

Leading-Edge Asset Management

# 2nd IWA Leading-Edge Conference & Exhibition on Strategic Asset Management

### Planning maintenance strategies for Italian urban drainage systems applying CARE-S

## Ugarelli Rita, Pacchioli M. & Di Federico V.

## Agenda

- •Brief introduction of CARE-S project
- •CARE-S: case study
- •The project
- •Results
- Discussion



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•CARE-S : Computer Aided RE-habilitation of Sewer networks computer based system designed for sewer networks rehabilitation planning.

#### •CARE-S provides

CARE-S

State of the art, condition of sewer assets, risk of failures Investment needs

Project prioritisation and technology recommendations

Behind CARE-S is European Commission and a number of forefront water research institutes of Europe and Australia



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# **CARE-S TOOLKIT**

- Predictable performance indicators
- Sewer condition classification and assessment tools
- Deterioration process tools
- Hydraulic performance tools
- Tools for socio-economic assessment
- Rehab multi-criterion decision-making tool

### CARE-S manager to integrate the tools

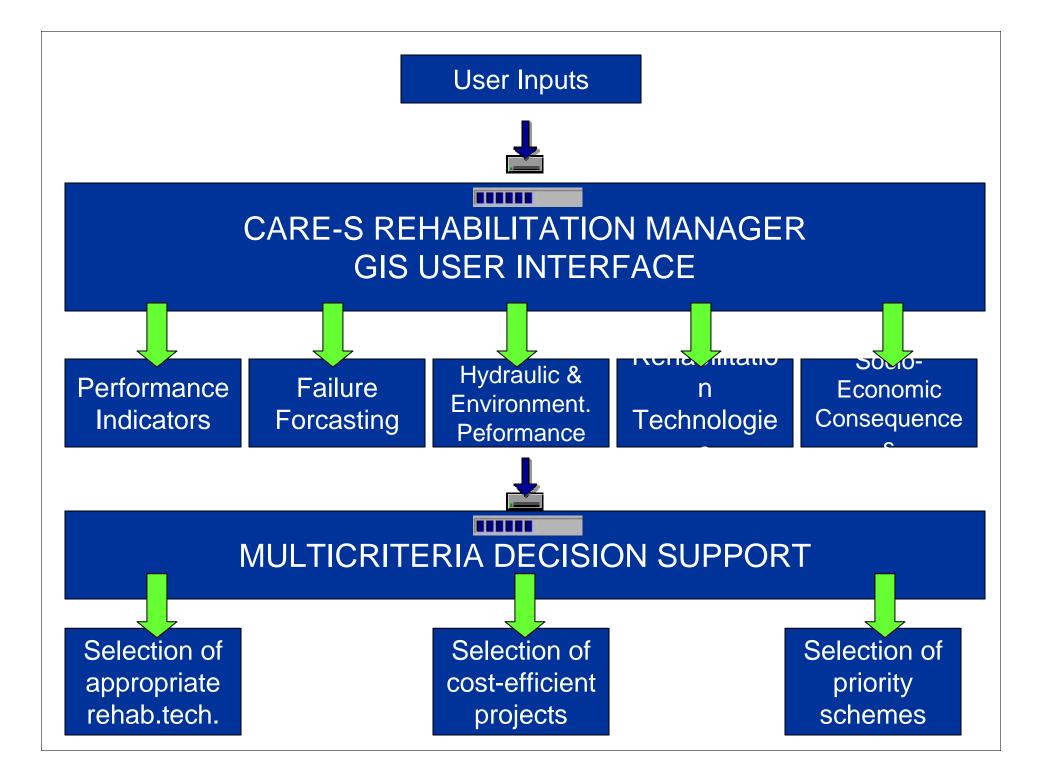


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# Area: Reggio Emilia hystoric centre



Utility: ENIA s.p.a – Reggio Emilia – Italy; very recently doubled its service area; merging with other companies to form a larger company

### 950 pipes 918 nodes Network Length: 30,161 km 30000 inhabitants



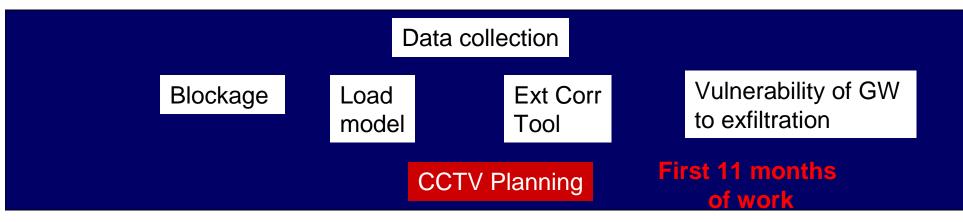
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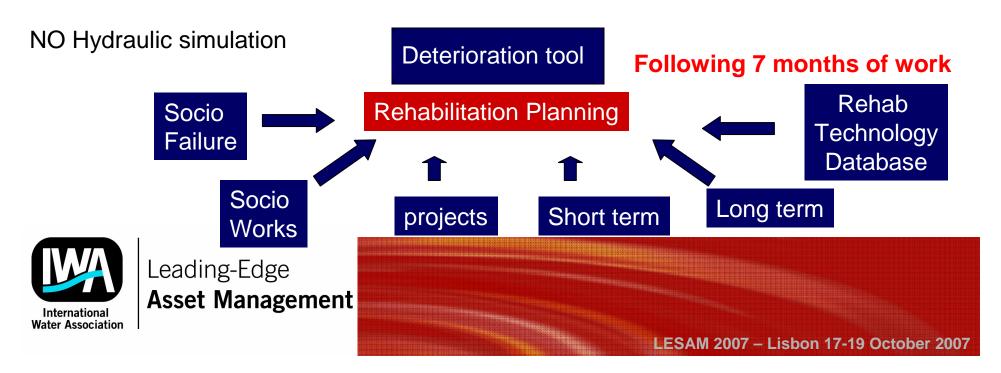






#### **Duration**: April 2006 – October 2007







## **Project – Data Collection**

-Shape files including Pipes characteristics:

- Pipe ID;
- US Node ID;
- DS Node ID;
- Material;
- Shape;
- Width;
- Height;
- Length;
- System Type;
- US Invert level;
- DS Invert level.



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557/950 pipes with wall thickness known- from literature –new pipes

enia

- Soil Only Silt and Medium sand
- Groundwater Level
- Maps (5,5 metres)

- Traffic Data
- number of lines for each road;
- road type;traffic flow

- Basements



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- Installation Year
   (627/950 pipes)
   Steps:
  - 1. Find the projects of wastewater (from 1930);



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- Installation Year (627/950 pipes)
- Only on paper sheet format Steps:







- Installation Year Only on paper sheet format
   (627/950 pipes) Steps:
  - 1. Find the projects of wastewater (from 1930);
  - 2. Analyse project referred to the hystoric centre;



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- Installation Year (627/950 pipes)
  - 1. Find the prc
  - 2. Analyse pro

Only on paper sheet format Steps:

storic centre;

from 1930);



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- Installation Year Only on paper sheet format (627/950 pipes)
   Steps:
  - 1. Find the projects of wastewater (from 1930);
  - 2. Analyse project referred to the hystoric centre;
  - 3. Project are referred to the streets, need of associating each project the correct Pipes ID manually.

## History of pipe installation

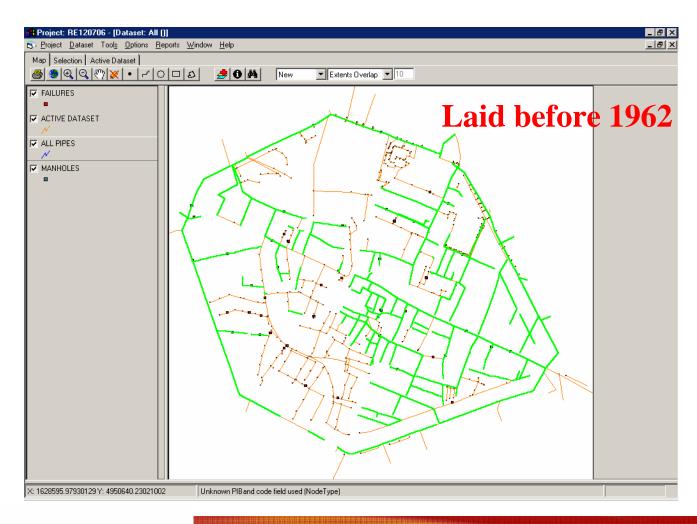


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## **Project – Data Collection**



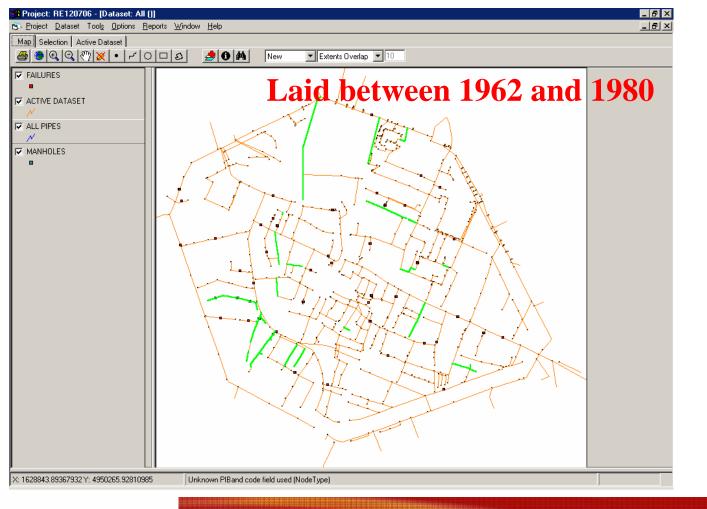


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## **Project – Data Collection**

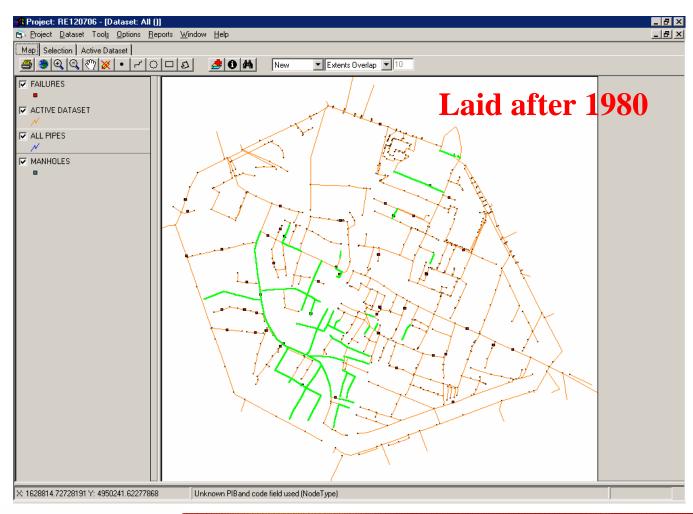




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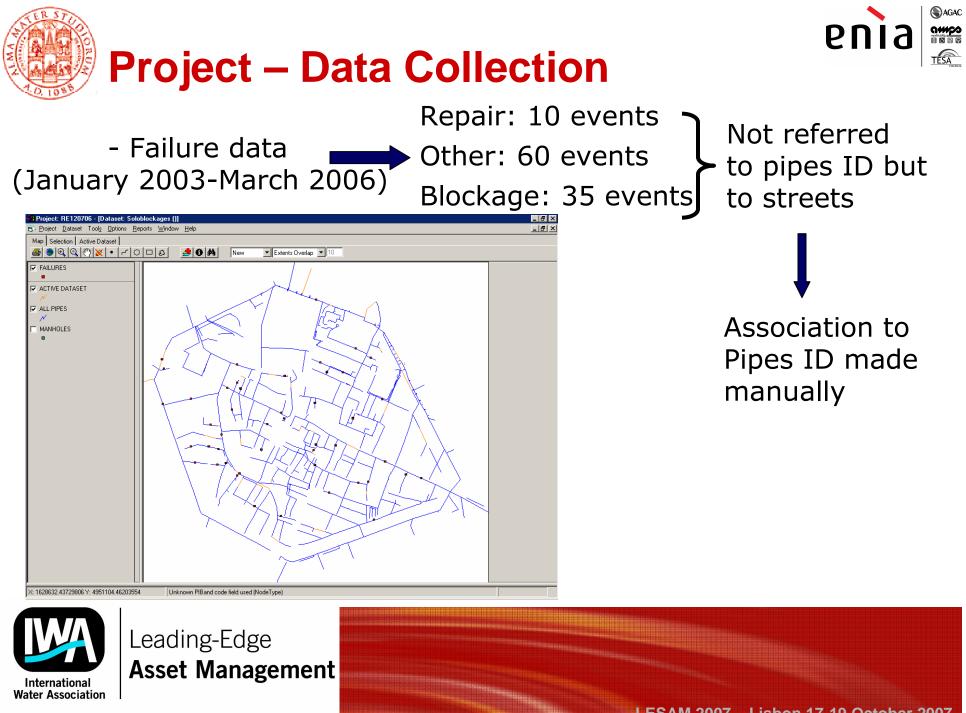








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Wa



### 39 Pipes inspected **Defect** Code registered manually

"Score" and "Current Condition Grade" computed manually

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	1	218	BAB	В		0	0	14	12		- IU	
	1	272	BAG			10	0	11	02		0	
	1	272	BAG			10	0	12	12		0	
	1	272	BAG			20	0	14	10		0	
	1	272	BAJ	В		0	0	48	1001		40	
	1	272	BCA			0	0	11	02		0	
	1	272	BCA			0	0	12	12		0	
	1	272	BCA			0	0	14	10		0	
	1	298	BCC	В		0	0	51.3			0	
	1	364	BBB	A		0	0	1	0507		0	
	1	417	BBB	A			0	21	0507		0	
	1	438	BAB	В			0	3.5	12		10	
	1	447	BCC	A		0	0	52.9			0	
	1	551	BAG			10	0	21.9	01		0	
	1	551	BAG			50	0	31.9	12		0	
	1	551	BCA			0	0	21.9	01		0	
	1		BCA			0		31.9	12		0	
	1		BBB	A		0	0		0507		0	
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	1		BAJ	В		0	0	36.8	1212		40	
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<u>.</u>		
FT	Fine Del tubo	BCE-A
GLD	Giunto leggermente disossato	BAJ-B
FPT	Foro nella parete del tubo	BAB-B
AMS	Allacciamento mediamente sporgente	BAG
CDD	Cambio di direzione verso destra	BCC-B
CDS	Cambio di direzione verso sinistra	BCC-A
OST	Ostacolo	BBE
MDGT		BAJ-A
	erators codes 🖊	BBB-A
		BDC
FSNR	·	BDC
ALS	Allacciamento leggermente sporgente	BAG
LST	Leggera scrostatura parete del tubo	BBB-A
LRPT	Leggera rottura parete del tubo	BAC-A
MAF		BAJ-C
LDGT	EN 13508 codes $$	BAJ-A
LDT		BAF-J
MIRA	Media infiltrazione di radici	BBA-A
GPG	Grave protuberanza materiale della giunzione	BAI-A
MPG	Media protuberanza materiale della giunzione	BAI-A
MRG	Media rottura della giunzione	BAC-A
AME	Allacciamento non correttamente eseguito	BAH + BC
GFDD	Grossa formazione di depositi duri nella giunzione	BBB-A
MRT	Media riduzione dello spessore della tubazione	BAF-J
L		•



Water Association

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ASSOCIAZIONE NAZIONALE MANUTENZIONE E SPURGO DELLE RETI FOGNARIE E IDRICHE



Ente Nazionale Italiano di Unificazione

Rita Ugarelli

18th of April'07 EN13508 translated and adapted to italian reality:

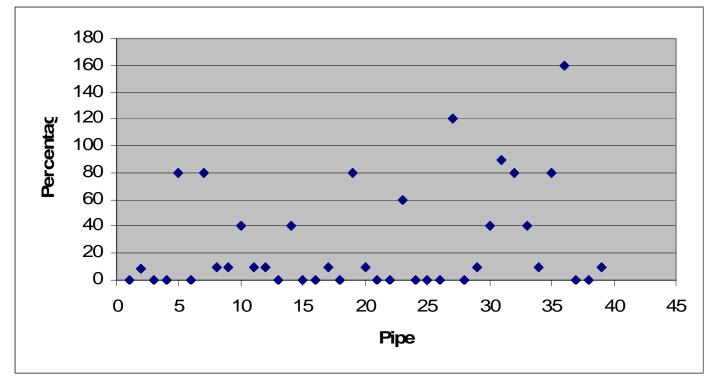
#### <u>Uni-ASPI Standard</u>



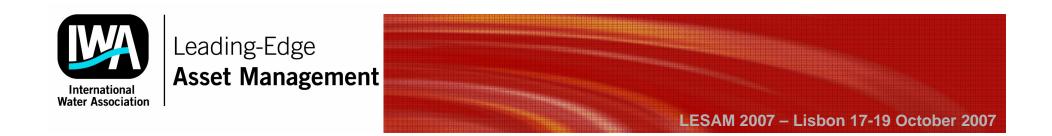


## **Project – Data Collection**

Condition grade	"Percentage"
5	220
4	170
3	80
2	10
1	0



### 26/39 pipes in c.g. 1-2

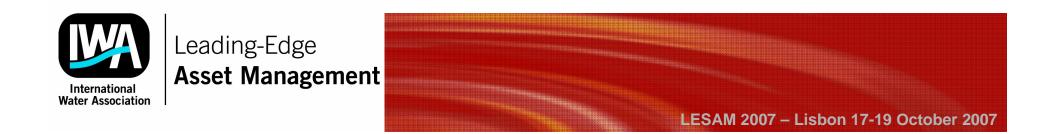






### **Pipes Burial Conditions**

- In order to run the 'load model' it was necessary to review projects from 1937 to understand pipes burial practice:
  - 1937-1950: pipes laid on reinforced concrete;
  - 1950's: main pipes laid on concrete with reinforcement in concrete for 2/3 of height and 10 cm of insole at the bottom; same for secondary pipes but without reinforcement;
  - 1980's: reinforced concrete turbo- centrifuged with a 20 cm insole and ¼ of Height reinforcement;
  - ... 1980's PVC appeared, filling material: compacted sand.







#### Current External Corrosion Rate (644 / 950 pipes analysed)

Selected water-cement ratio looking at different cement quality in time:

Parameter a (external corrosion in mm/year)						
	soil type					
moisture grade dry medium wet	non corrosive 0.01 0.05 0.01	medium corrosive 0.1 0.2 0.5	high corrosive 0.3 0.5 0.7			
Parameter b (pipe quality, water-cement ratio)						
resistance grade good medium poor water-cement ratio < 0,30 < 0,45 >=0,45						
ь		0.3 0.	7 1			

-	Quality of concret pipe (water-cement ratio)					
	ratio	year				
poor	>=0,45 including	1960				
medium	< 0,45 including	1975				
good	< 0,30 from	1976				

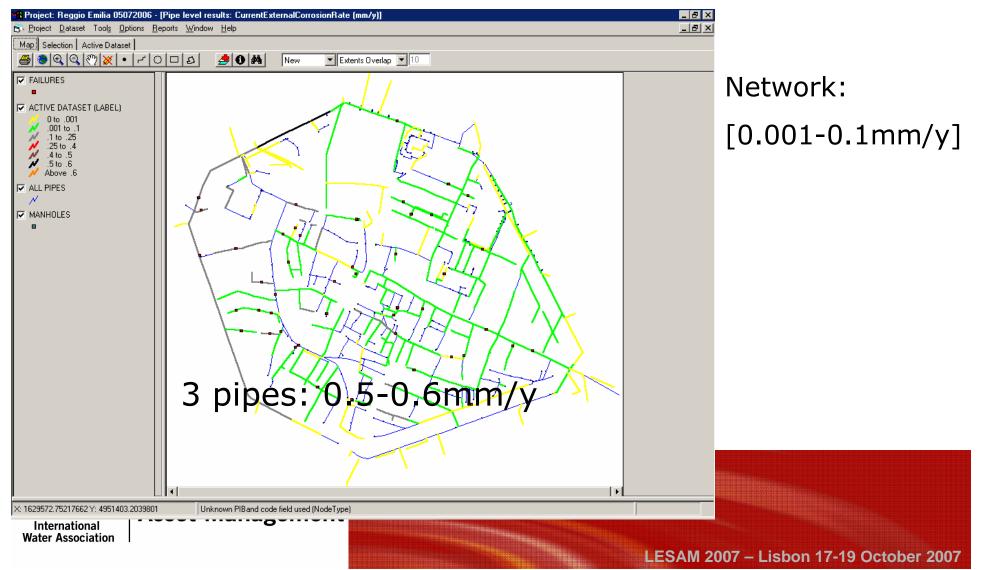


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#### Current External Corrosion Rate (644 / 950 pipes analysed)



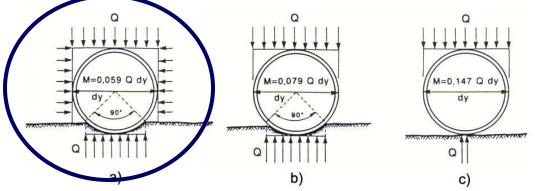


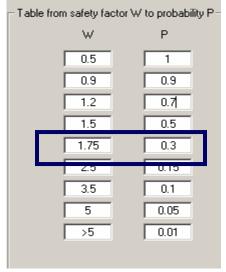


Predicted Probability of Collapse (301 / 950 pipes analysed)

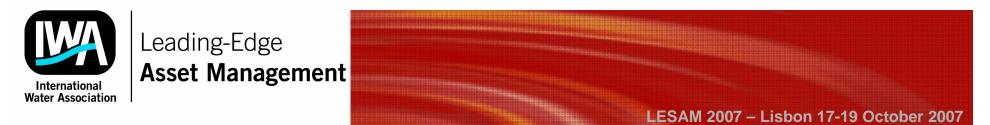
- Selection of pipes under high traffic load;
- Import results from Extcorrosion tool;

Imported info on different construction practices in time and compaction conditions;





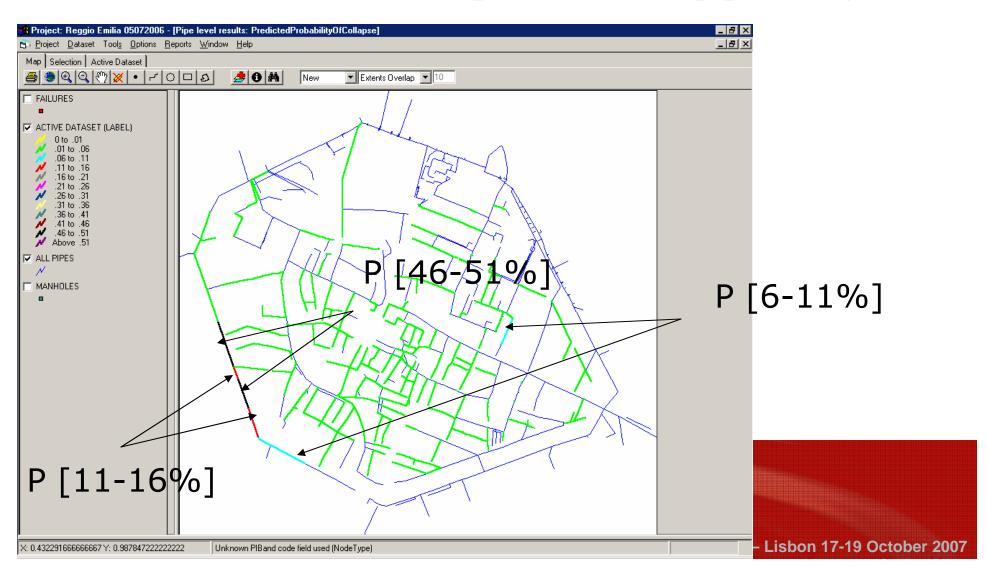
Definition of pipe design strength.Calibration of safety factor/probability







### Predicted Probability of Collapse (301 / 950 pipes analysed)







-groups and classes defined:

-Material	-System type	-Soil type:
-Steel	-Separated	-Sand
-Others	-Combined	-silt
-Cement		
-Concrete	Tractallations vesses	
-Reinforced concrete	Installation year: -1930-1970	
-Fiber concrete	-1970-2006	
-PVC		



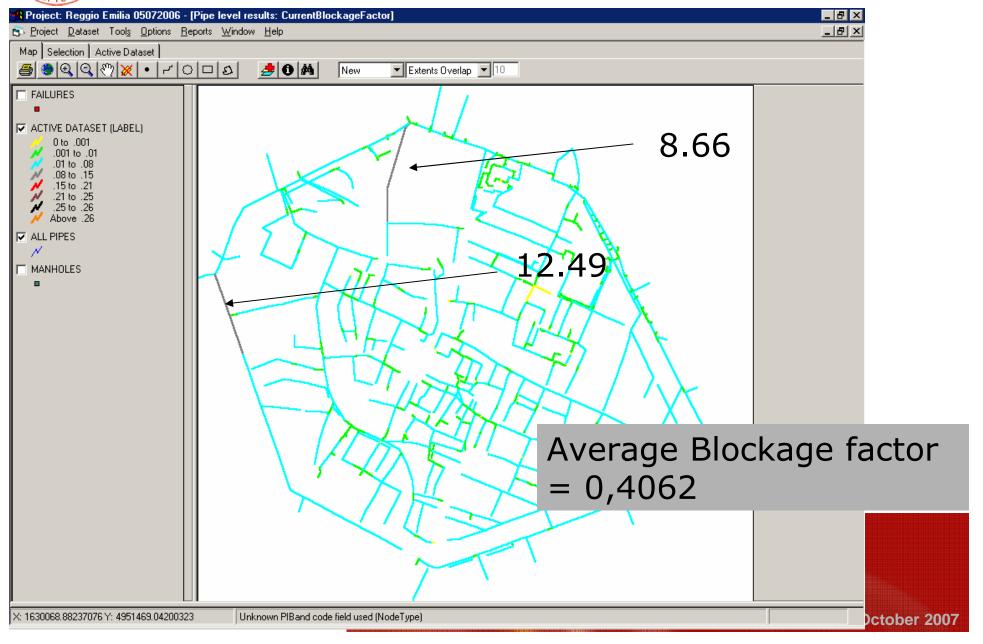
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# **Project – tools application**







### Groundwater vulnerability

Since no hydraulic simulations available we applied the Perm-Ground method.



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# **Project – tools application**







### **CCTV PLANNING**

CCTV PLAN BASED ON DIFFERENT CRITERIA:

- 1. LOAD, BLOCKAGE, EXTCORR AND GAT results;
- 2. Past rehabilitation and renovation projects (i.e. pipes with higher rehabilitation rate);
- 3. Traffic type and load (i.e. streets with bus)
- CCTV data (i.e. from previous CCTV pipes with fissures to be checked);
- 5. Material and burial conditions (i.e. select PVC pipes under high traffic load, or deeper depth (heavy load).







### **CCTV PLANNING**

CCTV plans for single criteria or combining criteria have been suggested.

Including ALL the criteria 2986km (51 pipes) have to be inspected.

ENIA completed the inspections as outsourcing projects





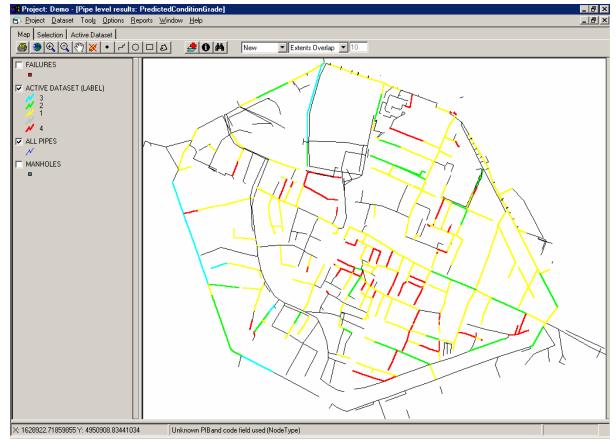
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## Predicted Condition Grade (CG) at 2011

For the 483 pipes of the analysis, 330/483 pipes in CC1, best case, 30/483 in CC2, 6/483 in CC3 and 117/483 in CC4, the worst case.





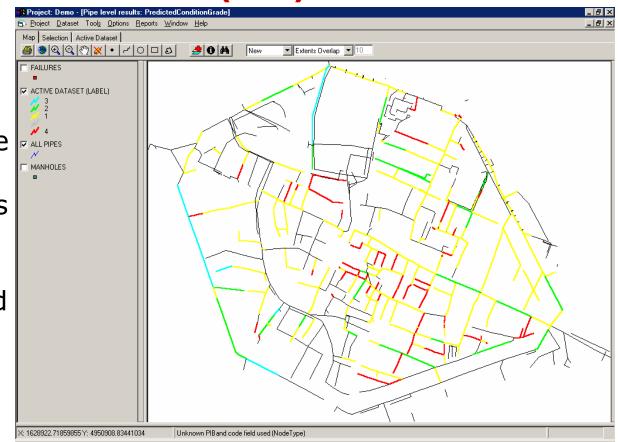
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## Predicted Condition Grade (CG) at 2011

Looking at the worst case (CC4), the most representative material is Gres (64 pipes - 1759 metres) then PVC (52 pipes - 1026 metres) and Concrete (1 pipe - 52 metres).





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### Time horizont: 2040

Long term analysis (SRS tool):

- 2 strategies have been compared
- 1. Strategy length
- 2. Strategy budget



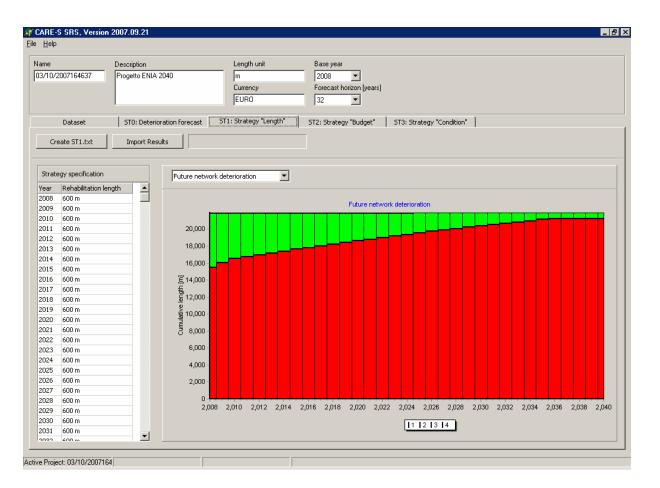
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## Project – Strategy 1 : Length

Testing hypothesis: Strategy: 600m/year Cost: 600€/m

Future network deterioration





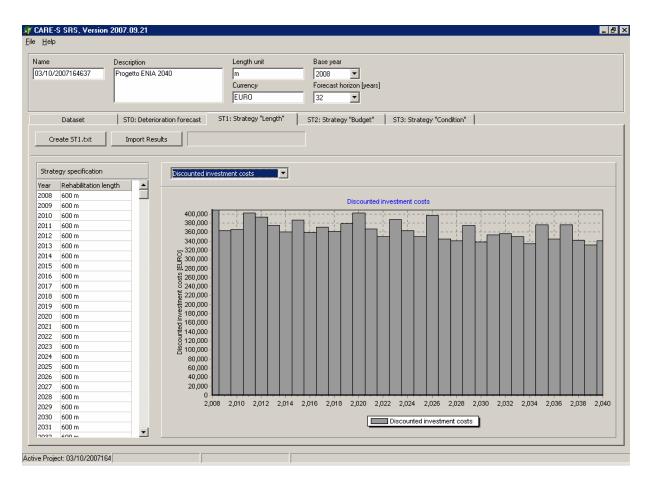
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## Project – Strategy 1 : Length

Testing hypothesis: Strategy: 600m/year Cost: 600€/m

Discounted investment costs





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# Project – Strategy 1 : Length

Testing hypothesis: Strategy: 600m/year Cost: 600€/m

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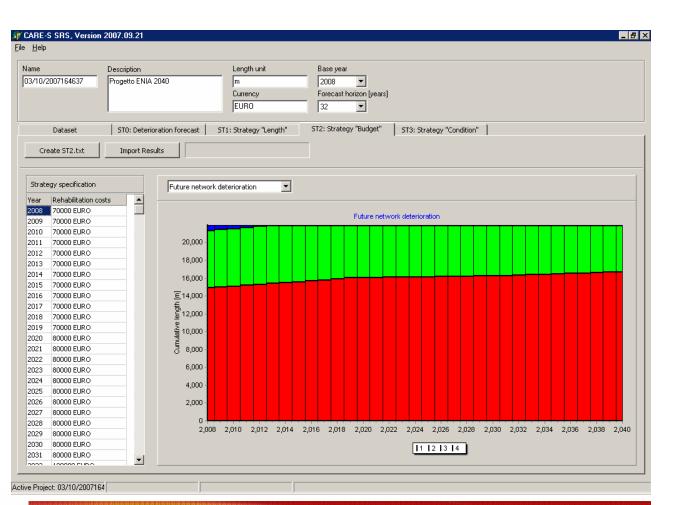
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Strategy: 70000€/y until 2019 80000€/y until 2031 100000€/y until 2040

Future network deterioration





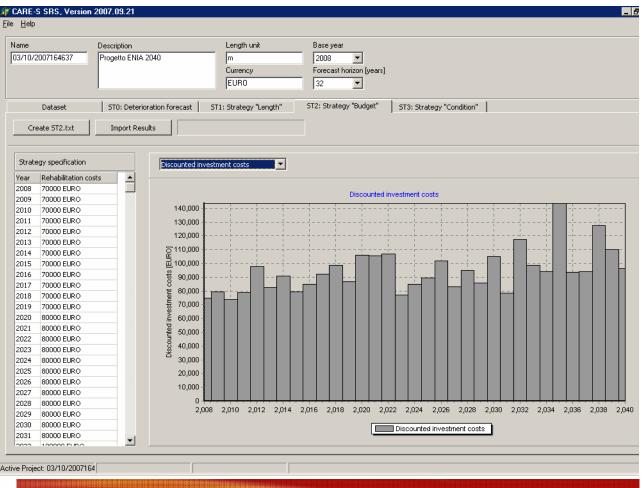
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#### Strategy: 70000€/y until 2019 80000€/y until 2031 100000€/y until 2040

## Discounted investment costs



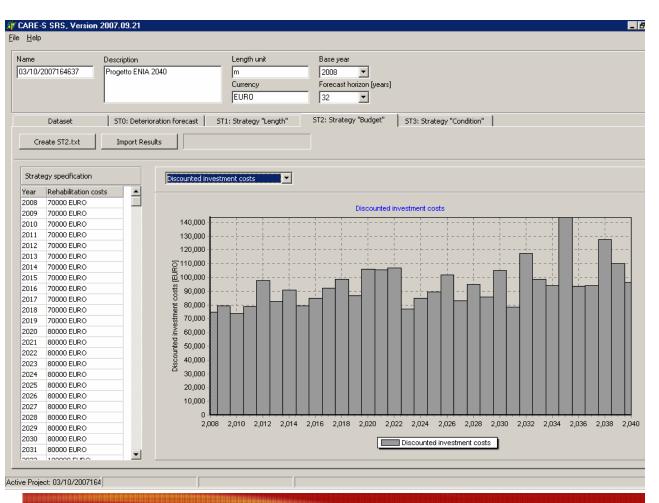


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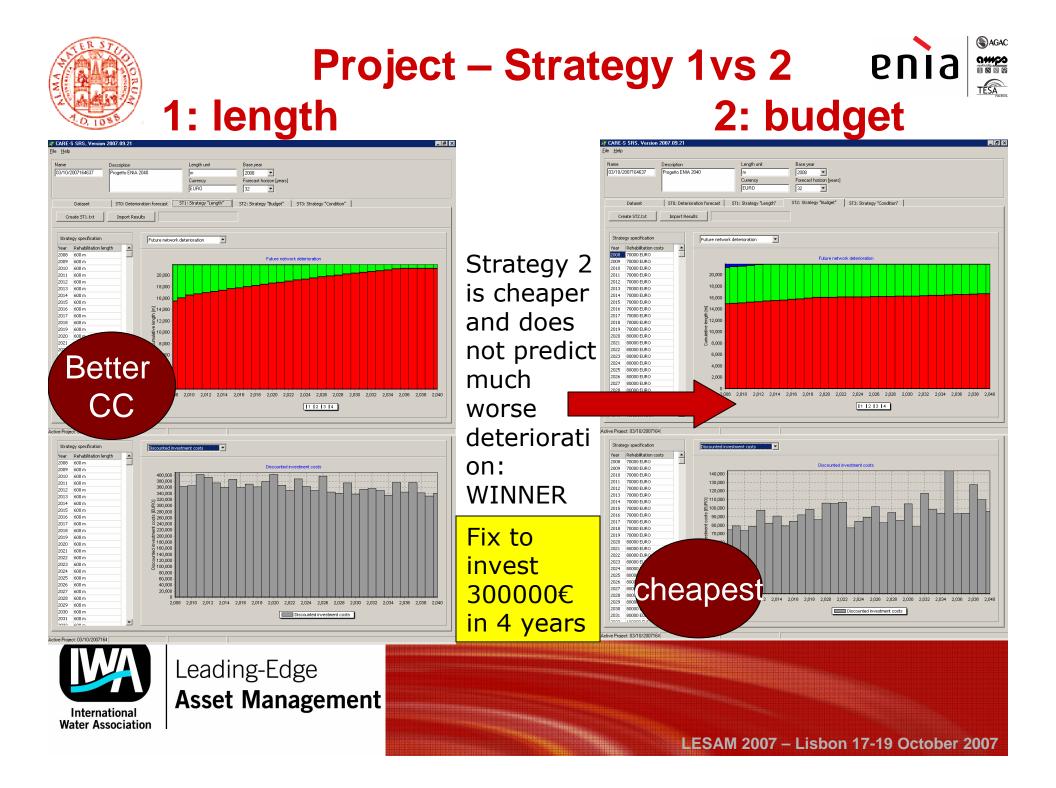


#### Strategy: 70000€/y until 2019 80000€/y until 2031 100000€/y until 2040





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# Project – Selection of priority pipes Pnia

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Filters :

- •CC = U; CC = 1; CC = 2
- •Diameter < 400mm
- •Diameter > 900mm
- •Sewer type & material "unknown"
- •ExtCorr < 0.07mm/y
- •Probability of collpse < 0.3



Leading-Edge Asset Management

# Project – Selection of priority pipes Pnia

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Filters :

- •CC = U; CC = 1; CC = 2
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- •Probability of collpse < 0.3

Priority of rehabilitation for: 16 pipes = 887 metres = 2,71% of net Estimated cost (600€/m): € 532200 >>€300000



Comparison of Rehabilitation technologies:

- •CIPP: € 328000
- •Trench: € 407000

Note: the hypothesis of  $600 \notin m$  was too high since the computed investment (532200 $\notin$ ) >> fixed budget (300000 $\notin$ )

Instead of reducing the number of pipes with priority of rehabilitation (16) a cheaper rehabilitation technology can be chosen, CIPP.



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Sociofails (impact of failures on customers/inhabitants) has been applied to the 16 pipes for 3 criteria (to start):

ICF service interruption

ICF wastewater dry weather flooding on street

ICF odours, rodents insects

PipeID ICF service interruption ICF wastewater dry weather flooding on street ICF odours, rodents insects 62 0.146166602 0.031321415 0.033682635 64 0.096917548 0.030279795 0.258097166 For 2008 114 0.032684072 0.013927872 0.180899296 167 0.103719755 0.01983675 0.104051297 we 0.044288364 0.485054348 173 0.133160348 180 0.003076254 0 0.049227799 prioritize 265 0.211342647 0.025281176 0.013946952 4 pipes =379 0.062001968 0.006992703 0.013047483 433 0.035888193 0.015973973 0.213576858 307 m 443 not calculed not calculed not calculed 0.066230106 505 0.484834389 0.044035821 545 0.128895939 0.03933752 0.064867157 625 0.046843447 0.006928138 0.005674232 899 not calculed not calculed not calculed 918 0.088796363 0.038991377 0.086328125 1015 not calculed not calculed not calculed Leading-Edge **Asset Management** International Water Association



Socioworks (impact of works/intervenitions on customers/inhabitants) has been applied to the 1 of the 4 pipes selected (for example)

EX: pipe 505 = 165 m

Impact of 3 technologies compared

Technology ID	Rehabilitation Technique	Day or night work	Duration value (days)	ICW noise	ICW dust	ICW pollution of ground water	ICW service interrupti on	ICW road traffic disturbance	ICW loss
16	in situ repair	d	110.10	0.00	0.00	0	0.00	817,492.50	1,998.32
16	in situ repair	n	110.10	0.00	0.00	0	0.00	245,247.75	599.49
38	CIPP hot water cure	d	2.06	0.00	0.00	0	0.01	16,060.28	49.35
38	CIPP hot water cure	n	2.06	0.00	0.00	0	0.00	4,818.08	14.81
42	conventional trench	d	33.03	0.17	0.17	0	0.17	33,814,462.50	458,211.98
42	conventional trench	n	33.03	1.72	0.09	0	0.04	10,144,338.75	137,463.59

CIPP has the lower impact and quicker, in addition we are working in the historical centre of Reggio Emilia (historical pavement)



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### **Further work**

- Complete the analysis of different possible strategies in long and short period comparing investment needs, impact of failures and interventions on customers, improvement or deterioration of the network following different rehabilitation criteria and
- Provide the Utility with alternative solutions...



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## Conclusion

 The Reggio Emilia case study has been presented: first italian complete application of CARE-S;

•Applying Asset Management practice in reality is a challenge due to the need to re-build utilities databases and rehabilitation philosophy before being able to start the application of AM.

 The Utility ENIA took advantages from this experience recognising the need of improving the data collection practice, in defining areas and/or priority components and in comparing their usual practice with alternatives.



Leading-Edge Asset Management









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