WORKSHOP
Non-Revenue Water (NRW) Reduction in Urban Water Utilities
Experiences and Challenges in the Mediterranean Region

Center for Mediterranean Integration, Marseille, France

January 22-23, 2013

Non-Revenue Water Management in Cyprus

Bambos Charalambous
Head Technical Services
Water Board of Lemesos
Lemesos, Cyprus (until October 2012)

Managing Director
Hydrocontrol Ltd
Lemesos, Cyprus
Water Management in Cyprus
Recent Water Situation in Cyprus

- Gradual change in the climate
- Substantial decrease in annual rainfall >20%
- Reduction in the runoff into the reservoirs > 40%
- Periods of low rainfall are becoming more frequent
- Demand is continuously increasing
- Frequent periods of low or no rainfall: 1991-92, 1997-2000, 2008-09
- Government forced to apply water restriction measures
  - Drastic water cuts in irrigation
  - Severe restrictions to domestic water supply
- Add Water to the National Balance:
  - Construction of Desalination plants: 60Mm$^3$ (75% of total potable needs)
  - Use of treated effluent in agriculture: 10Mm$^3$ (5% of total irrigation needs)
- Need for water conservation and leakage management
Lifeline from Athens to Lemesos in August 2008: 35,000 m³/day
NRW Management

- Is a continuous activity
- Is an integral part of distribution network management
- Is based on a long term strategy
- Is cost effective especially in water scarce areas

HOWEVER ITS SUCCESS DEPENDS:

- On commitment and dedication at all levels
- Adoption of appropriate methodologies and technologies
- Use of appropriate and reliable indicators for benchmarking, such as: litres/service connection/day and ILI
### Key Performance Indicators

<table>
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<tr>
<th>Water Board of Nicosia</th>
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<tr>
<td><strong>YEAR</strong></td>
</tr>
<tr>
<td>2007</td>
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<td>2011</td>
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<table>
<thead>
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<th>Water Board of Larnaca</th>
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<td><strong>YEAR</strong></td>
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<tr>
<td>2007</td>
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<table>
<thead>
<tr>
<th>Water Board of Lemesos</th>
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<tr>
<td><strong>YEAR</strong></td>
</tr>
<tr>
<td>2007</td>
</tr>
<tr>
<td>2011</td>
</tr>
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</table>
Network Design and Development
Major Network Developments

Water Board of Lemesos

- **1986 - 1990**
  - Major expansion of storage and supply network
  - Establishment of pressure zones and DMA
  - Installation of SCADA system

- **1991 - 1993**
  - Pressure reduction study
  - Installation of PRVs in 8 out of 27 DMAs

- **1994 - 1995**
  - Digitization of all maps of the water distribution system

- **1997 - 1998**
  - Review of the leakage control activities by external consultant
  - Recommendations for the establishment of a leakage management policy

- **1999 - to date**
  - DMA re-design and pressure management
  - Use of advanced technology in DMA monitoring and leak detection
  - Adoption of IWA WLTF “best practice” approach to NRW management

Source: WBL
Key Considerations

DMA categories
- Small: <1000 properties
- Medium: 1000 – 3000 properties
- Large: 3000 – 5000 properties

Factors considered in DMA design
- Minimum variation in ground level
- Single entry point into the DMA
- Well defined DMA boundaries
- Area meters correctly sized and located
- Apply pressure management
- Continuous monitoring

Source: WBL
Typical DMA Inlet Chamber

- **Pressure reducing valve**
  - (downstream pressure control, open/close capability)
- **Pressure sensor**
  - (downstream pressure monitoring)
- **District meter**
  - (mechanical “Woltman” type)
- **Strainer**
  - (meter protection)

Source: WBL
Monitoring and Data Transfer

Dedicated Computer in Control Room

PSTN and GSM Network

Data Communication
- E-mails / sms sent from each DMA
- Alarms sent to Operator’s mobile phone for:
  - High/Low pressure
  - High MNF
  - No flow
  - Low battery status

PROGRAMMABLE CONTROLLERS IN DMAs

January 22-23, 2013  Center for Mediterranean Integration  Marseille, France
Pressure Management

Reduction in:

- surges and excess pressures
- burst rates and background leakage, cut repair costs
- flow rates of all leaks
- some components of consumption
Pipeline and Asset Management

- High quality materials / Proper installation
- High standard of maintenance
- Pipeline replacement using a decision support system
Accurate and Comprehensive Metering

the first step in establishing how much water is produced and/or being used

Accurate measurement of:

- Water produced and/or imported
- Water flow to and out of treatment plants
- Water flow to and out of storage reservoirs
- Water flow into Districts
- Customer consumption

Eliminate or minimise Authorised Un-metered Consumption
NRW Activities
# Annual Water Balance (m$^3$) (“Top - Down”) Reaching the point of Accountability

<table>
<thead>
<tr>
<th>System Input Volume</th>
<th>Authorised Consumption 10 714 505 83,14%</th>
<th>Billed Authorised Consumption 10 650 065 82,64%</th>
<th>Billed metered consumption (including water exported) 10 650 065 (82,64%)</th>
<th>Billed unmetered consumption Zero</th>
<th>Revenue water 10 650 065 82,64%</th>
<th>Unbilled Authorised Consumption 64 440 0,50%</th>
<th>Unbilled metered consumption Zero</th>
<th>Unbilled unmetered consumption 64 440 (0,50%)</th>
<th>Non-revenue water 2 237 811 17,36%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Losses</td>
<td>2 173 371 16,86%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apparent Losses 451 076 3,50%</td>
<td>Unauthorised use 64 440 (0,50%)</td>
<td>Metering inaccuracies 388636 (3,00%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Real Losses 1 722 295 13,36%</td>
<td>Real losses on raw water mains and at the treatment works Zero</td>
<td>Leakage on transmission and/or distribution mains 90 215 (0,7%)</td>
<td>Leakage and overflows at transmission and/or distribution storage tanks 12 888 (0,10%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leakage on service connections up to the metering point 296 421 (2,30%)</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Commercial Losses
(Apparent losses)

All customers are metered

Water theft
- Theft from hydrants
- Meter by-passes
- Tampering with meters

Meter under-registration
- Improve meter accuracy
- Volumetric meters
- Certified meter test bench

Meter reading errors
- Hand-held devices
- Change meter readers’ routes
- Check zero/low consumption

Accounting errors
- Billing software
- Threshold alarms

Commercial Losses
= Loss of Revenue
(valued at retail billing rates)

Source: Rizzo and Cilia, 2005
Physical Losses
(Real Losses)

Main Causes are:

- Ageing pipes
- Damage to pipes by others
- Lack of or poor maintenance
- Improper installation / materials
- Pressure (excess/fluctuation/transients)
- Seasonal weather variations
- Traffic loading and vibration
- Intermittent water supply
Speed and Quality of Repairs

**Tactics:** Minimize “Leak Run Time”; Manage leak ID, location and repair processes; Measure leak run & repair times; Use quality materials & specification; Perform quality repairs & inspection; Corrosion control

### Number of Pipes Repaired

- **House connection polyethylene:** 1,169 (55%)
- **House connection galvanised iron:** 712 (34%)
- **Distribution pipework:** 243 (11%)

### Response Repair Time

- **Same day:** 1,169 (85%)
- **Next day:** 712 (13.5%)
- **Next two days:** 243 (1.5%)

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Center for Mediterranean Integration
Marseille, France

January 22-23, 2013
Active Leakage Control
### Pressure Management

<table>
<thead>
<tr>
<th>DMA (Sector 2)</th>
<th>AZNP (m)</th>
<th>Actual MNF (m³/hr)</th>
<th>Background losses (m³/hr)</th>
<th>Locatable losses (m³/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>before</td>
<td>after</td>
<td>before</td>
<td>after</td>
</tr>
<tr>
<td>220</td>
<td>64</td>
<td>32</td>
<td>3.92</td>
<td>2.16</td>
</tr>
<tr>
<td>221</td>
<td>63</td>
<td>36</td>
<td>5.69</td>
<td>3.85</td>
</tr>
<tr>
<td>222</td>
<td>54</td>
<td>28</td>
<td>3.07</td>
<td>2.24</td>
</tr>
<tr>
<td>223</td>
<td>53</td>
<td>29</td>
<td>5.50</td>
<td>2.52</td>
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<tr>
<td>224</td>
<td>64</td>
<td>34</td>
<td>12.96</td>
<td>9.78</td>
</tr>
<tr>
<td>225</td>
<td>64</td>
<td>34</td>
<td>10.04</td>
<td>6.84</td>
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<tr>
<td>226</td>
<td>59</td>
<td>38</td>
<td>15.52</td>
<td>10.44</td>
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<tr>
<td>227</td>
<td>64</td>
<td>35</td>
<td>7.87</td>
<td>5.85</td>
</tr>
<tr>
<td>228</td>
<td>53</td>
<td>29</td>
<td>4.49</td>
<td>3.49</td>
</tr>
<tr>
<td>Total before</td>
<td>117.92</td>
<td>43.75</td>
<td>34.32</td>
<td>21.02</td>
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<tr>
<td>Total after</td>
<td>87.96</td>
<td>27.09</td>
<td>21.02</td>
<td>21.02</td>
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</table>
## Reduced Burst Frequency

(Reported Leaks)

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of bursts reported</th>
<th>Reduction of leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before (7 months)</td>
<td>After (7 months)</td>
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<tr>
<td>Distribution mains</td>
<td>49</td>
<td>27</td>
</tr>
<tr>
<td>Communication pipes</td>
<td>296</td>
<td>178</td>
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</tbody>
</table>

### Comparison of Results

**ANNUAL COST SAVING IN PIPE BURST REPAIRS**

€100,000

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>Reduction</th>
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<tbody>
<tr>
<td>Cyprus (Water Board of Lemesos)</td>
<td>32%</td>
<td></td>
<td>41%</td>
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<tr>
<td>Australia (A.Lambert)</td>
<td>40%</td>
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<td>55%</td>
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Leakage Monitoring
DMA Flow and Pressure Monitoring
## MNF Analysis

<table>
<thead>
<tr>
<th>District No</th>
<th>Actual AZNP m</th>
<th>Actual MNF m³/hr</th>
<th>Target MNF m³/hr</th>
<th>Equiv Serv Pipe Bursts no</th>
<th>Actual Tot Losses m³/d</th>
<th>Locatable Losses m³/d</th>
<th>Locatable Loss Value £/a</th>
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<tbody>
<tr>
<td>130</td>
<td>43</td>
<td>39.5</td>
<td>16.51</td>
<td>15</td>
<td>576.79</td>
<td>459.86</td>
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<tr>
<td>121</td>
<td>45</td>
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<td>127</td>
<td>39</td>
<td>20.3</td>
<td>8.50</td>
<td>8</td>
<td>299.92</td>
<td>236.10</td>
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<td>38</td>
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<td>188.09</td>
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<tr>
<td>125</td>
<td>45</td>
<td>18.4</td>
<td>9.40</td>
<td>6</td>
<td>196.65</td>
<td>180.01</td>
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<td>2.16</td>
<td>4</td>
<td>142.34</td>
<td>120.88</td>
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<td>322</td>
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<td>7.87</td>
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<tr>
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<td>320</td>
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<td>16.9</td>
<td>11.03</td>
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<td>222.73</td>
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<td>0.00</td>
<td>£</td>
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<tr>
<td>120</td>
<td>58</td>
<td>1.5</td>
<td>0.89</td>
<td>0</td>
<td>12.77</td>
<td>0.00</td>
<td>£</td>
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<tr>
<td>325</td>
<td>52</td>
<td>0.7</td>
<td>0.61</td>
<td>0</td>
<td>9.32</td>
<td>0.00</td>
<td>£</td>
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<td>122</td>
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<td>1.4</td>
<td>1.24</td>
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<td>189.37</td>
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<td>£</td>
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<td>4.7</td>
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<td>-1</td>
<td>77.97</td>
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<td>115.58</td>
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<td>44.39</td>
<td>-4</td>
<td>276.44</td>
<td>0.00</td>
<td>£</td>
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</tbody>
</table>

**Summary for the 20-Nov-02**

- **No of ESPB’s**: 86
- **Total Losses Estimate**:
  - **5002 m³/day**
  - **2562 m³/day**
- **Locatable Losses**:
- **Total Cost of Locatable Losses**: £319,771

**Prioritise Leakage Activities Based on ESPB and on Value of Water Saved**
MNF Monitoring

District 227
Year 2005 Minimum Night Flow

District 226
Year 2005 Minimum Night Flow

District 232
Year 2005 Minimum Night Flow

Data entry
Country | Currency | Volume units | System
---|---|---|---
Cyprus | EC | m³

Utility
Water Board of Lemosos

Min Flow

Month

Data from another Worksheet

Conf. limits +/-

Length of mains
17.6 km

Number of service connections
1500

Variable cost of water CV
0.550 EC / m³

Full system Intervention cost CI
3650 EC

Natural Rate of Rise of unreported leakage RR
41 m³/day in a year

is categorised as being
Low

Economic Intervention every
11 months

Economic annual % surveyed
106% of system

Annual Budget for Intervention
3.9 Thousand EC

Economic Unreported Leakage
12.9 litres/service conn./day

1.08 m³/km of mains/day

LEAKS software

January 22-23, 2013
Center for Mediterranean Integration
Marseille, France
Leak Location and Repair

Three leaks were located and fixed.

Awareness (A)=2days
Location (L)=8days
Repair (R)=1day

Loss of water=4200 m³

District 129
April, May 2004 Flow & Pressure

January 22-23, 2013
Center for Mediterranean Integration
Marseille, France
Targeting and Benchmarking
Targeting and Benchmarking

Goal Setting
• Identified areas to be improved
• Prioritised most effective actions

Benchmarking (Process and Metric)
• Decided on Key Performance Indicators
• Checked and compared performance to other utilities
For the years 1987 to 2011, the chart illustrates the percentage of non-revenue water (NRW) in relation to the supply. The NRW is expressed as a percentage of the total supply. The years 1989 and 1993 show the highest NRW percentages, while the supply shows a decline in recent years. The chart is based on data from WBL, with the source specifically noted as the Center for Mediterranean Integration, Marseille, France.
Technical Performance Category: A – pressurised system: average pressure 40 m
(Developed Countries)

: <100 litres/connection/day

Source: Liemberger, 2005

Drought Years
Intermittent
Supply

Source: WBL
January 22-23, 2013
Center for Mediterranean Integration
Marseille, France
Infrastructure Leakage Index

Operational PI for Real Losses Detailed (IWA Level 3, Op 25)

Technical Performance Category: A
(ILI 1-2: Excellent – no specific intervention required)
(Developed Countries)

Source: Liemberger, 2005

Drought Years
Intermittent Supply

Source: WBL
International Comparison

Source: Seago, McKenzie, Liemberger, Halifax 2005
Total of 146 data from 31 countries

DEVELOPED COUNTRIES

DEVELOPING COUNTRIES

January 22-23, 2013
Center for Mediterranean Integration
Marseille, France
Intermittent Water Supply
### Effects of Intermittent Supply

Significant increase in the number of *reported pipe bursts*

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of reported breaks</th>
<th>2007</th>
<th>2010</th>
<th>%increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mains</strong></td>
<td></td>
<td>1/7,14km</td>
<td>1/2,38km</td>
<td><strong>300</strong></td>
</tr>
<tr>
<td><strong>Service connections</strong></td>
<td></td>
<td>15,5/1000 connections</td>
<td>29,7/1000 connections</td>
<td><strong>200</strong></td>
</tr>
</tbody>
</table>
Effects of Intermittent Supply

Significant increase in **Total Leakage**

<table>
<thead>
<tr>
<th>TOP DOWN</th>
<th>1 January to 30 December</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
</tr>
<tr>
<td>Zone 1</td>
<td>5,185,434</td>
</tr>
<tr>
<td>Zone 2</td>
<td>5,150,320</td>
</tr>
<tr>
<td>Zone 3</td>
<td>939,659</td>
</tr>
<tr>
<td>24 Ag.Phila</td>
<td>180,690</td>
</tr>
<tr>
<td>Zone 5</td>
<td>141,591</td>
</tr>
<tr>
<td>Zone 6</td>
<td>83,118</td>
</tr>
<tr>
<td>Zone 7</td>
<td>20,759</td>
</tr>
<tr>
<td>Total (m³)</td>
<td>11,701,571</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BOTTOM UP</th>
<th>MNF (aver.)</th>
<th>Consumers</th>
<th>Night use</th>
<th>Background</th>
<th>Losses &amp; Bursts</th>
<th>Night use + Background</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>385</td>
<td>549</td>
<td>164</td>
<td>m³/h (period)</td>
<td>60,730</td>
<td>66,684</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>113</td>
<td>10</td>
<td>m³/h</td>
<td>392,419</td>
<td>430,892</td>
</tr>
<tr>
<td></td>
<td>5,914</td>
<td>9,149</td>
<td>3,235</td>
<td>m³ (per day)</td>
<td>1,969,454</td>
<td>3,046,663</td>
</tr>
<tr>
<td>Night use + Background</td>
<td>2,361,873</td>
<td>3,477,555</td>
<td>1,115,683</td>
<td>m³ (period)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minimum Night Flow

Years 2007 and 2010 (All Reservoirs)

January 22-23, 2013
Center for Mediterranean Integration
Marseille, France
# Effects of Intermittent Supply

## System Input Volume Vs Consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>System Input Volume (m$^3$)</th>
<th>Customer Consumption (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Difference</td>
</tr>
<tr>
<td>2007</td>
<td>12.914.576</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>10.655.626</td>
<td>-2.258.950</td>
</tr>
<tr>
<td>2010</td>
<td>14.568.052</td>
<td>1.653.476</td>
</tr>
</tbody>
</table>
## Effects of Intermittent Supply

### System Input Volume Vs Consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>System Input Volume</th>
<th>Customer Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 Before Intermittent Supply</td>
<td>0% (base line)</td>
<td>0% (base line)</td>
</tr>
<tr>
<td>2008 Intermittent Supply</td>
<td>-17,5%</td>
<td>-9,2%</td>
</tr>
<tr>
<td>2009 Intermittent Supply</td>
<td>-9,1%</td>
<td>-8,9%</td>
</tr>
<tr>
<td>2010 After Intermittent Supply</td>
<td>+12,8%</td>
<td>-1,2%</td>
</tr>
</tbody>
</table>
Cost of Intermittent Supply

Cost to the Water Board of Lemesos for the 2 years (2008 – 2009) of Intermittent Supply:

Loss of revenue:

- Reduction in sales – cost of water saved: € 300.000

Additional operational expenses:

- Staff overtime for opening / closing valves: € 365.000
- Repairing additional reported breaks: € 325.000

Additional cost after Continuous Supply was established:

- Additional leakage (2010 – 2012): € 1.700.000
- Estimated cost of locating leaks: € 175.000
- Estimated cost of repairing leaks: € 125.000
Thank you

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