Rehabilitation in Oeiras & Amadora: a practical approach

MJ Marques, AP Saramago, MH Silva, C Paiva,
S Coelho, A Pina, SC Oliveira, JP Teixeira,
PC Camacho, JP Leitão, ST Coelho

Presentation Outline:

- Introduction
- Strategic Planning
- Tactical Planning
- Diagnosis
- Alternatives
- Final Remarks

Introduction

During the 1970s and 1980s there was a rapid urban growth with inadequate planning.

Nowadays those systems, with decades of insufficient capital maintenance, are facing problems related to early deterioration, as well as by inadequate original designs.

Introduction

SMAS O&A

- Providing urban water services to the municipalities of Oeiras and Amadora, in the vicinity of Lisbon (Portugal).

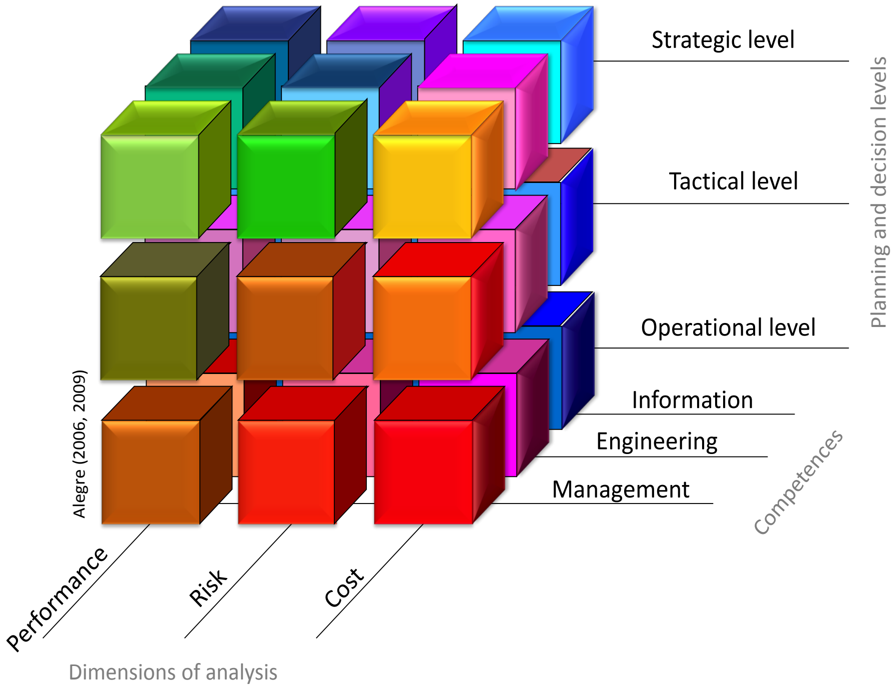
- covering approx. 70 km^2 and a population of about 350,000

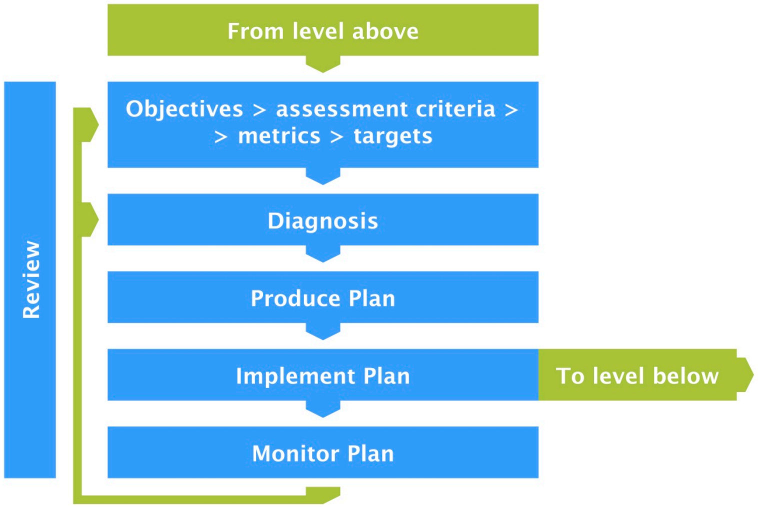
- many of the existing water mains have reached their expected lifetime, and high capital investments are required to renovate them

- well-devised IAM approaches are thus necessary to assist in defining priorities and solutions

Introduction

SMAS O&A are conducting a detailed asset management analysis of their water supply, wastewater and stormwater systems based on the AWARE-P IAM approach (Alegre *et al.*, 2011)





Strategic Planning

Main objective - establish long-term utility corporate policy, based on knowledge of internal strengths and weaknesses, and of key external opportunities and threats

Table 1 Strategic objectives and assessment criteria

Strategic objectives	Criteria
1. Adequacy of the service provided	1.1 Service accessibility; 1.2. Quality of service provided to customers
2. Sustainability of the service provision	2.1. Economic sustainability; 2.2. Infrastructural sustainability; 2.3. Physical productivity of human resources
3. Environmental sustainability:	3.1. Efficiency of use of environmental resources; 3.2. Efficiency in pollution prevention

Table 2 Strategies of SMAS O&A for water and wastewater and stormwater systems

Water supply system	Wastewater and stormwater systems
Perform planned rehabilitation	Perform planned rehabilitation
Reduce water leakage	Reduce illegal connections
Promote the efficient use of water	Evaluate the potential for wastewater reuse
	Update inventory and perform structural condition surveys

Tactical Planning

- establishes the interventions to be implemented in the medium term, at the systems level.

- the selection of the DMAs with higher priority of intervention was based on the assessment of the applicable strategic metrics and on direct knowledge of the existing systems’ response.

- predicted evolution of external factors (e.g. demands, regulation, funding opportunities, economics)

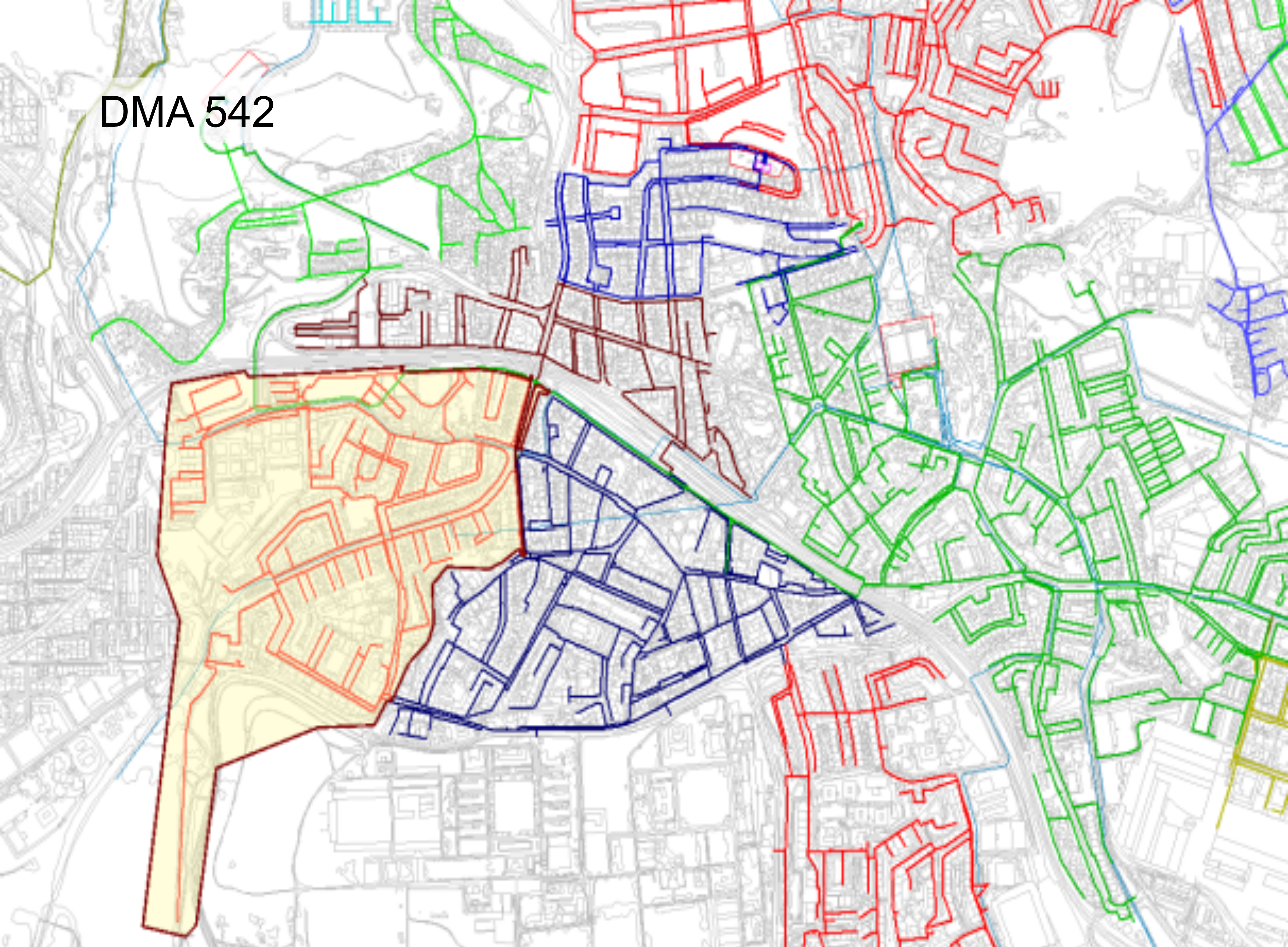
5-Year Tactical Plan for DMA 542

Based on the strategic objectives and criteria presented in Table 1, SMAS O&A selected DMA 542 as a pilot since it failed to comply with 4 of the criteria

The following tactical objectives were set:

- Increase system reliability in normal and emergency conditions;
- Ensure economic sustainability;
- Ensure the infrastructural sustainability of the system;
- Decrease water losses.

DMA 542



Performance, risk and cost metrics

C1: investment cost

C2: comparative design efficiency

C3: infrastructure value index (IVI)

P1: minimum pressure under normal operation

P2: minimum pressure under emergency conditions

P3: percentage of total pipe length in asbestos cement

P4: real losses per connection

R1: risk of service interruption (water supply)

Detail of the risk metric

Table Scales of pipe failure likelihood and consequence

Classes	**Pipe failure likelihood** (failure 100km^{-1} year^{-1})	**Pipe failure consequence** (population not supplied)
1 (likelihood: rare/ consequence: insignificant)	0 – 30	0 – 100
2 (likelihood: unlikely/ consequence: low)	30 – 40	100 – 200
3 (likelihood: moderate/ consequence: moderate)	40 – 60	200 – 500
4 (likelihood: likely/ consequence: high)	60 – 100	500 – 2000
5 (likelihood: almost certain/ consequence: severe)	> 100	> 2000

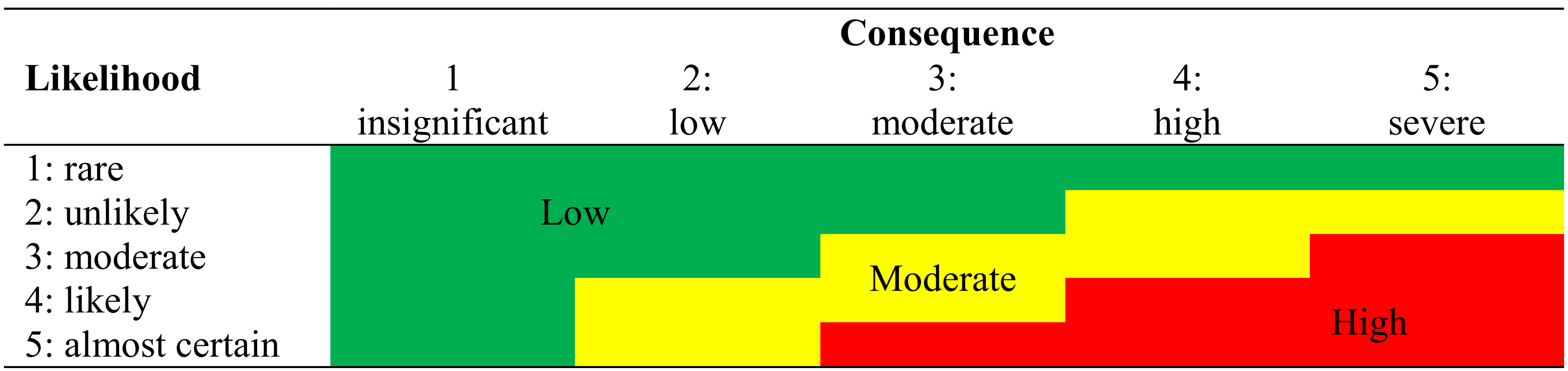


Figure 1 Risk matrix

Performance, risk and cost metrics

The values of the metrics were further assigned into three classes (Good, Fair and Poor), set based on the experience of key personnel.

Table Multi-criteria reference values

	Good	Fair	Poor
C1 (cost units)	[0, 350[	[350, 450[	[450, ∞[
C2 (-)	[0, 1[	[1, 1.5[	[1.5, ∞[
C3 (-)	]0.45, 0.55[	[0.30, 0.45[; [0.55, 0.70[	[0, 0.30]; [0.70, 1]
P1 (-)	[3, 2[	[2, 1[	[1, 0]
P2 (-)	[3, 2[	[2, 1[	[1, 0]
P3 (%)	[0, 5[	[5, 10[	[10, 100]
P4 (l connection^{-1} day^{-1})	[0, 100[	[100, 150[	[150, ∞[
R1 (%)	[0, 1[	[1, 5[	[5, 100]

Diagnosis

DMA 542 is a fairly stable area in terms of water demand; however, some new residential and office development permits have been issued.

A thorough hydraulic model analysis showed that this would not significantly impact the network.

A single scenario was taken into account, already including future water demand associated with the proposed developments.

A 6% annual increase in pipe failure rates was assumed.

Diagnosis

Table Diagnosis of the existing DMA 542 system at year 0, using the assessment metrics

	Assessment metrics							
	C1 (c.u.)	**C2** (-)	**C3** (-)	**P1** (-)	**P2** (-)	**P3** (%)	**P4** (l conn.$^{-1}$ day^{-1})	**R1** (%)
Diagnosis	0	1	0.5	3.00	0.00	37.2	116	2.0

Alternatives

A0: the status quo alternative - base case.

•Maintaining the existing network and a reactive capital maintenance policy (i.e. repairs after break only).

A1: alternative 1 - *like-for-like* rehabilitation practice.

•A higher priority given to pipes with higher risk of failure, replacing them with pipes with the same size. Replacement rate of 1 km/year, to fit the available budget.

A2: alternative 2 - optimal network design.

•It was taken into consideration in order to assess how much the existing configuration differs from an optimal configuration from the cost and energy viewpoints, under normal operating conditions.

Alternatives

A3: alternative 3 - A2 design with improved resilience.

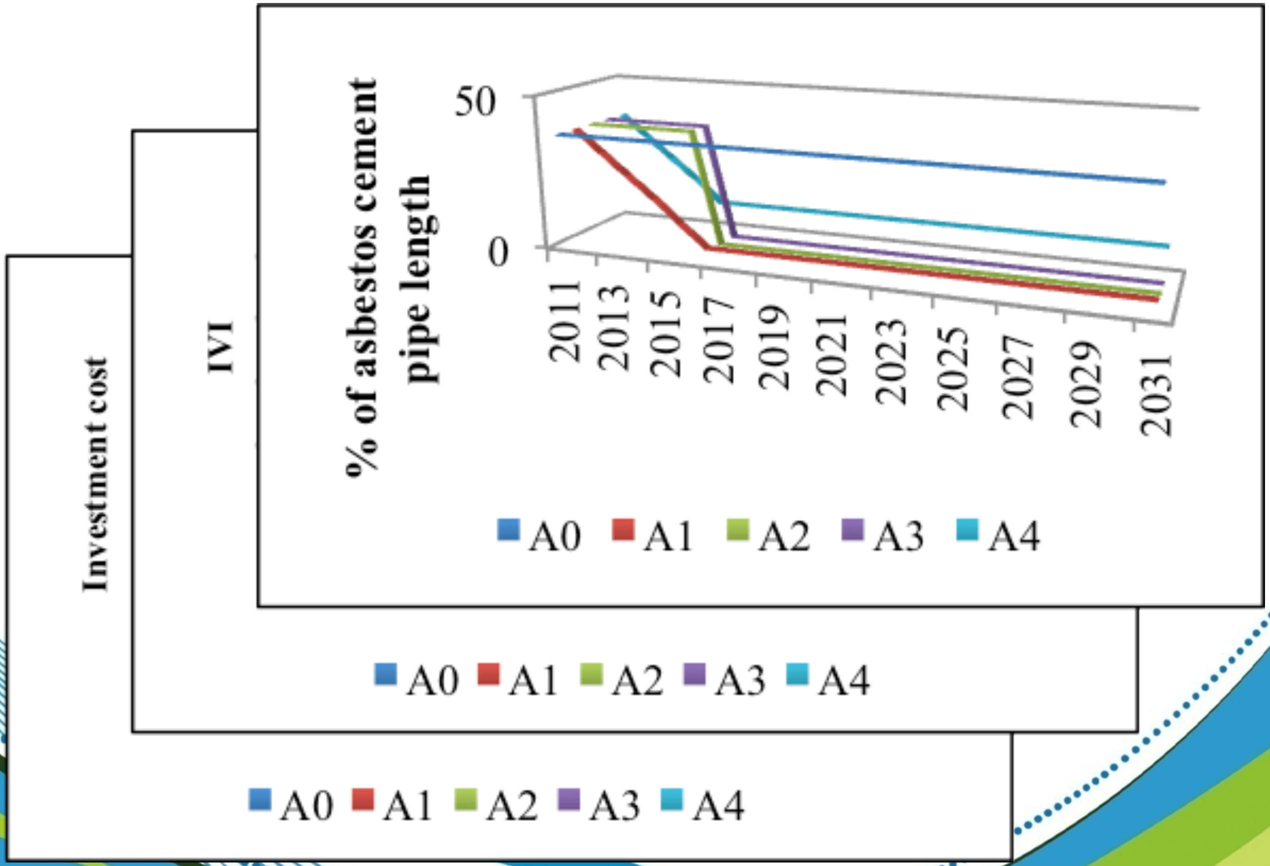
•The AWARE-P software's component importance model was used to identify critical pipes. This allowed for design adjustments such that demands can be adequately supplied in the event of a critical main failure or of a supply interruption from the current DMA source point.

*A4: alternative 4 - r*esulted from comparing A0 and A3.

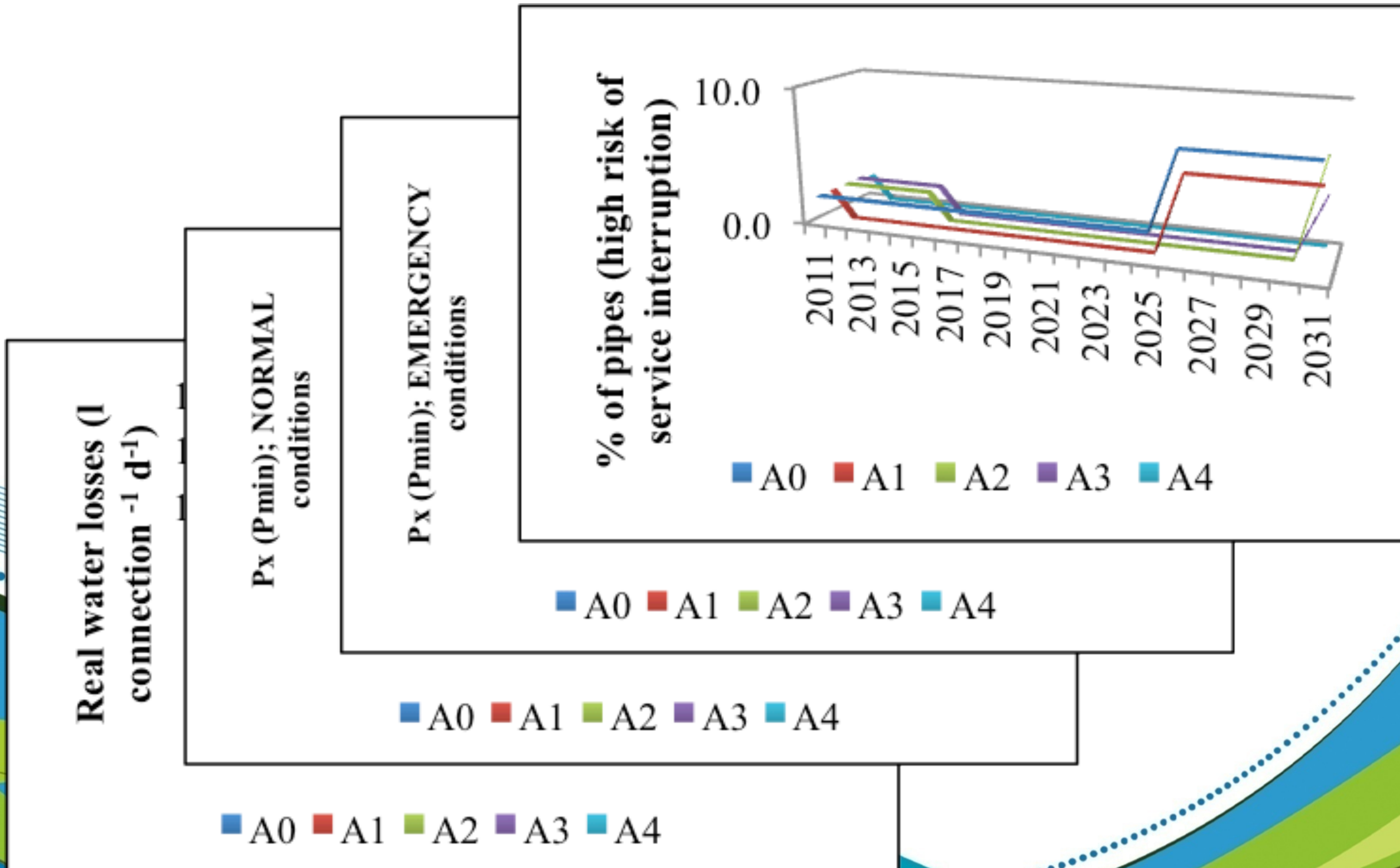
•In recent years the DMA had already been partially rehabilitated on a *like-for-like* basis, including pipe sizes that are now questionable. However, it would be unreasonable to start replacing newly laid pipes without good reason. Some minor new pipes were included, as in A3, to allow using the emergency source. Replacement of the asbestos cement pipes was scheduled based on relative importance, at a rate of 1 km per year.

Assessment of Alternatives

- 5 alternatives
- 5-year planning horizon
- 20-year analysis horizon



Assessment of Alternatives



Comparison of Alternatives

- Results at the end of the tactical planning horizon (year 5).

	Assessment metrics							
	C1 (c.u.)	**C2** (-)	**C3** (-)	**P1** (-)	**P2** (-)	**P3** (%)	**P4** (l conn.$^{-1}$ day^{-1})	**R1** (%)
A0	0	1	0.4	3.00	0.00	37.2	116	2.0
A1	243	1	0.7	3.00	0.00	1.5	51	0.0
A2	664	0.8	1.0	3.00	0.00	0.0	49	0.0
A3	729	0.9	1.0	3.00	2.97	0.0	49	0.0
A4	332	1.1	0.7	3.00	2.86	8.8	65	0.0

Comparison of Alternatives

The results at year 5 were ranked in two different ways:

Alternatives	Ranking I – w/o investment costs		Ranking II – w/ investment costs	
	Comparison results	Ranking	Comparison results	Ranking
A0	1.47	5	1.73	5
A1	2.12	3	2.16	2
A2	2.00	4	~~1.79~~	~~4~~
A3	2.50	**1**	~~2.13~~	~~3~~
A4	2.35	2	2.25	**1**

•Ranking I focuses mainly on the performance and risk metrics (the only cost metric included was C2). The purpose was to understand the potential for improvement of the existing system regarding performance and risk. In Ranking I, A3 is the best solution, followed by A4; it responds well in normal conditions, and better than the other alternatives in emergency conditions (as highlighted by significantly better values of P2). The worst alternatives are A0 and A2, revealing the shortcomings of the current network design and, in the case of A0, higher levels of leakage and the poor result in terms of C3 in the case of A2.

•Ranking II, the basis for the final selection, includes all assessment metrics and takes into consideration the limited available budget – if the investment cost of an alternative is higher than the available budget, then the alternative is outright rejected. Alternatives 2 and 3 are thus precluded. Of the three remaining, A4 is ranked first, then A1 and A0. A4 clearly corresponds to a good trade-off between performance, risk and cost; it sheds the network design deficiencies of A0 and A1 and, additionally, has better flexibility for emergency operation (as reflected by P2). It should be added that, after year 5, whenever a plastic pipe needs replacement, the corresponding A3 diameter will be adopted.

Final Remarks

- SMAS O&A are using this case as a model to prepare a new style of IAM tactical plan.

- The project has been an to review and improve data collection, data quality control, information management.

- The on-going process of creating a new asset accounting registry, more informative and fully coherent with the GIS – key in relating GIS, inventory and IAM analysis results.