductile cast iron pipe work (100 km). But it doesn't seem that they are regularly used.

Only a few Compression PE pipe fittings were found in the Central Storage House

The conclusion of the interviews is that all repairs on steel and cast iron pipes (98%) are made with what is available:

- Leaks due to corrosion on steel pipes ("hole in pipe" type of failure) are being repaired with wooden cones. The 1st of the following pictures shows the wooden cones prepared for a repair on a Ø500mm Steel Pipe, and the other ones leaks found by SEURECA leak detection campaign on previously repaired holes with wooden cones.

- We have been said that on big steel pipes, a piece of steel is welded on top of the wooden cones, and then that, normally, bitumen is applied on top on the welding to protect it from further corrosion. But we have not witnessed such a practice. Furthermore, and reportedly, it seems that this protection is not always done because of the bad smells for the residents.
- Circumferential breaks: This type of failure occurs on cast iron pipes when differential pressure applies on the pipe. The cast iron pipe is very sensible to this phenomenon, and breaks happen mostly at thaw, but not only. For this type of failure, the repair is done within ACC using a piece of steel pipe cut lengthways in 2 pieces (see photo below). 2 twisted wires are welded 5 cm from the extremity of each side.

The 2 pieces are then welded together around the circumferential break on the iron cast pipe. The tightness is done with some rope mixed with bitumen, and then beating some lead to finish.

The risk or problem of this technique is that the welding will corrode quickly and a new leak will happen. Problems happen also with the tightness of the lead. We have witnessed such a problem on the leak we inspected on Wednesday 16th November.

- Longitudinal splits: This type of failure occurs on both cast iron pipes and steel pipes in case of high pressure. For this failure, and any other type which requires the replacement of a portion of the pipe, the repair is done within ACC using a piece of steel pipe with 2 couplings made as described above (with a piece of steel pipe cut lengthways in 2 pieces and then welded together around the pipe to link). Again, this type of repair, with the corrosion of welding, will lead to further failures.

It seems also that there is a problem at Riscani sector, where repairs from the findings of Seureca's leak detection were declared to have been completed, but after verification on the ground, it was not the case. Off the 52 original leaks detected and said repaired, 41 were checked, and 8 were not repaired (2 on mains, 5 on valves, and 1 on hydrant).

3.4.2. SHORTCOMINGS

Current practices within ACC for repairs must be improved. In regards to international best practices, they are far to be satisfactory. This is mainly due to the following reasons:

- The lack of resources. As there are no water pipe repair parts available, repairs are made with "what is at hand". It is worth pointing out that ACC technicians are achieving good results taking into account the available means.
- The culture (skills) within ACC is more of welders, steel industry, than of plumbers, and people may not be so inclined to use new techniques.

We fear that the increase of number of leaks repaired over the past 5 years is the consequence of such practices, which weaken the network (new leaks appear on previous repairs). Therefore, we strongly recommend ACC to adopt new worldwide recognised practices.

The costs of the water lost, and of a further excavation, exceed by far the cost of some water pipe repair parts. For example, if we consider 4 hours for a repair with excavation (with time of transport), the cost for the excavation is at minimum 2,200 LEI (137€). If the cost of water lost (electricity for pumping) is 0.1 €/m3, and the volume lost 2,000 m3 (by the time the leak is detected and repaired) the cost of water is 200 €. The average cost of technicians and material for one leak is 1081 LEI (68€). The total direct cost is therefore 405€. The cost of water pipe repair parts to repair a leak on a diameter 100 is 30€ for a circumferential break and 50€ for a longitudinal split.

In addition to those direct costs, there might be collateral costs, which could badly impact the image of ACC, such as property damages (flooding of structures and vehicles), traffic disruption, etc.

3.4.3. RECOMMENDATIONS

Our recommendations mainly consist to introduce within ACC international best practices for pipe repairs. Although ACC will have to invest in water pipe repair parts, this will be economically interesting as a repair made according these principles should be effective over 20 years.

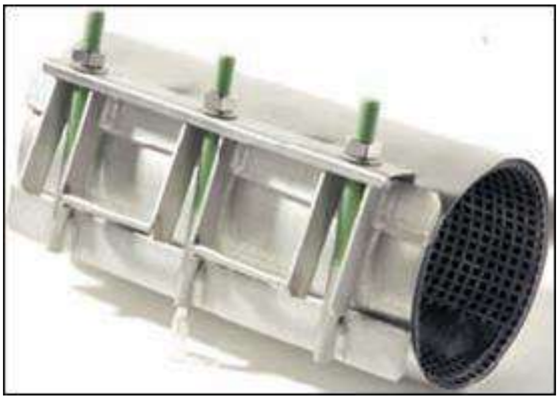
In theory, proper repairs on pipes to be replaced are a waste of money and should be as cheap as possible. Unfortunately, the needs in Chisinau are huge, and only a part of the network will be replaced in a short term (PIP) (in priority all steel pipes – 759 km, and then all cast iron pipes - > 500 km). We recommend during the first years to replace at least 45 km per year (2.5% of the total network). This means that 17 years will be necessary to replace all the existing steel pipes.

Therefore, it is crucial that the repairs done on pipes last 20 years.

Eventually, if a pipe is planned to be replaced within the next 2 years, repairs can continue to be done as currently, with no parts, but with some improvements.

3.4.3.1. Repair of a circumferential break

A circumferential break will be repaired using a Stainless Steel Pipe Repair Clamp, type Sainte Lizaigne MI.



Before applying, the pipe around the break must be cleaned with a scraping band.

A stainless steel pipe repair clamp can also be used to repair holes in steel pipes, when the hole is “clean”. In that case, the coating must be removed where the clamp will be installed. And an anticorrosion steel pipe wrap tape, type greased fibre band, will be applied where the coating will have been removed, but not covered with the stainless steel clamp.

3.4.3.2. Repair of a longitudinal split

A longitudinal split or any repair where a piece of pipe needs to be replaced (excessively corroded pipe, joint leaks, or an outburst), will require a piece of pipe of the same material (cast iron on a cast iron failure), and 2 couplings large tolerance, type Bayard TGT (“Very Large Tolerance”) series C2 25 for diameters 40 to 400 mm (dedicated couplings series C2-11 for further diameters), or eventually type Saint-Gobain Leya 3100 (Ø 50 to 800 mm), but with less tolerance range.

Bayard Gamme TGT

Ø Ref	DE mini	DE maxi	Weight
mm	mm	mm	Kg
40	44	144	2,7
40-50	55	159	2,9
60-65	68	171	4
80	84	197	4,9
100	106	225	6,1
125	125	241	7,2
125	140	251	7,8
150	159	281	8,5
200	180	304	12,2
200	200	327	13,9
200	218	345	14,4
250	243	375	21,5
250	270	357	23,3
250	292	376	24,9
300	311	393	33,5
300	334	421	36,2

Saint-Gobain type Leya 3100

Ø Ref	DE mini	DE maxi	Weight
mm	mm	mm	Kg
50	40	75	9
60/65	60	95	8
80	80	115	11
100	105	135	12
125	130	165	16
150	155	195	18
175	190	230	21
200	215	258	23

225	240	280	27
250	235	275	26
250	270	310	29
300	310	350	33
300	350	390	36
350	395	435	39
400	435	470	42
400	470	505	45
500	505	540	50
500	540	575	71
500	575	610	74
600	610	645	58
600	645	680	82
600	680	715	82
700	710	745	86
800	810	845	95

It has to be noted that these couplings are not self-bolted, therefore if the coupling is installed with an angle, an anchorage must be built.

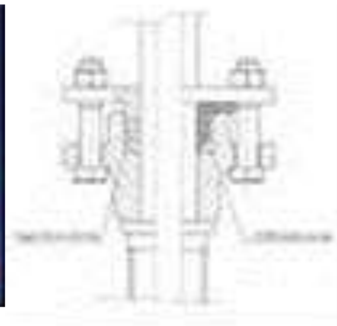
On a steel pipe, the same principal will be applied in terms of coating and of protection, as for the stainless steel pipe repair clamp.

3.4.3.3. Repair of a leak on a valve

Most leaks on valves (many examples found by the leak detection team) are due to defective “stuffing box assembly”.

We haven’t seen during our visits any specific repair parts for this type of failure.

The best practice to repair a leak on a stuffing box assembly is to use a “permatight” seal.



The valve stem must be dismantled, and a specific permatight diameter seal put in place.

3.5. Techniques of Connections

During the visit of the Service Line Division work, we inspected the material used for new connections.

There was no indication of pressure on the collars and they seem to be parts for irrigation rather than for drinking water network

We recommend to use a all-in-one solution adaptable for several diameters

This solution reduces the number of seals and therefore the risk of future leaks.

We also recommend the connection valves to be installed under a service box with cast iron cover, and not within a manhole as it is common within ACC area.

This will avoid corrosion, and maitenance costs of the manholes.

This is also the case for all valves on the network, except very big ones (from Ø500mm).

3.6. RECOMMENDATIONS IN TERMS OF STOCKS

Based on experience from DW network sector in France (Burgundy), and considering the ratio of pipe repairs completed per year, here are the recommendations in term of stocks per sector:

Stainless Steel Pipe Repair Clamps PN16:

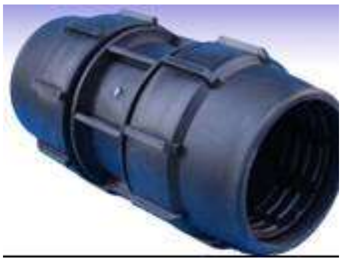
Ø Ref	DE mini	DE maxi	#	Unit price Veolia France	Stock value ACC (France +20%)
mm	mm	mm		€	€
50	46	50	20	18.16	2,179.20
50	54	61	10	18.16	1,089.60
50	61	70	5	18.16	544.80
60	75	82	10	24.30	1,458.00
60	82	90	5	27.61	823.30
80	96	103	10	28.47	1,708.20
80	100	110	5	30.20	906.00
100	114	124	20	30.49	3,658.80
100	125	135	10	30.67	1,840.20
125	140	150	2	34.32	411.84
125	151	161	2	34.32	411.84
150	168	180	20	36.56	4,387.20
175	193	203	2	41.70	500.40
200	219	230	20	46.49	5,578.80
250	271	281	10	62.66	3,759.60
300	314	334	20	115.83	13,899.60
350	348	368	2	180.44	2,165.28
350	365	385	2	180.44	2,165.28
400	414	434	10	190.33	11,419.80
Total					**58,912.74**

Couplings Large Tolerance Bayard Gamme TGT and
Saint-Gobain type Leya 3100 from Ø 500mm (price extrapolated)

Ø Ref	DE mini	DE maxi	#	Unit price Veolia France	Stock value ACC (France +20%)
Mm	mm	mm		€	€
40	44	57	20	11.98	1,437.60
40-50	55	70	30	13,72	2,469.60
60-65	68	86	20	15.82	1,898.40
80	84	106	20	19.44	2,332.80
100	106	130	20	22.16	2,659.20
125	125	148	2	25.34	304.08
125	140	161	2	27.35	328.20
150	159	184	30	37.38	6,728.40
200	180	205	10	43.91	2,634.60
200	200	227	10	51.33	3,079.80
200	218	245	10	54.15	3,249.00
250	243	271	6	60.13	2,164.68
250	270	297	6	62.25	2,241.00
250	292	318	6	68.68	2,472.48
300	311	336	20	79.35	9,522.00
300	334	361	10	99.32	5,959.20
350	360	386	2	103.83	1,245.96
350	386	410	2	130.81	1,569.72
400	408	435	4	148.66	3,567.84
400	425	458	4	157.05	3,769.20
400	465	500	4	218.62	5,246.88
500	505	540	4	220	5,280
500	540	575	4	250	6,024
500	575	610	4	290	6,888
600	610	645	2	330	3,960
600	645	680	2	380	4,560
600	680	715	2	440	5,280
700	710	745	2	500	6,000
800	810	845	4	580	13,920
Total					**116,792.64**

Pipes: We recommend having 2x6 meters of each diameter of each material in stock in each sector for diameters with more failures (Ø 60, 80, 100, 150, 200, 300 mm), and 1x6 meters of each diameter of each material for the other diameters.

Service Lines: Our recommendations of stock for each sector are in brass repair couplings and PE compression couplings



10 of each type for each diameter (Ø 25, 32, 40, 50 mm)

Very useful can be compression coupling for PE on one side, and any other material on the other:

Valves: Many valves will have to be replaced due to their state of corrosion. We recommend having in stock 2 to 3 valves of each diameter per sector.

Various: It will be useful also to have some “Té”,

some pipe bends, some major stop flange, and some large tolerance flange adaptors.

In conclusion, the estimation of stock to have within ACC (the distribution between central storage and sectors can be optimised consequently) is estimated in total at **200 K€.**

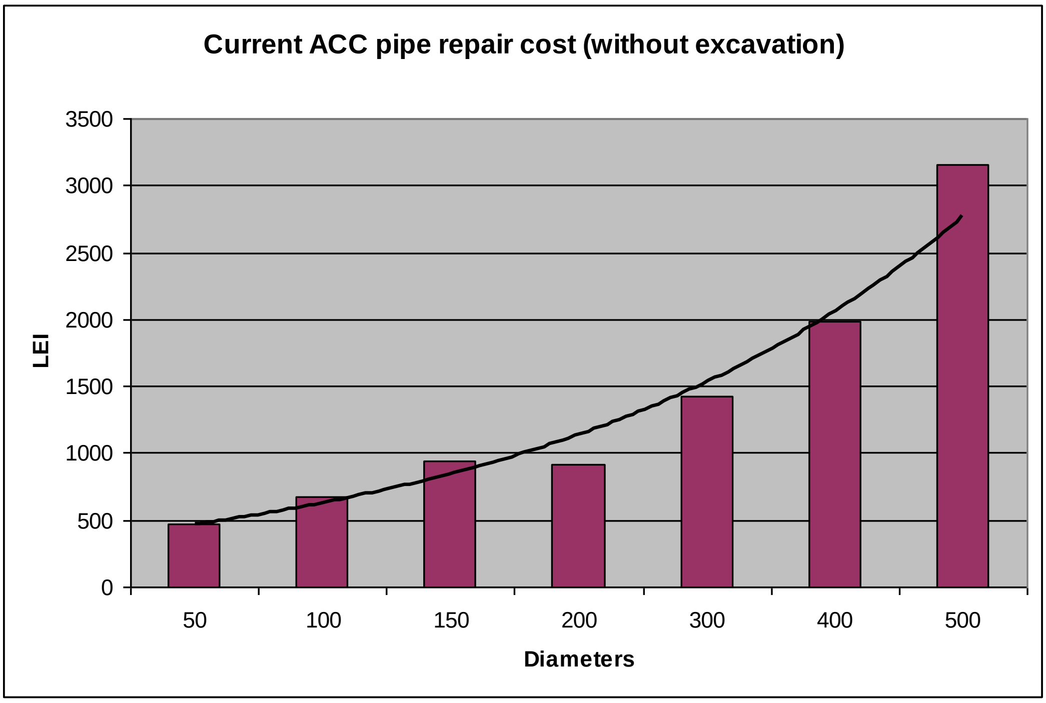
3.7. Repair Costs

3.7.1. Current ACC costs

Based on the information about the cost of the repairs completed by the Botanica Sector in October 2011 (for a total of 316 repairs on steel and cast iron pipes), we can conclude that the **average cost without excavation** is currently 1,081 LEI (68€).

Ø	#	Cost
<100	55	466
100	64	674
150	64	943
200	48	918
300	37	1,429
400	31	1,989
500	17	3,158
Total	**316**	**1,081**

This cost increase with the diameter:



3.7.2. Excavation costs

The cost of excavation can be estimated at 2,176 LEI (136€) per repair on average, based on 4 hrs per repair (including transport) of a JCB and a lorry.

We can consider that 80% of leaks will require an excavation. Therefore, the weighted cost of excavation is 1,741 LEI (109€).

3.7.3. COUPLINGS COSTS AND OTHER HYPOTHESIS

We will consider that all repairs will be done with couplings, except those to be performed on steel pipes Ø150 and Ø200 which should be replaced within the next 2 years.

The unit cost corresponds for each diameter to 2 large tolerance couplings for the largest diameter considered. We have applied to the Veolia's price in France 20% increase.

3.7.4. OTHER HYPOTHESIS

Although we could consider that the number of leaks will drop down on the second year, considering ACC will avoid some leaks by repairing with couplings (up to 30%) and by replacing some steel pipes and connection lines, we will retain the same number than in 2010 in order to take into account the leaks that the detection teams will find out.

We will consider only the leaks on steel and cast iron pipes as they represent 98% of the total.

3.7.5. CONCLUSION ON PIPE REPAIR COSTS WITHIN THE NEXT 2 YEARS

Ø	Cast iron	Steel	Total	Current costs		Excavation costs	Couplings costs		Total costs
						1741			2 years
				LEI	k MDL	k MDL	LEI	k MDL	k MDL
50	151	2,409	**2,560**	**455**	**1,165**	**4,457**	**527**	**1,350**	**13,943**
100	523	3,450	**3,973**	**674**	**2,678**	**6,917**	**851**	**3,381**	**25,951**
150	471	2,045	**2,516**	**943**	**2,373**	**4,380**	**1,455**	**685**	**14,876**
200	329	1,392	**1,721**	**918**	**1,580**	**2,996**	**2,079**	**684**	**10,520**
300	364	1,574	**1,938**	**1,429**	**2,769**	**3,374**	**3,814**	**7,391**	**27,070**
400	80	464	**544**	**1,989**	**1,082**	**947**	**8,395**	**4,567**	**13,192**
500	43	377	**420**	**3,158**	**1,326**	**731**	**11,136**	**4,677**	**13,469**
800		111	**111**	**5,000**	**555**	**193**	**22,272**	**2,472**	**6,441**
Total	**1,961**	**11,822**	**13,783**		**13,528**	**23,996**		**25,207**	**125,463**

This cost should decrease significantly from the 3rd year, with the benefit of replacing 122 km of the worse steel pipes and associated service lines, and with the improvement of the effectiveness of the repair techniques.

Also, if we consider that 40,000 m3/day of Non-Revenue Water could be avoided. The associated benefit for not spending electricity for pumping can be estimated to 23,360 k MDL / year (1.6 LEI / m3).

3.8. EMERGENCY RECOMMENDATIONS

3.8.1. DESCRIPTION

3.8.1.1. Replacement of the network's mains

With a Linear Repair Index higher than 20 repairs / km / year, **the steel pipes with a Nominal Diameter of 150 and 200 mm have to be rehabilitated in priority**. Their total length is 122km.

ACC should start rehabilitating the oldest pipes located in the seven distribution zones with the highest Linear Leakage Index and the worst efficiency.

The annual rate of rehabilitation of the current network should not be less than 1/40 = 2.5% which represents 46 km per year in order to rehabilitate half of the total network within the next 20 years (922 km).

We consider that a special effort should be done during the next 2 years by replacing the 73 km of steel pipe Ø150 and the 49 km of steel pipe Ø200.

3.8.1.2. Replacement of the connections

Around 90% of service connection bursts appear on steel service connections. **These steel connections have to be replaced in priority.** They are mainly connected to the steel and cast iron pipes.

The ones which are connected to the steel pipes that should be rehabilitated during the urgent phase will be replaced simultaneously. This should represent around 2,000 connections per year.

The ones which are connected to steel or iron pipes to be rehabilitated later (not within the first 2 years) should be replaced as soon as a leakage occurs on them.

In the same way, the annual rate of replacement of existing connections should not be less than 2.5% per year = 3,000 units/year.

3.8.1.3. Equipments & Fittings

See sections 3.3 to 3.6.

3.8.2. ROUGH COST ESTIMATES

Cost estimate is based on the four following unit costs (Tax Free):

- Replacement of a ND150 steel pipe by a ND160 HDPE PN10 pipe (internal diameter = 144 mm): 758 MDL / m
- Replacement of a ND200 steel pipe by a ND225 HDPE PN10 pipe (internal diameter = 196.6 mm): 1,193 MDL / m

- The average unit cost for the replacement of steel pipes with a Nominal Diameter of 150 and 200 mm has been estimated to 1,100 MDL / m.
- Replacement of service connection: 13,750 MDL / connection (for a 12 m HDPE service connection and its accessories, excluding the water meter)

These costs include 10% for preliminary design and works supervision:

Therefore, the cost estimate of the urgent rehabilitation works within the next 2 years is (Tax Free):

Table 13: Cost estimates of the Emergency Program for the drinking water network

Item	Quantity	Total cost k MDL
Replacement of steel pipes with a Nominal Diameter of 150 and 200 mm	122 km	134,200
Replacement of service connection	6,000 U	82,500
Equipments and fittings for the repair / service line teams		25,600
Equipments and fittings for the leak detection teams		1,320
Stock (repair couplings…)		3,200
Cost of leaks repairs		125,180
TOTAL COST		**372,000**

Total Cost = 372 M Lei (Tax Free) = 23.3 M Euros

4. WASTEWATER NETWORK OPERATIONS

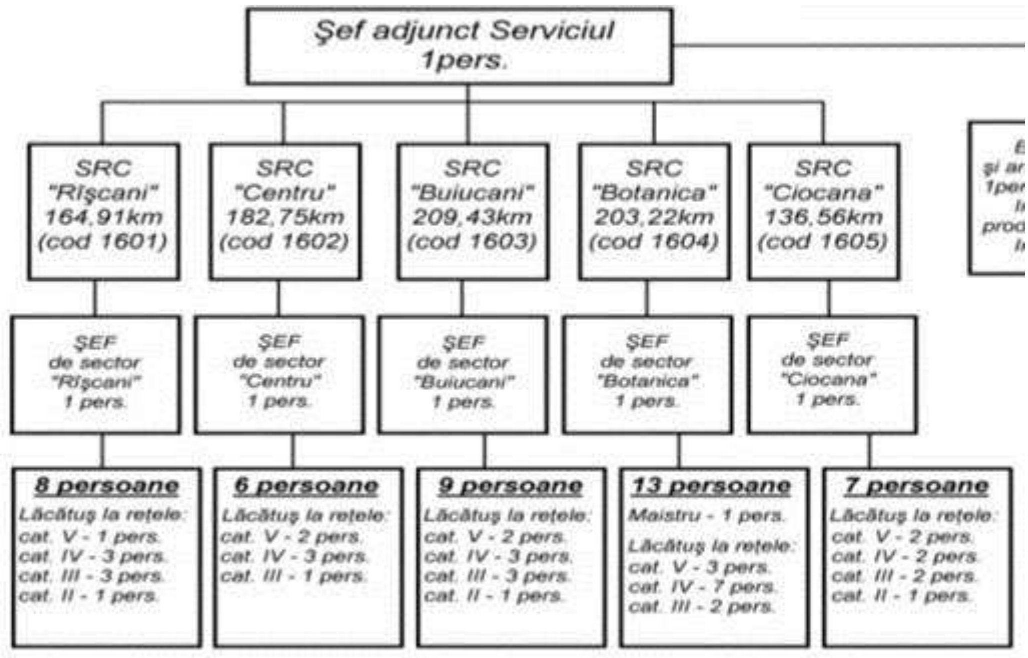
4.1. ORGANISATION

4.1.1. STAFF

Table 14: Teams organization for operations on WW network

Department and Service	Teams organization	Staff	Key figures
Waste water Department	-	**320**	**-**
Network O&M and PS Service		142	
• Sector (x5)	Total: 5 sectors x 9 staffs (on average)	48	950 km WW 28,900 inter.
• Pumping Stations	4 men per PS without alarms (x 16) 1 man per PS with alarms (x 9) 20 men for maintenance	93	25 PS 9 with subm pumps 9 with alarms

Organizational chart for WW network operations



4.1.2. NETWORK OPERATIONS

- The network of ACC was laid a long time ago, approximately from 1935 to 1975.

Table 15: Length of WW network operated by ACC in 2010

DN (mm)	Ceramic	Cement asbestos	Concrete	Reinf. Concrete	Steel	Cast iron	HDPE / PVC	total (km)
100	367	2 967			2 030	7 020	3 629	16
150	95 329	69 008			1 817	12 359	23 734	202
200	103 034	81 942			3 138	17 559	8 970	215
225							56	0
250	6 668	1 463				100	2 669	11
300	52 917	58 987	19 435		3 647	40 821	5 424	181
350	2 147							2
400	43 540	47 403	19 692	64	281	11 427		122
500	378	23 006		61 174	20	30		85
600		107		41 929	1 060	4 700		48
700				3 960	290			4
800				28 992	101			29
900				1 840				2
1 000				14 125				14
1 200				3 220	98			3
1 500				8 003				8
1 600				1 509				2
2 x 1.5				1 930				2
2 000,0				3 020				3
2 x 2.5				5 850				6
Total	**304 379**	**284 883**	**39 127**	**175 616**	**12 482**	**94 016**	**44 482**	**955**
%	**31,9%**	**29,8%**	**4,1%**	**18,4%**	**1,3%**	**9,8%**	**4,7%**	**100%**

- The majority of the pipes in concrete or asbestos cement is in a bad structural condition because they are old and affected by H2S release due to Over-Sizing.
- Obstructions happen when the pipes collapse. The repair is done replacing 6 meters of pipe. The pipe installed is usually PVC and the couplings are usually made with what is available (a piece of PVC pipe cut in 2 parts and then tighten together). From discussions, it seems that about 150 repairs of that type are performed every year, which corresponds to the "Earthwork" type of intervention in the table 16.

Table 16: Total repairs on WW network per type

Interventions on wastewater network	2008	2009	2010	Average	%	
Clean out	12 175	11 586	11 662	**11 808**	**55%**	100%
Cleaning pipes roots	1	7	12	7		0%
Cleaning pipes with jetting truck	4 147	2 960	3 104	3 404		10%
Extracting roots of the manholes	0	0	5	2		2%
Extraction of sludge from the manholes	367	381	348	365		41%
Liquidation of clogging	7 660	8 238	8 193	8 030		44%
Control	8 213	8 502	9 061	**8 592**	**31%**	100%
Earthwork	167	148	191	**169**	**0,5%**	
Public works	1 063	934	862	953	**3,5%**	
Total	**21 618**	**21 170**	**21 776**	**21 521**	**100%**	

Table 17: Cross analysis between operations and diameter of pipe in 2010

Operations	<100 mm	<300 mm	<700 mm	< 800 mm	<1 000 mm	<1 500 mm	Total
Clean out	176	52,490	839	59	17	119	**53,590**
Control	81	25,135	475	54	21	54	**25,776**
Earthwork	9	445	49	2	0	93	**506**
Public works	25	2,614	186	22	8	579	**2,859**
Total	**291**	**80,684**	**1,549**	**137**	**46**	**845**	**82,731**
% of operations	**0.4%**	**97.5%**	**1.9%**	**0.2%**	**0.1%**	**1.0%**	**100.0%**
% of total length	**1.7%**	**63.8%**	**27.4%**	**3.0%**	**1.7%**	**2.5%**	**100.0%**

- Main information from this table is that problems are concentrated (97.5%) on 150 mm ≤ Ø ≤ 300 mm pipes.

These charts raise the following comments:

- Very few intervention (clean out and control) are performed on connexion where are usually concentrated problems;
- Interventions are both concentrated on Clean out (65%) and on pipes (70%);
- In the past 3 years, Clean out along with Control operations are increasing constantly;
- Correlation between Clean out and Control operations suggests that they are linked and that each Clean out operations is associated (on the field and in the database) to a control operation;
- Public works operations correspond to small civil works on wells (bricks, covers…);
- Considering previous elements, the fact that suction pumps and jetting system have relatively to very poor performances and finally the oversized pipes, the main reasons for clogging may be sedimentation in the network over time

- From discussions, roots seem to be also a significant issue in Chisinau, and difficult to clean-out with only manual tools.

- There are also some issues with the steel pipes constituting the pressure lines from the Pumping Station.

4.1.3. PROCEDURE TO DEAL WITH BLOCKAGE / CLOGGING

All emergencies that occur in the WW network of Chisinau are flagged and resolved / managed /coorindated through the Central Dispatch Service (CDS).

Within this service operate two intervention teams dedicated to solving urgent problems, and each Sector has its own team for intervention.

In case of a large accidents the program of intervention teams, is modified by order, they work around the clock in two shifts of 12 hours until the accident will be remedied. If they do not have sufficient equipments to deal with the accident, by order, the technique is supplemented.

First, the intervention team from the CDS try to unclog the pipe with manual tools and if it cannot be done like this, the Sector team is called. Meanwhile, the CDS intervention team communicate information to CDS office.

The sector team either tries to unclog the pipe manually with more workforce, mobilize a mud drains or jetting truck.

Once the unclogging operation is done, information is transmitted to CDS.

4.2. PUMPING STATIONS

ACC is in charge of 29 Pumping Stations + the one at the WWTP.

It has to be noted that:

- 16 are old pumping stations, with a dry well and horizontal pumps
- 4 are also old pumping stations with dry well and horizontal pumps, but their electrical panel has been replaced and an alarms system has been installed.
- 7 are pumping stations with submersible pumps
- 12 of these pumps are automatic, among which 3 are submersibles pumps.

All the old pumping stations are equiped with manual fine bar screens and manuel inlet valve.

We have been told that these old pumping station present a risk of flooding the dry well and the pumps. The 2 pumping station visited – Sculeni and Petricani – are not in this situation, with a high wall (higher than the ground level) separating the 2 wells. However, effectively, there is still a small risk of flooding if a leak occurs on the pipes.

The electrical panel on the 16 old pumping station not rehabilitated are effectively quite old, but indeed quite basic and easy to maintain.

The horizontal pumps of the 20 old pumping stations are also quite old, but from the visits, all the pumps were operationnal and in place, and from the discussion with ACC operation staff, our conclusions are:

- The fine screens are very effective and very solid waste can damage the pumps;

- The pumps have a robust design;
- The pumps are regularly controlled, and a preventive mainrtenance will be performed if the pumps indicates an excessive wear. And a preventive maintenance is applied systematically after a number of working hours;
- The pumps are similar and easy to repair internally.

The only problems can be their low yield because of their age, and the lack of available spares.

As the old pumping station are over-watched in continue, and a good preventive maitenance is applied, the pumping stations don’t seem to be a big operationnal issue.

4.3. EQUIPMENTS

4.3.1. EQUIPMENT AND VEHICLES

- Due to a lack of budget, investments were scarce in wastewater network equipment and ACC has to work with old trucks and devices.

Table 18: List of major WW equipments and associated characteristics

Type	N°	Average worked days / yr	Average Life time
Crane	2	112	24
Hydrodynamic trucks	3	161	27
Mobile workshop	8	183	20
Mud drains	6	143	20
Tipper	1	118	24
Total	**20**	**157**	**21**

Figure 7: Examples of ACC Hydrodynamic and Mud-drain Trucks

Remark: no public works equipment was mentioned in the data collected besides the crane and the tipper. However, during interviews, one excavator was said to be allocated to WW department.

According to their functions, Hydrodynamic machine, Mud drains and Mobile workshop should have a maximized availability rate for the Company. It is respectively 73%, 83% and 65% which can be considered as quite good according to their life time. However, their performances on the field could be poor.

For example, the jetting trucks (hydrodynamics machine) deliver a pressure of 25 bars to 40 bars; initial nominal pressure being 120 bars. Current performances are too low to deal efficiently with blockages and perform clean out on Ø < 600 mm pipes. According to French manufacturer, pressure and flow from the jetting system should range between 50 to 200 bars for pressure and 80 to 400 l/min for flows.

On the field indeed, ACC teams face difficulties when they have to deal with blockages on Ø > 400 mm. For bigger pipes (Ø > 600 mm), ACC has no mean to perform appropriate clean out operation. Another issue is that plants are too big to operate in the small streets in the center of Chisinau.

In addition to this, there is not any dedicated CCTV equipment or equivalent to assess the structural conditions of the network in order to define precisely the need for rehabilitation and most effective techniques.

4.3.2. Work safety

- ACC staff is often put at risk (no gas detector, no electrical protection…) when working on the network because there is a lack of awareness and a lack of means.

4.3.3. Knowledge of the system

- ACC staff has a good knowledge of its system but it is empirical, not systematic and not centralised. The data is in majority paper based and a lot of the information are not stored anywhere but just passed verbally.

4.4. Shortcomings and Best-Practices

4.4.1. Shortcoming

First, the characteristics of the network are quite poor with 8.8 blockages / km which are at least 3 times above average value in Western countries. The number of pipe collapse is also quite high, with 150 events per year.

Regarding equipments, it must be said that performances of these jetting trucks and drain-mud trucks are quite poor.

Considering operations, WW operations are mainly reactive to events and not proactive. 9 inspections out of 10 lead to a liquidation of clogging operation, meaning that they are almost exclusively triggered by customers. There is no preventive action on WW network, and the number of corrective interventions is increasing along the time.

There is no dedicated CCTV for the WW network to perform precise assessment of pipe and select the most appropriate rehabilitation technique.

Concerning the data, there is too much type of operations and as far as we know, there is no relation to one single event that triggered the whole thing. Analysis is therefore very difficult.

4.4.2. BEST PRACTICES

Best practices on WW network are summarized in the table below:

Table 19: Summary of Best practices for WW network operations

Issue	Actions
Control of inputs Separation of waste water from storm water should be monitored to assess the quantity of storm water coming into the network. Storm water leads to blockages by flushing waste into the network, to overconsumption of electricity at pumping station and to dysfunction at the WWTP.	Monitoring can be done by periodical measure on WW network (done in the scope of Seureca's mission for modelling purpose) or by follow up of running time of pump Other elements can come from the operations database. Pipe with a lot of clogging due to grease will reveal an issue regarding inappropriate discharge into WW network. Based on this information, area with specific problems can be identified and actions plans can be built. Actions plans consist in specific control (presence of pre-treatment in restaurant, right connexion for domestic service lines, good practices in waste management near market places, etc...). Once, control are done, communication and/or coercive actions plans must be enforced. Update GIS with on-field data.
WW network operation Operations should limit the nuisance to the neighbourhood by preventing flooding and odours by preventive actions.	Build preventive clean out campaigns based on historical data from GIS and modelling results. Operation should focus on planned (each year) preventive actions: 5% to 20% of total length cleaned out as preventive action. This preventive action can be associated with a follow up of on-going clogging. Based on historical data and/or modelling, blackspots are identified and a frequency rate for intervention is set. Curative actions should be limited afterward (0.5 - 3 blockages / km on Western network). Evacuate sludge in appropriate process. Update GIS with on-field data.
WW network assessment **WW network renewal/rehabilitation** Knowledge of the network allows the operator to enhance performance of operations and to target the most efficient rehabilitation. Network should undergo steady rehabilitation (<5% generally).	Create and update GIS. Create a modelling of the network. Build rehabilitation programmes based on historical data from GIS and results of modelling. CCTV is performed each year on x % (5% < x <10% generally) of the total length of the network Each year, a planning for CCTV inspection must be set along with preventive clean out operations planning. Rehabilitation programme (1% to 5% of total length of network) per year. Update GIS. Update modelling.

4.5. RECOMMENDATIONS

4.5.1. CREATE GIS AND ADJUST DATABASE

To enhance the comprehension of the WW network, GIS is a very powerful tool. It is even more powerful when data from the operations are integrated into it. This tool can be used by many stakeholders of WW network:

- Asset manager to prepare rehabilitation programmes based on characteristics of networks (age, depth, environment, etc.)
- Team leader to prepare preventive clean out campaigns based on historical operational data;
- Jetting truck operator to follow his programme;

- Operator to print out specific area of the network with updated data;
- Etc.

GIS issue is tackled by other reports, the reader is invited to the reading of these reports.

Concerning the existing database, it seems that it can be enhanced to ease the analysis of events and operations. The following improvements could be done:

- Have one single number for each event;
- Associate the series of operations to one event;
- Reduce the number of operations available;
- Create additional details if needed (material, number of bricks added, presence of grease, presence of roots, etc.).

4.5.2. IDENTIFY, SOLVE OR KEEP BLACKSPOTS

From the existing database and operators' knowledge, it seems that blackspots could be identified quite quickly. It is suggested to do so with by doing a thorough analysis of historical data and discussion with Heads of Sector.

For each blackspot, an analysis should be done to identify the reasons of the recurrent blockages. Generally, it is either due to structural problems (confluence, opposite slope, local configuration, etc.) or problems associated to inputs into the network (roots, grease, rain water, waste, etc.). Therefore, it can be solved by:

- Investment: Works (pipe rehabilitation, flush, etc.);
- Operations: Recurrent clean out (existing situation);
- Customer's relations: Actions plans toward customers with or without coercive actions.

To assess more effectively and precisely the issue at stake at blackspots, visual inspections should be done either by classical CCTV equipment or by punctual snapshots with specific equipment such as QuickView®.

Both techniques are complementary:

- QuickView®. should be used to identify and deal with very punctual problem and to define more precisely the parts of the network that need a CCTV inspection;
- CCTV should be used as a preliminary to define specifications for network rehabilitation programmes.

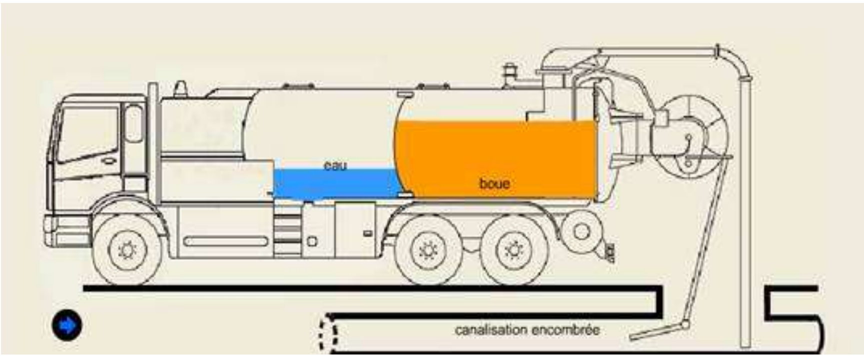
CCTV issue is tackled in details in another report, the reader is invited to the reading of these reports.

4.5.3. PERFORM PREVENTIVE ACTIONS

Preventive cleaning work of the sewage system is carried out according to the “Plan of Preventive Works”, with deviations caused by the lack of necessary equipment

It is recommended to have 2 dedicated teams to performed planned actions. Teams in charge of preventive clean out must be equipped with combined jetting and pumping trucks.

Principle of combined jetting and pumping units



Hydro vacuum combination unit on truck

Generally, such teams are able to do 300 ml to 500 ml per day of cleaning. This rate depends on the urbanization (decrease with density because of traffic and thinner street) and on the storage capacity (fixed or mobile partition or recycling system). The most recent combined units have a recycling system that enable them to work almost all day without stopping to refill water tank or discharge sludge tank.

These teams should be mutualised at the WW network operations division level. At sector level, teams will keep on dealing with emergencies using jet units on trailer, but they will also be in charge of managing the planned intervention in coordination with these mutualised teams.

Jet unit on trailer

For Centru sector, the jet unit on trailer can be used to operate in smaller street if pumping system is not required. Otherwise, smaller equipment shall be used (see figure below).

Light hydro vacuum combination unit

4.5.4. CLEAN OUT OPERATIONS ON BIG DIAMETER PIPES

For Ø > 800 mm pipes and siphons, specific plants or techniques are needed to clean them out:

- Mechanical clean out with very specific plants;

- Flushes in the network executed by Hydrass® valves (mobile or permanent) for example;
- Mechanic rolling balls that clean out by being dropped into the network;
- Etc.

Hydrass® Valve and rolling ball

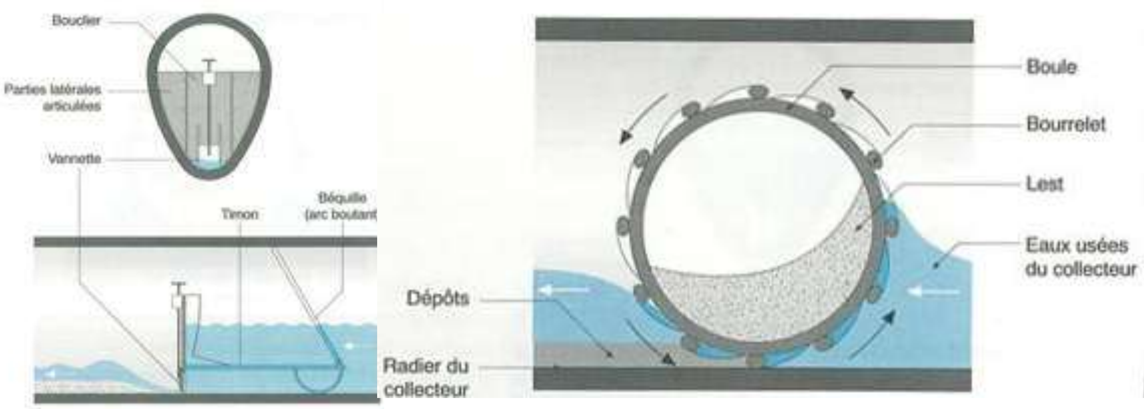
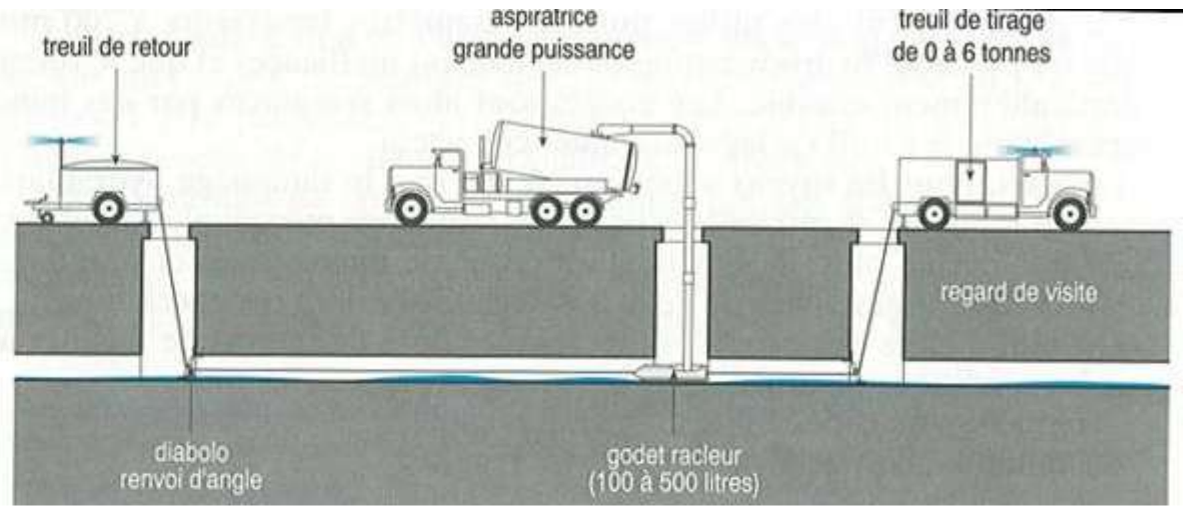


Illustration of mechanical clean out



For these pipes, according to their needs for cleaning out, it may be interesting to subcontract these types of operations to specialized companies.

4.5.5. NETWORK REHABILITATION

Considering the problems with the concrete and asbestos cement pipes, including the high number of pipe collapse, it is recommended to engage a vigorous network rehabilitation programme. The length of these old networks is 39 km for the concrete pipes, and 285 km for the asbestos cement.

ACC should use the result of the network modelling currently developed by SEURECA in order to identify the correct size for the pipes to be replaced. This will avoid in the future the current over-sizing's problems.

4.5.6. FEW FIGURES TO DESIGN WW NETWORK SERVICES

Key figures are given below for a first calculation of needs for staffs and plants and long-term projection. It cannot be emphasis enough that the context (age of installations for instance) and the qualification of staffs must be taken into account to have an adequate allocation of resources. Means of actions are detailed in the following table for several key operations:

Table 20: Key figures for staffs and plants allocation for WW network operations

Actions	Technical rate
Inspection of the network Lifting cover and visual inspection or with QuickView® system. Ideally, inspection should cover the total length of network every year. However, focus must be put on blackspots and sensitive areas (high traffic) or elements.	Rate: 5 km / day or 2 h / km Staff: 1 team of 2 operators Plant: 1 wagon or vehicle
CCTV operation Inspection on 10% of the total length of network (preliminary clean out operations to be added).	Rate: 100 to 200 ml / day on existing network Staff: 1 team of 2 operators Plant: 1 CCTV wagon
Follow up of works and GIS update Follow up of new network lay down operations and integration into GIS.	Rate: 1 km of new network / day Staff: 1 team of 1 operators / surveyor and 1 draftsman Plant: -
Clean out operations (Ø ≤ 600 mm) These operations should concern 20% of total length of network, including the 10% as preliminary clean-out to CCTV operation.	Rate: 300 ml to 500 ml / day Staff: 1 team of 2 to 3 operators Plant: 1 Hydro vacuum Combination Unit
Dealing with blockages Blockages can range from 0.5 to 3 blockages / km on waste water network. Blockages can range from 2 to 3 blockages / 1,000 service lines.	Rate: 1 to 4 h / blockage Staff: 1 team of 2 to 3 operators Plant: 1 Jetting Unit or Hydro vacuum Combination Unit

Small public works operations such as making chamber covers level must be added to this.

4.5.7. SET KEY PERFORMANCES INDICATORS

As said in previous report, operations should be driven by process. It implies that, in addition to the classic budgetary constraints, the activity should be evaluated according to the performances of each process.

For the purpose of monitoring operations on WW network, it is suggested the following list of KPIs:

- Network operations
    - Ml of CCTV network (ml and %) – Good Practices: 2% to 10%
    - Ml of preventive cleaned out network (ml and %) - Good Practices: 5% to 20%
    - Nb of blockages (#)
    - Nb of blockages on pipes per km (#/km) - Good Practices: 0,5 to 3 #/km
    - Nb of blockages per service lines (#/1,000) - Good Practices: 0,5 to 3 #/km
    - Nb of control (# and %)
    - Nb of blackspots (#)
    - Dilution rate (%)
- Waste

    - T of waste extracted from network (t)
- Works and maintenance
    - Rehabilitated network (km and %) - Good Practices: 1% to 2%
    - GIS coverage (%) - Good Practices: 100% of network with patrimonial and operational data
- Project of improvement
    - Number of projects (#)
    - Implementation progress rate (%)

In addition to this performance indicators related to operations, Customer satisfaction associated with DW should be considered.

4.5.8. Pumping Station Recommendations

Our recommendations concerning the old Pumping Stations – in case of risk of flooding – are to replace the old horizontal pumps by submersible pumps installed in the dry well. This solution avoids rebuilding totally the pumping station.

If the number of people employed on the pumping stations is also a problem, then the stations will have to be more automated, with automatic inlet valve, and automatic screen. The control panel will have to be replaced.

In that case, the remaining operators will have to visit several pumping stations every day with a vehicle.

Another recommendation would be to employ the operators to perform cleaning and painting of the pipes, in order to avoid their corrosion.

In terms of safety, some basic protection of all PS electrical panel must be installed: Plexiglas screwed cover of the electrical connection above 24V.

4.6. Emergency Recommendations

4.6.1. Description

In order to maintain a good operation of wastewater collecting system and a good quality of service to ACC customers, investments are needed in the following item:

- Intervention and obstruction removal
  - New vans (10) for staff and equipment transportation to the sites
  - Jet units on trailer (5) for the interventions on small diameters and in smaller streets that big truck cannot reach
  - New combined hydro-cleaning and pumping trucks (2), with nozzles for hydrocleaning (2 per truck) and special nozzles for removal of roots, gravel, grease, strong obstruction (4 per truck)
  - General intervention equipment (shavel, stick …)
  - Complementary CCTV equipment (1 van with all devices)
- Safety equipment
  - Gaz detector
  - Portable scale, rope and safety harness
  - Protection clothes (gloves, helmet…)
  - Road signalisation (traffic cones, reflecting jacket…)
  - Training and installation of safety signs on site
- Network rehabilitation: urgent pipe rehabilitation 2.5% per year – 24 km per year.

4.6.2. Rough Cost Estimates

The table below presents a preliminary and rough estimation of the cost for such investments described in Chapter 4.5.1:

Table 21: Cost estimates of the Emergency Program for the wastewater network

Item		Quantity	Total cost k MDL
Intervention and obstruction removal	Jet units on trailer	5	2,000
	Vans	10	1,620
	Hydrocleaning trucks	2	9,600
	Nozzles	12	10
	General intervention equipment	5	160
	CCTV equipment	1	900

Safety	Gaz detector	5	40
	Scale, harness and protection clothes	5	160
	Road signalisation	5	80
	Training and safety signs	5	570
Network rehabilitation : urgent pipe rehabilitation (24 km)		24	40,800
TOTAL COST			**55,940**

Total Cost = 56 M Lei (Tax Free) = 3.5 M Euros