

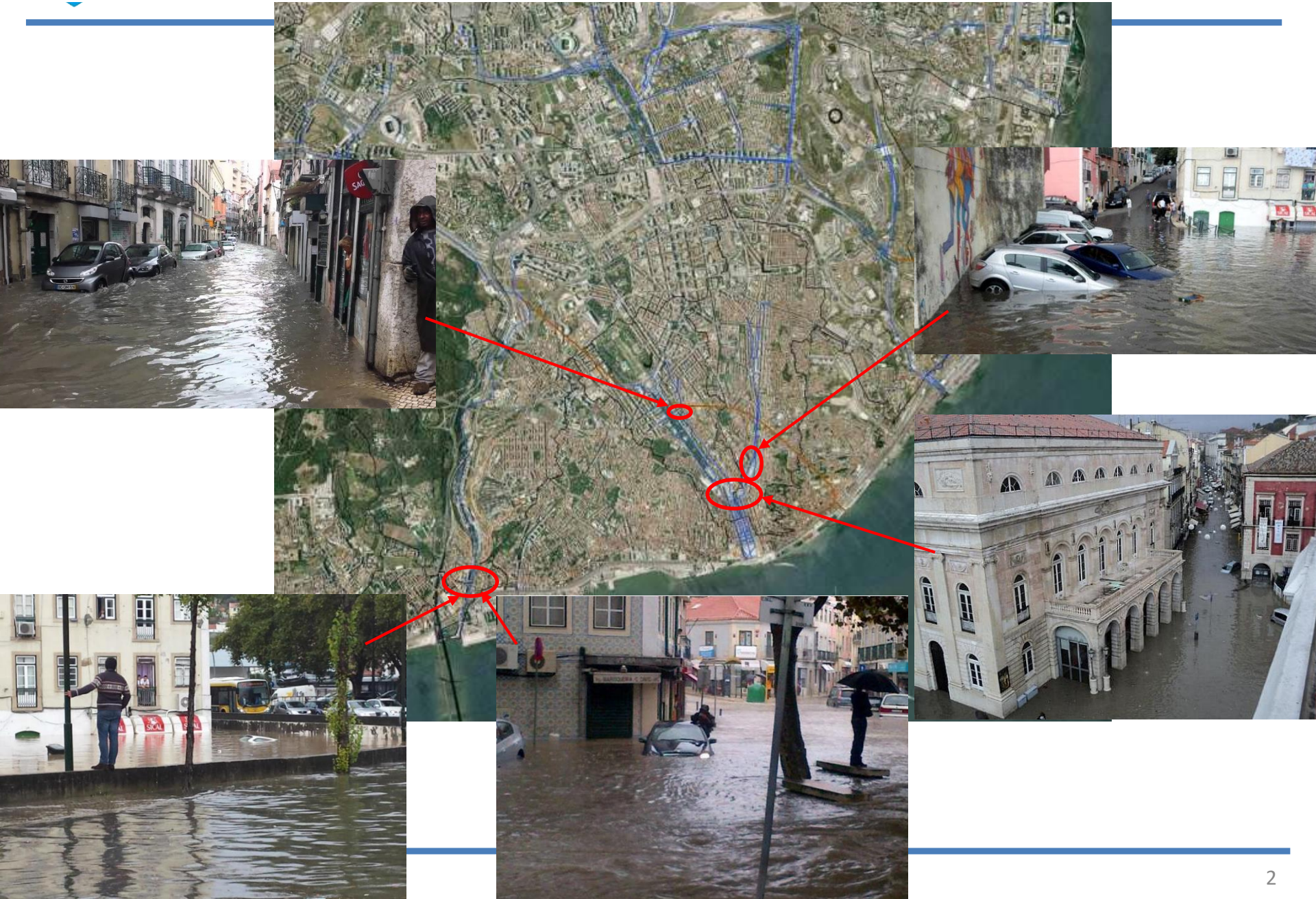
LISBON DRAINAGE MASTER PLAN

António Jorge Monteiro

José Saldanha Matos

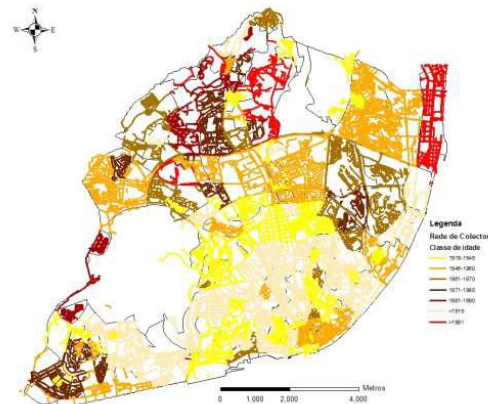
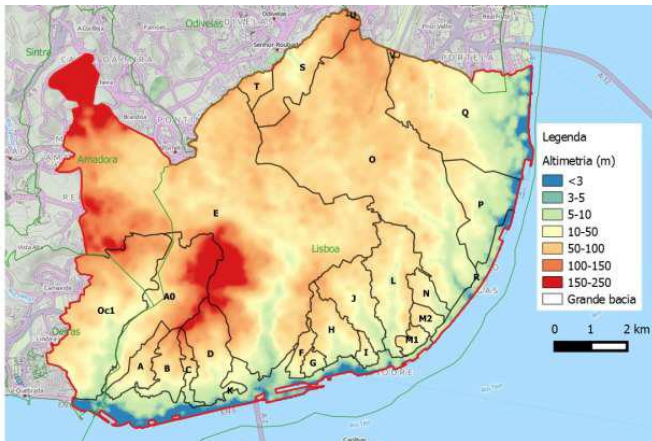
**PLANO GERAL
DE DRENAGEM
DE LISBOA** 2016 - 2030

Urban Flood Problem



Assets. Intervention Principles and Strategies

- Infrastructures buried as “life lines”.
- The value and complexity of the buried assets (1450 km of sewers with a replacement value estimated in EUR 950 million).



Saimel (Pombalino)



Cascões



Oval



Retangular



Circular (grés cerâmico)



Arco abatido

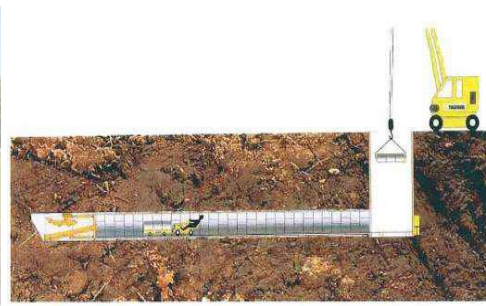
Assets

- Aging and need for renewal
- Urban Metabolism –Analogy between collectors and arteries: Cholesterol and biological film / sediment; Collector thrombosis/collapse; heart attacks/ power failures.
- Renew is required - **rehabilitation** of infrastructure and **adaptation** to new challenges (drainage flows).

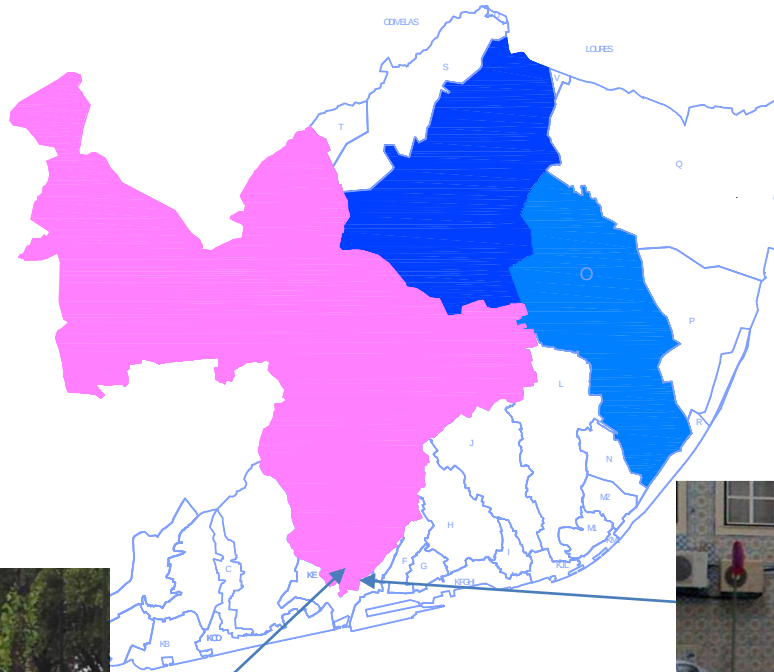


Intervention principles for planning

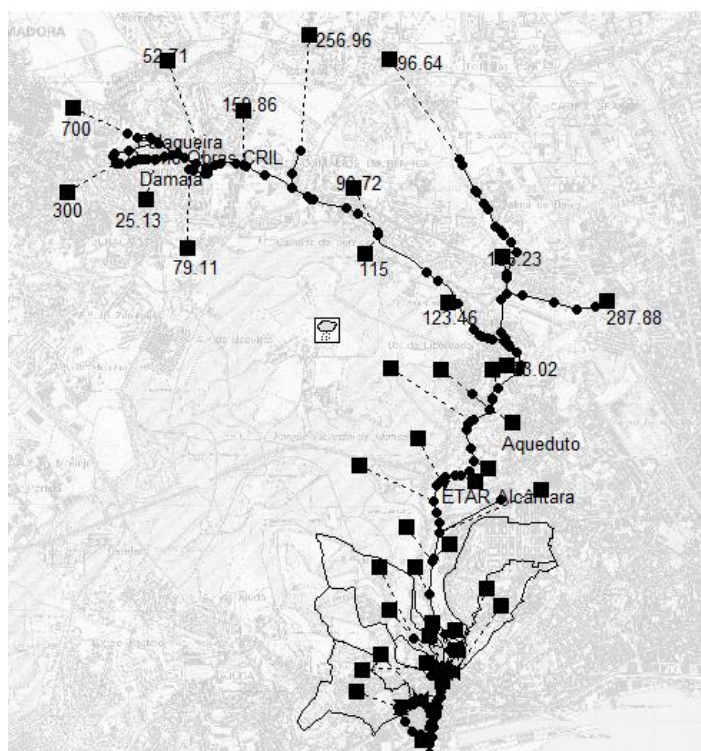
- Emphasis on **rainwater drainage** (flood control to serve people).
- **Minimization of major interventions** in a consolidated urban environment.
- Focus on the most cost-effective interventions (priority).
- Principle of combination of **structural solutions** with minimal surface impact (ie tunnel flow diversion) with **complementary decentralized solutions** (source control, retention ponds) and information to support smart management (monitoring and warning, training and capacity building).



Alcântara Bassin:

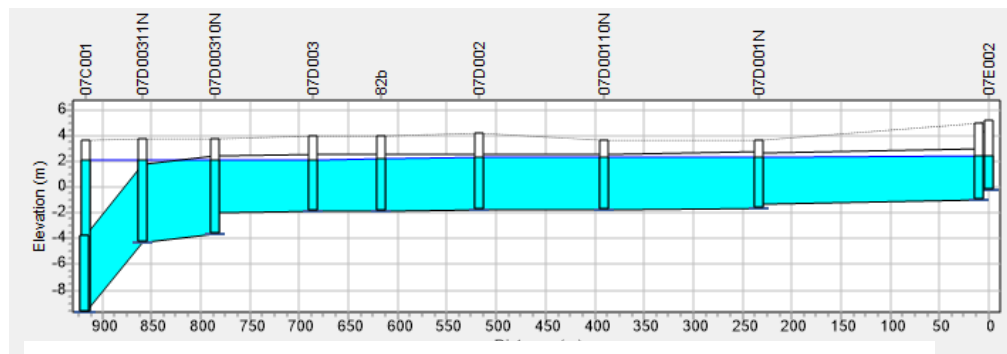


Alcântara Bassin: Dynamic Simulation Performance

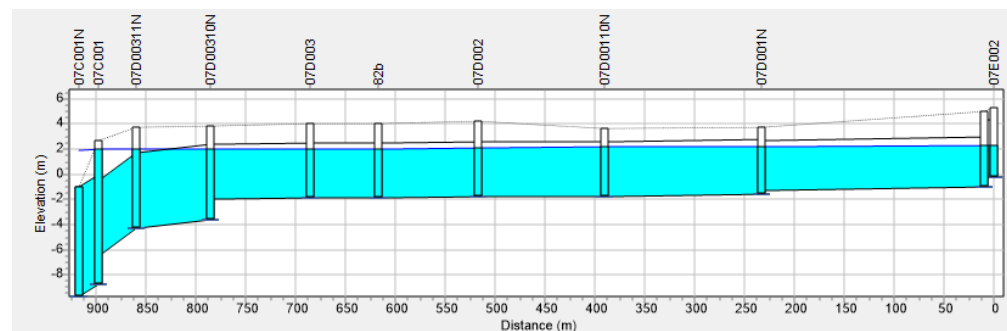


Dynamic Modelling: Present, T=10 years, $N_{tide}=1,95m$ e $1,00m$

Longitudinal Profile– without enlargement in final section of main sewer



Perfil Longitudinal – com alargamento na secção final do Caneiro



Maxim Flow main sewer final section:

Without discharge enlargement

A) Tide 1.95m: $85 \text{ m}^3/\text{s} < 140$

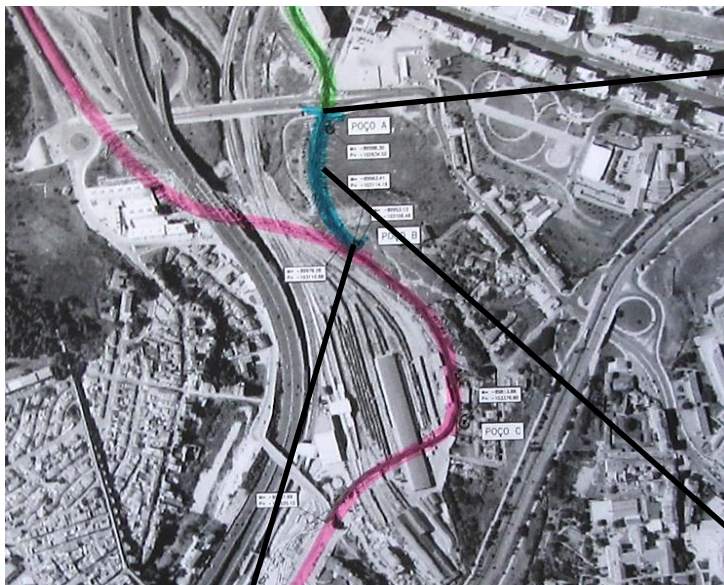
B) Tide 1m: $125 \text{ m}^3/\text{s} < 140$

With discharge enlargement

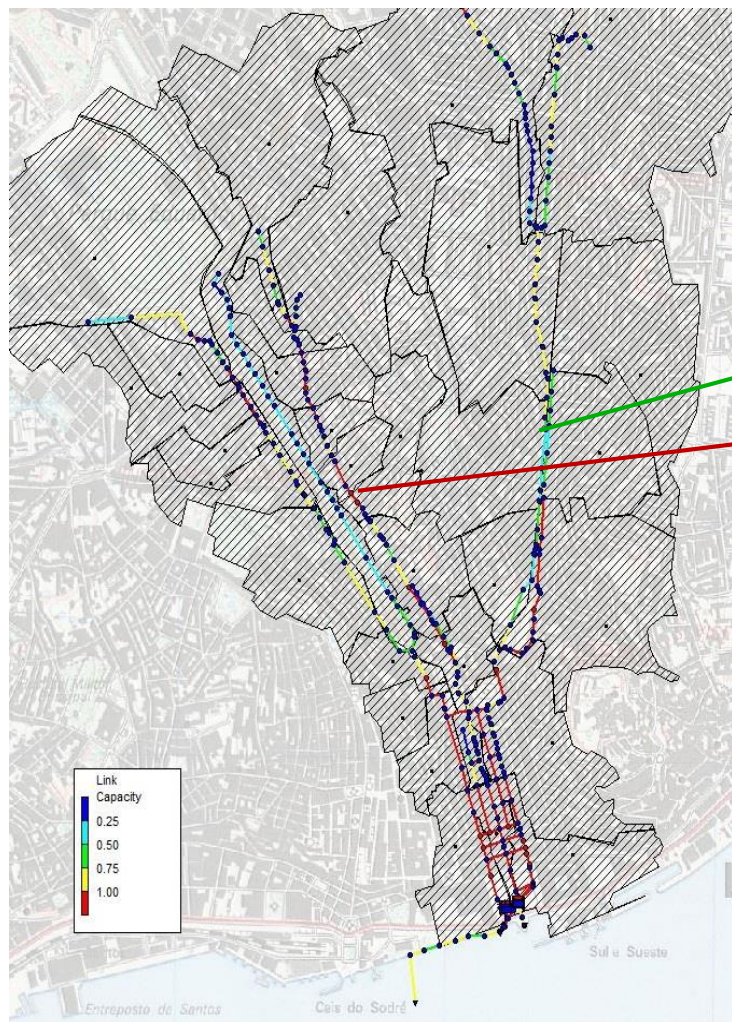
A) Tide 1.95m: $92 \text{ m}^3/\text{s}$

B) Tide 1m: $132 \text{ m}^3/\text{s}$

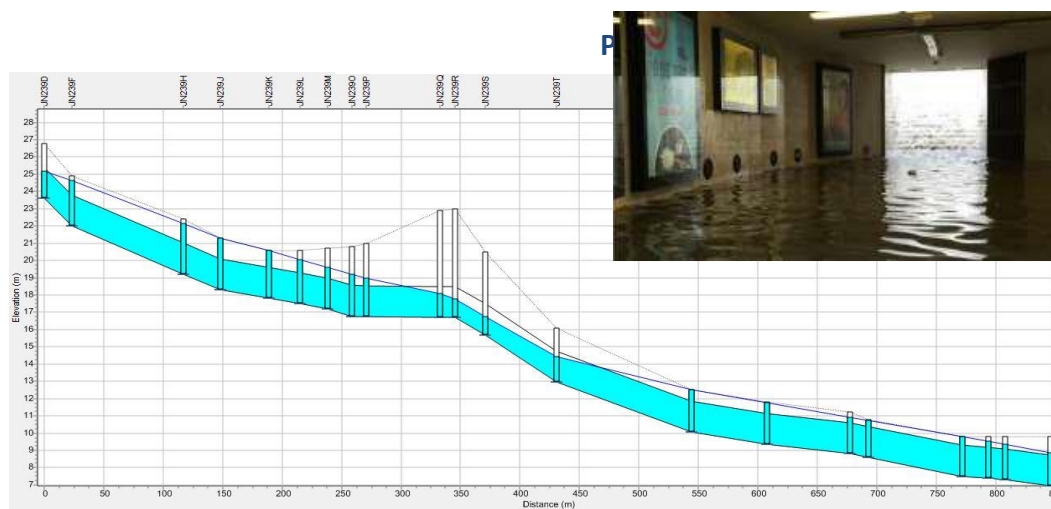
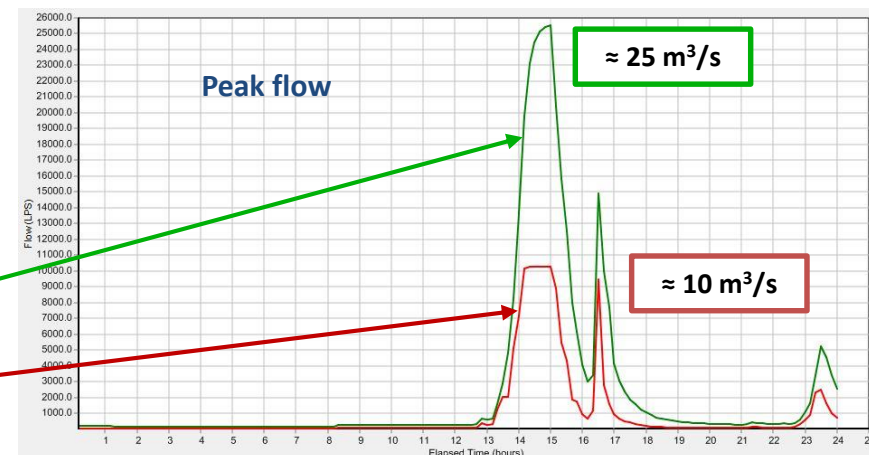
Caneiro de Alcântara (Main sewer)



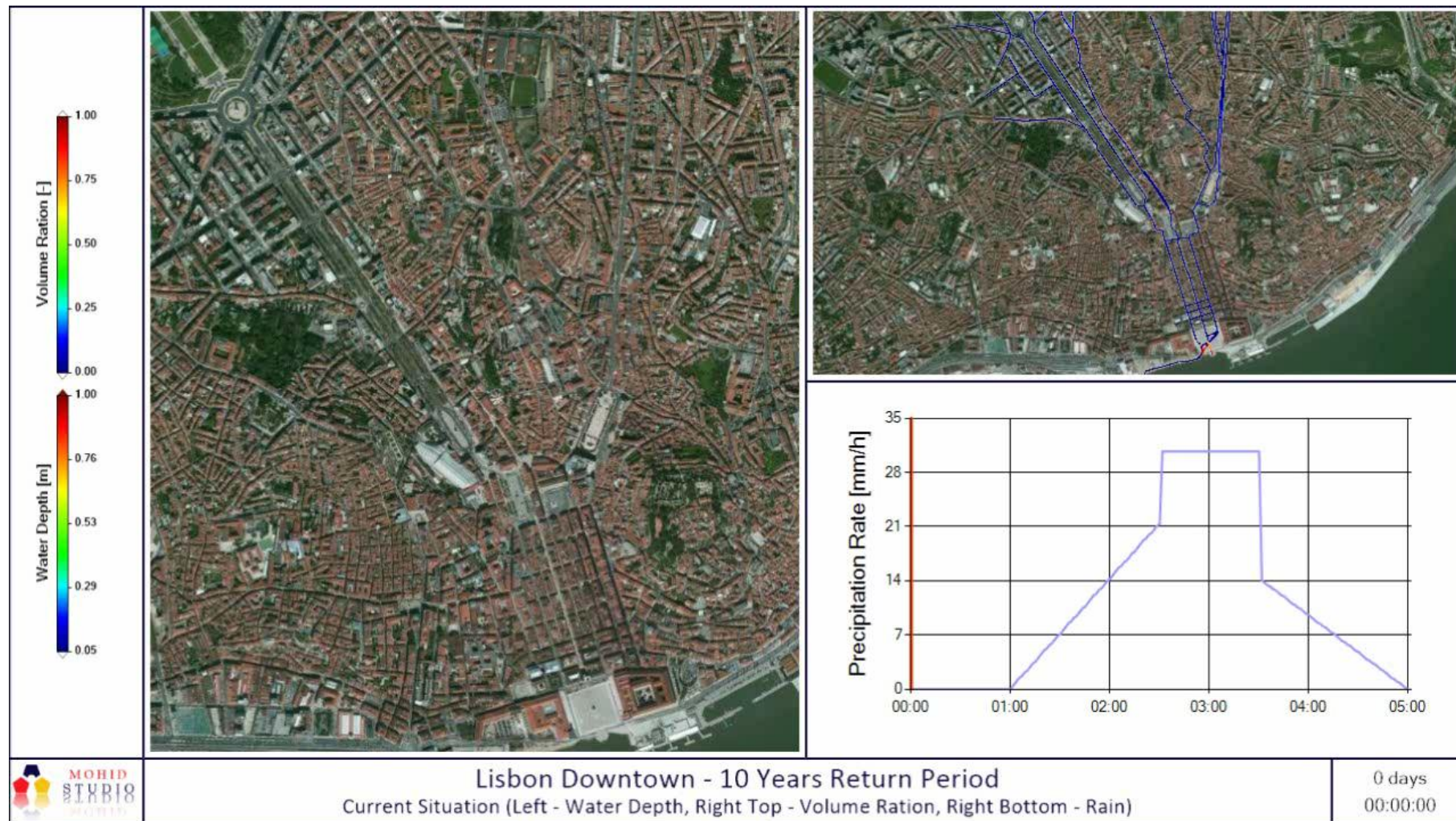
Bassins of Av. Almirante Reis and Av. da Liberdade: Performance



Dynamic Modelling: Present, T=10 years, N_{tide}=1,95m

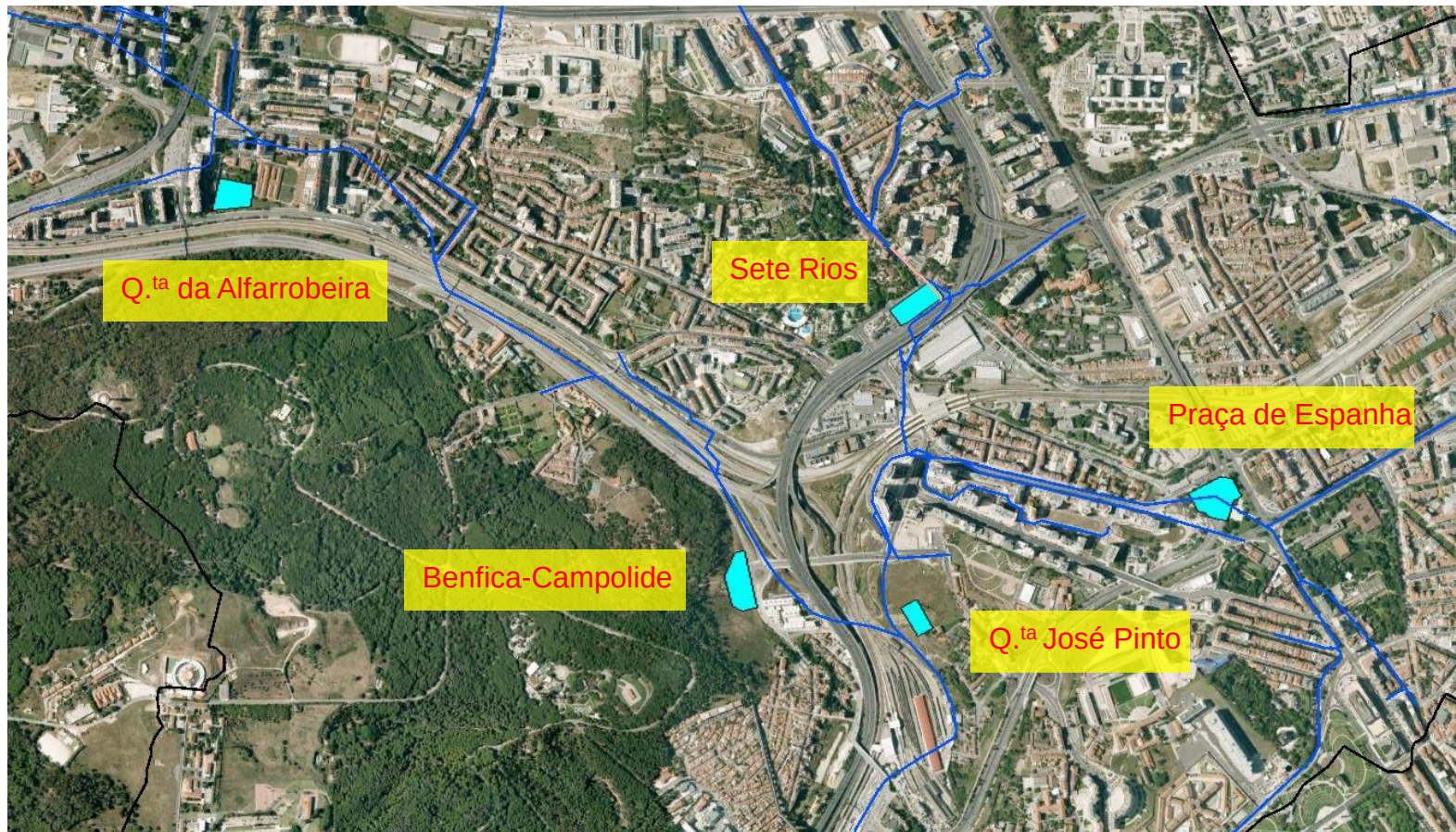


Dynamic Modelling: Present situation, $T=10$ years, $N_{\text{tide}}=1,95\text{m}$



Alternative Solutions in Lisbon:

- A (emphasis on reinforcement of sewers);
- B (emphasis on storage) Storage volumes on Alcântara basin (150 000 m³)



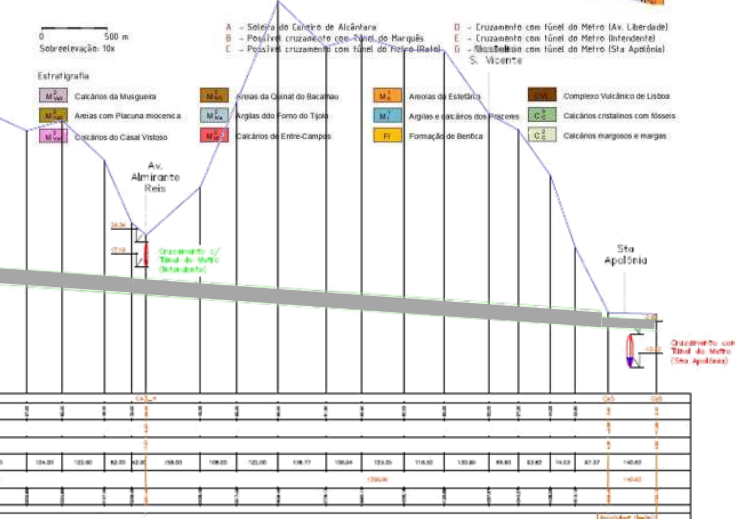
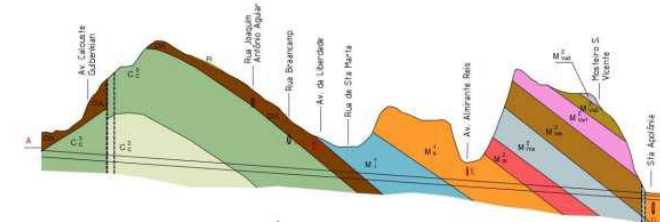
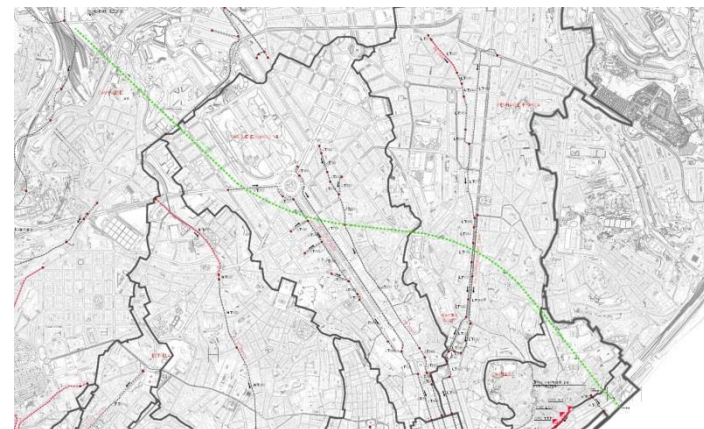
Recomended Solution (C): Flow deviation

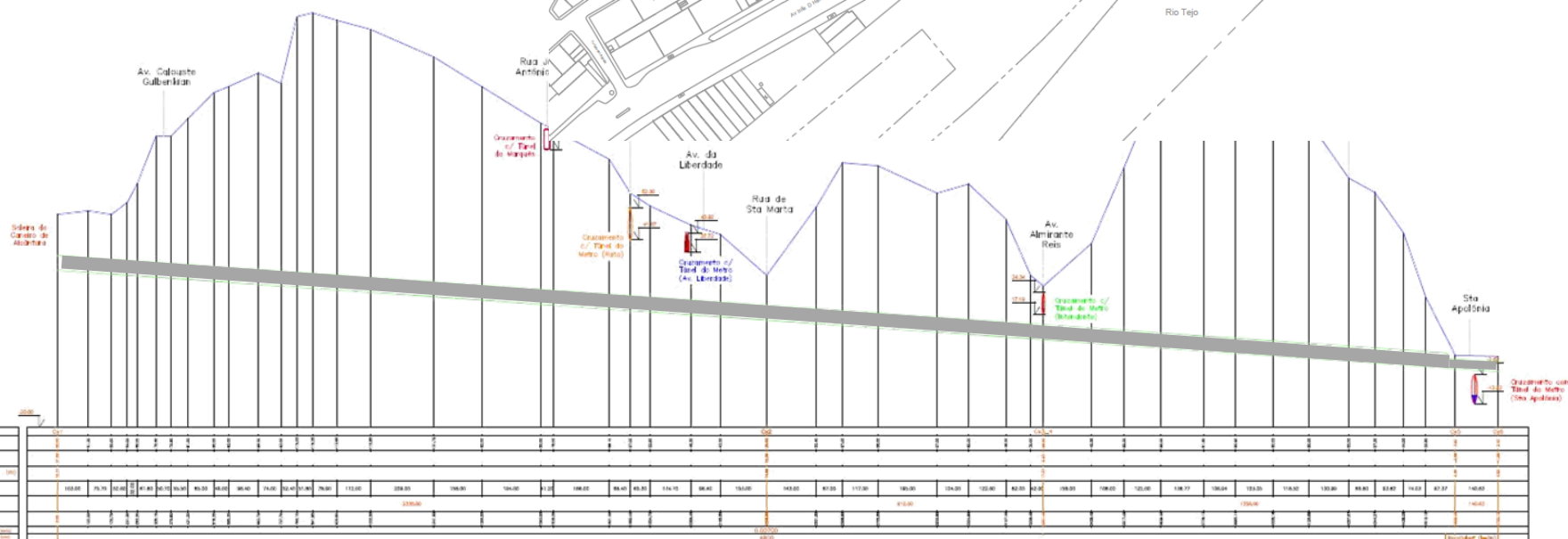
TUNNEL CAMPOLIDE – STA MARTA- STª APOLÓNIA



Solution: Tunnel by-pass (multifunctions)

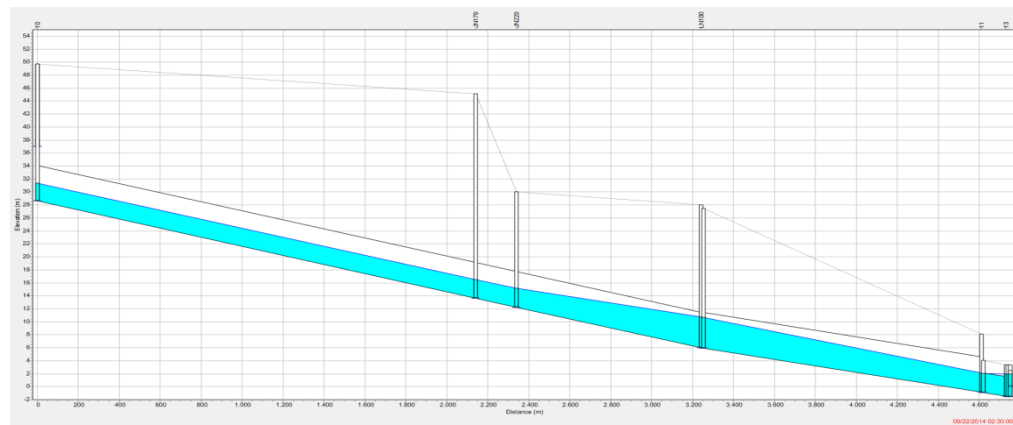
- Tunnel length 5 km
- Diameter 5,5 m (include piping for water reuse)
- Average slope: 0,5 e 0.7%
- Capacity > 130 m³/s;



 $V < 2 \text{ m/s}$ 

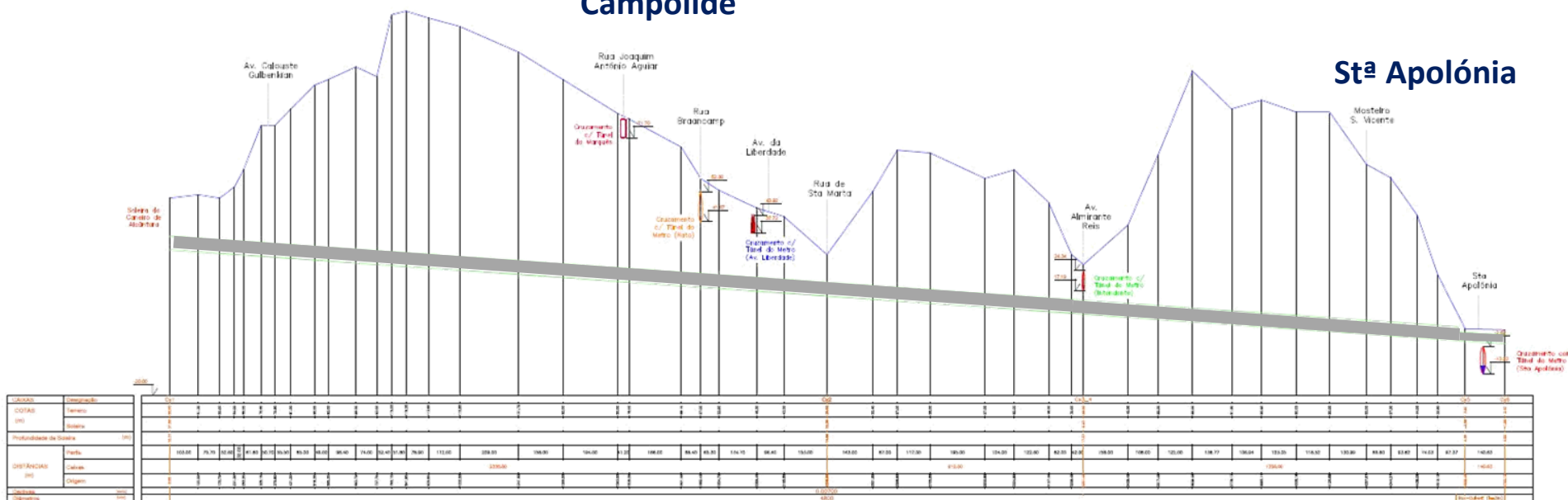


Deviation of the Main Sewer (Caneiro) of Alcântara flow from 3 to 4 m³/s (up to that amount goes directly to the WWTP), and up to about 100 m³/s.



Campolide

Stª Apolónia



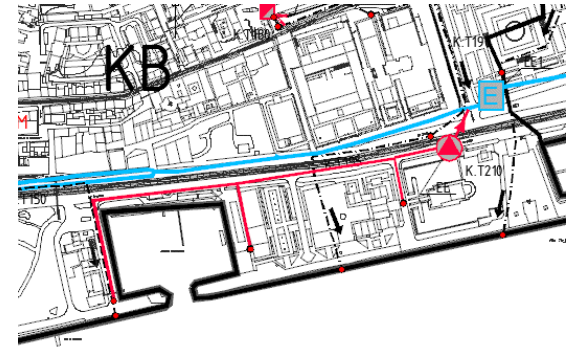
Summary of Local Interventions

- **Bassin A (Algés):**
 - Construction of dischargers
 - *Source Control – Infiltration trench to be built in Monsanto.*
- **Bassin B (Jerónimos):**
 - Construction of dischargers
- **Bassin C (Ajuda):**
 - Construction of dischargers
 - Rehabilitation of old sewers
 - Benefitation of discharge, in Tejo river
- **Bassin D (Cordoaria):**
 - Rehabilitation and renew of sewers network
 - Construction of dischargers
 - Construction of a infiltration pond (Monsanto, UTL)



Summary of interventions

- **Bassin F (Estrela e Av. Inf. Santo):**
 - Rehabilitation of the sewer network
 - Chambers for flow control and complementary systems.
- **Bassin G (Lapa):**
 - Rehabilitation of the sewer network
 - Chambers for flow control and complementary systems.
- **Bassin I (R. do Alecrim – Cais do Sodré):**
 - Rehabilitation of the sewer network;
 - Chambers for flow control and complementary systems.
- **Bassin M1 (Alfama):**
 - Renew of sewer network
 - Reabilitação da rede de drenagem
- **Outhers (Minimization of water energy losses, interception devices, etc.**



Priority Solution

Bassin O: Campo Grande - Olaias

Critical Area

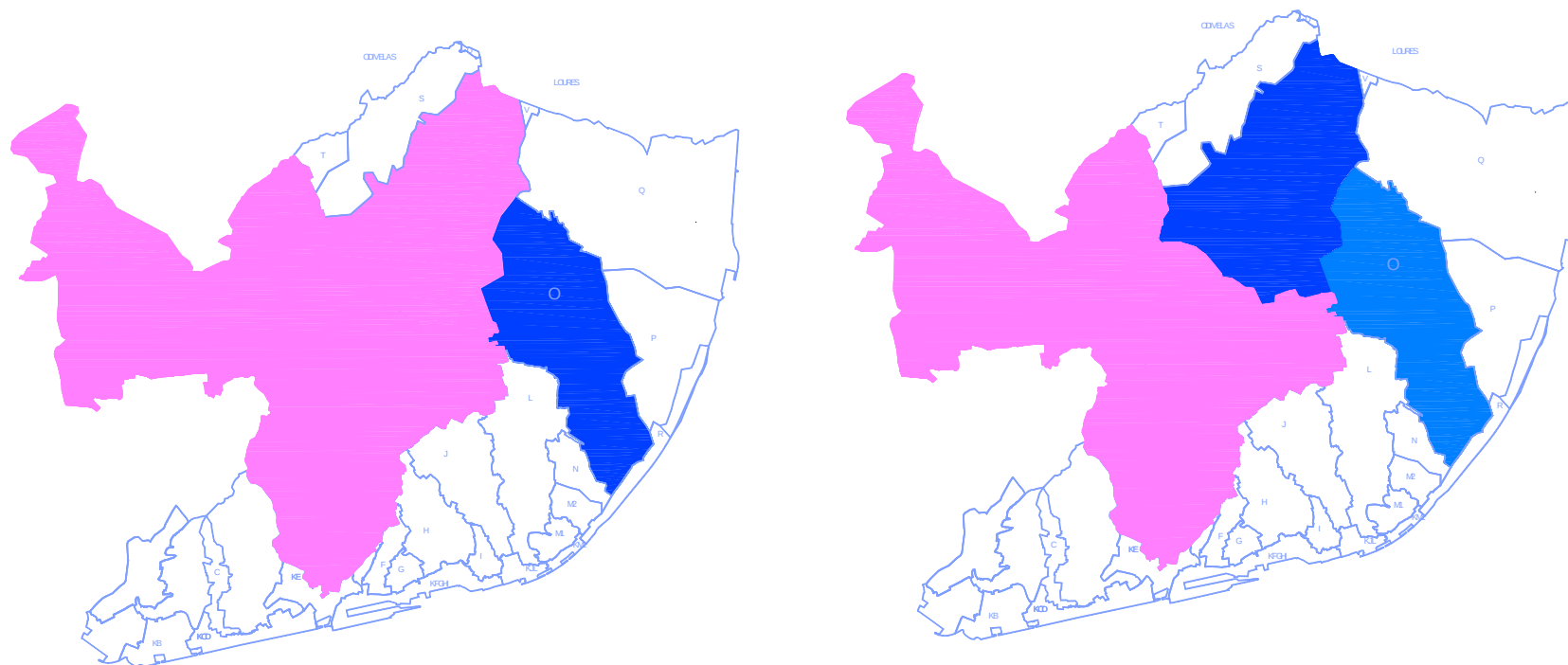
Zona baixa de Xabregas/Chelas



Priority Solutions

Bassin O: Campo Grande - Olaias

Context

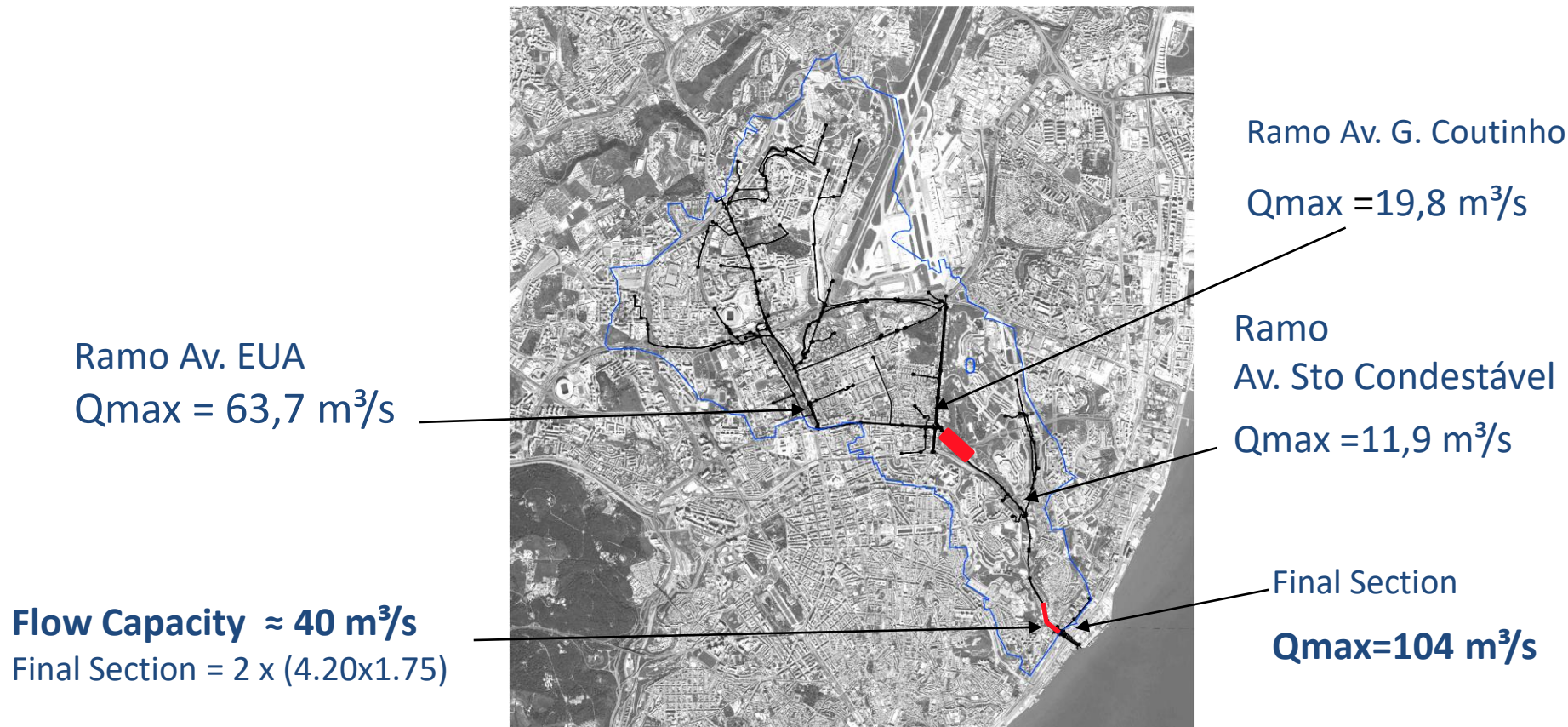


Bassin de Alcântara e Chelas – original and presente bassins

Priority Solutions (Storage + Sewers Reinforcement)

Bassin O: Campo Grande – Olaias

Dynamic Modelling: Flow for presente situation, T=10 years

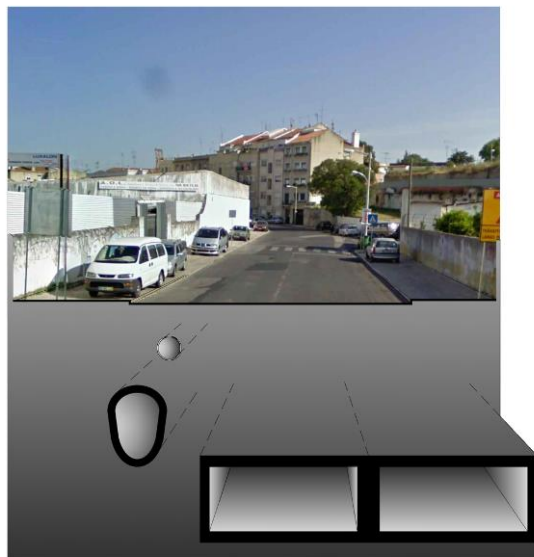


Priority Solutions (Storage + Sewers Reinforcement)

Bassin O: Campo Grande - Olaias

Disconnection

Critical Area - Existent situation



Upstream section

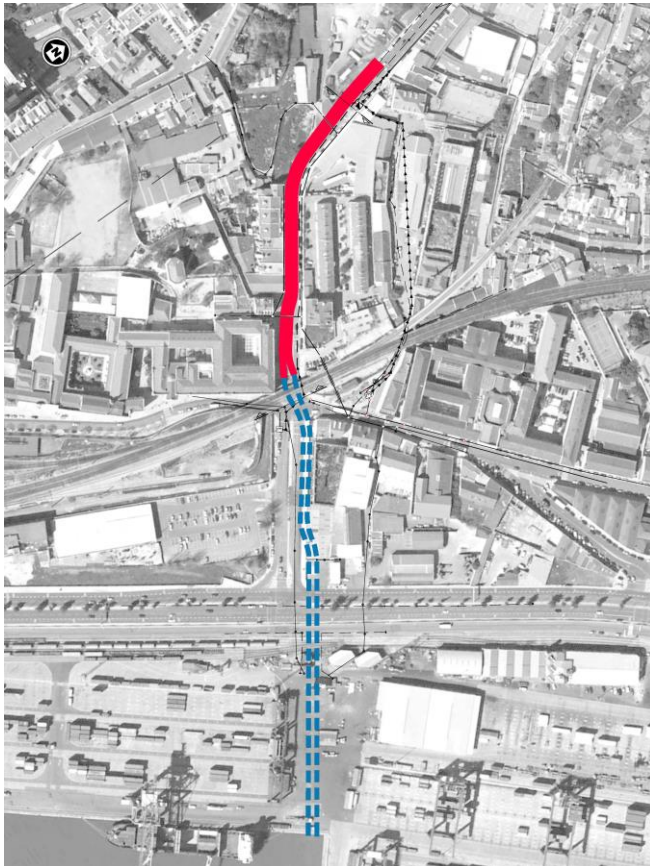


Downstream section

Priority Solutions (Storage + Sewers Reinforcement)

Bassin O: Campo Grande - Olaias

Disconnection solution

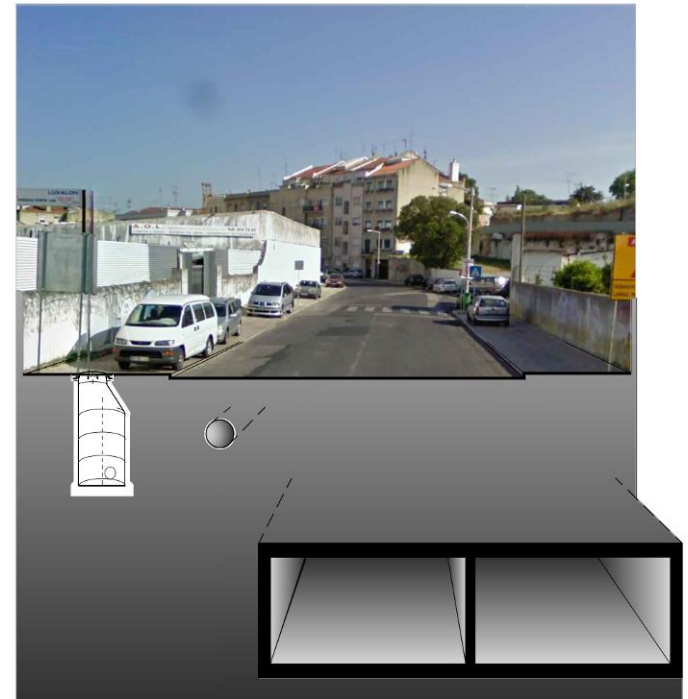
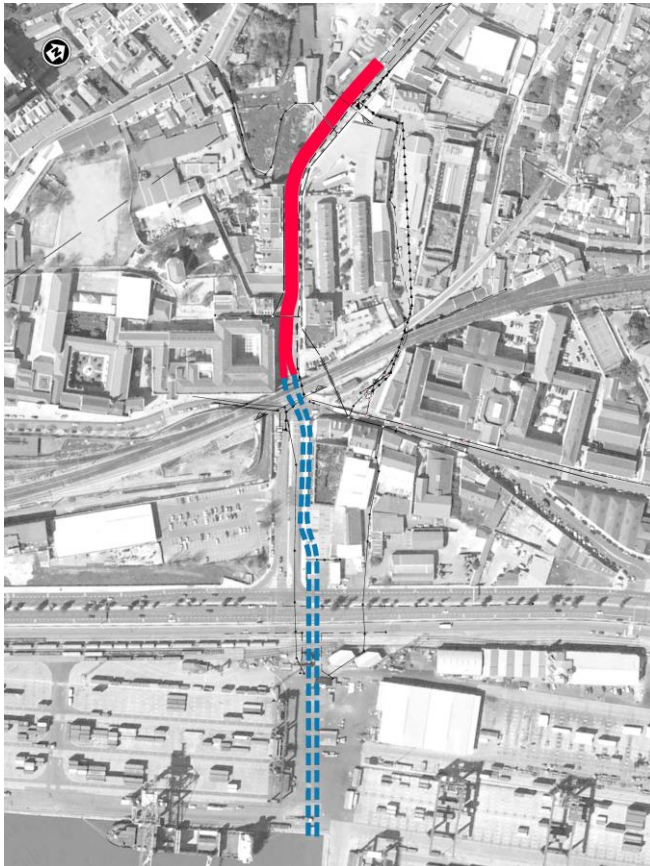


Demolition of existing infrastructures

Priority Solutions (Storage + Sewers Reinforcement)

Bassin O: Campo Grande - Olaias

Disconnection solution



Construction of a new
section 8,60x2,30 m²

Priority Solutions (Storage + Sewers Reinforcement)

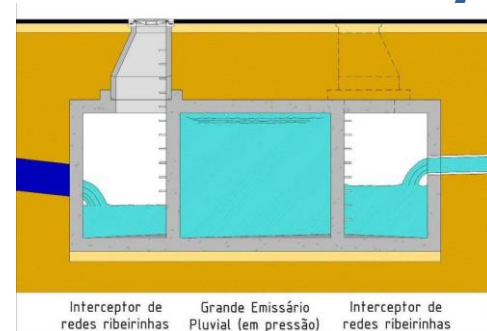
Bassin O: Campo Grande - Olaias

- Disconnection of sewers that serves downtown Xabregas and Chelas;
- Instalation of flow monitoring equipment;

Critical Issues:

- a) Social costs of construction and disconnection;*
- b) Structural resistance of existente sewers to pressure;*
- c) Only allows $T=2$ years, tide at 1.95m*

- Construction of Olaias storage tank (Vale de Chelas);

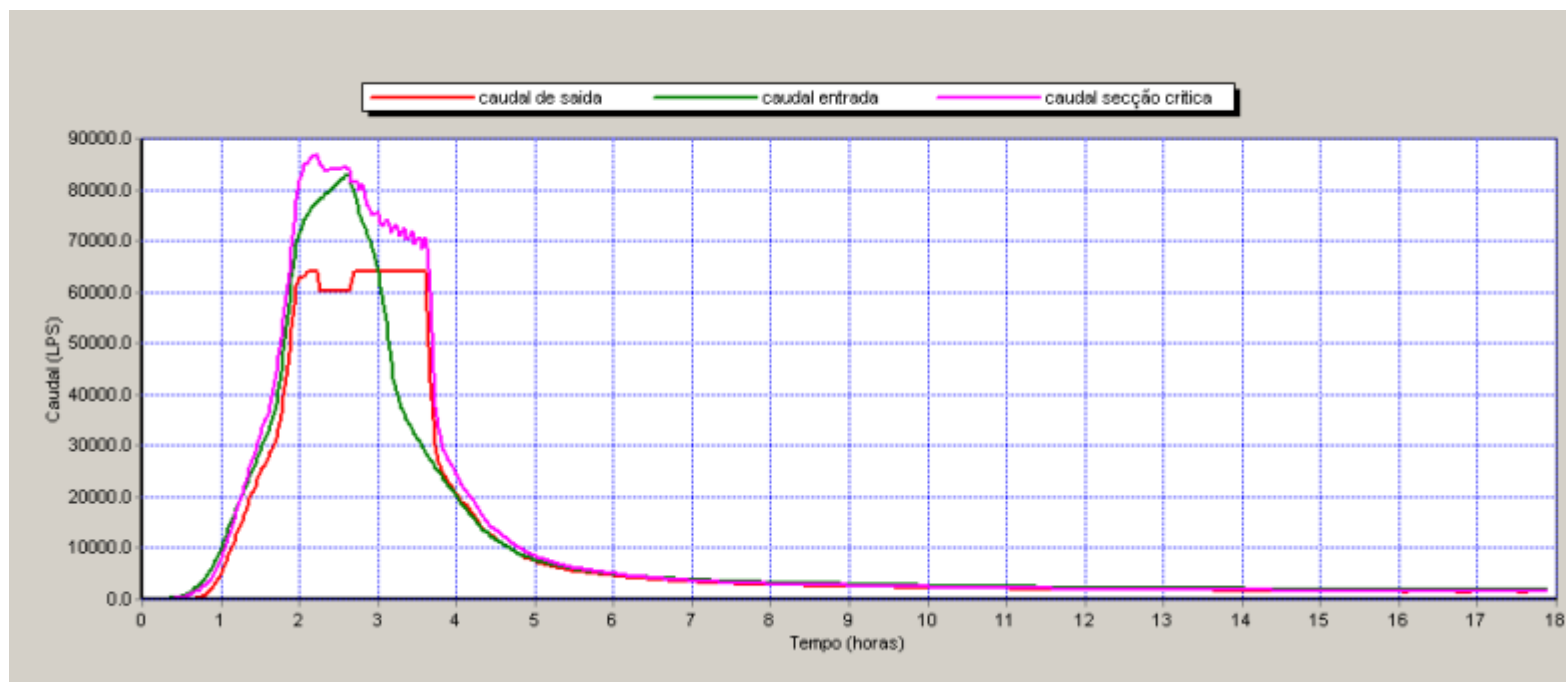


Priority Solutions (Storage + Sewers Reinforcement)

Bassin O: Campo Grande - Olaias

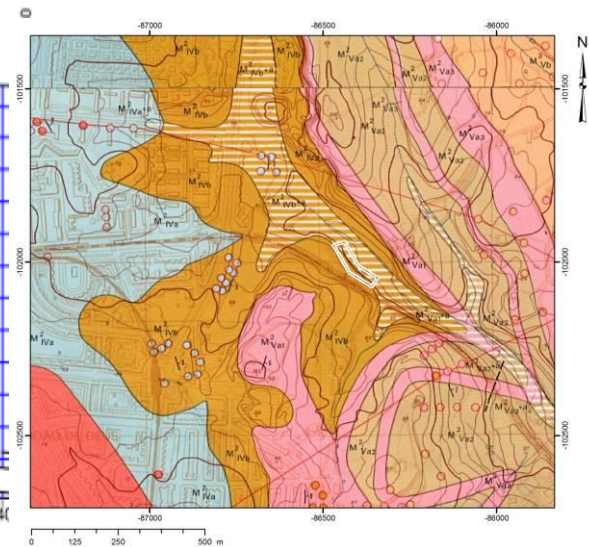
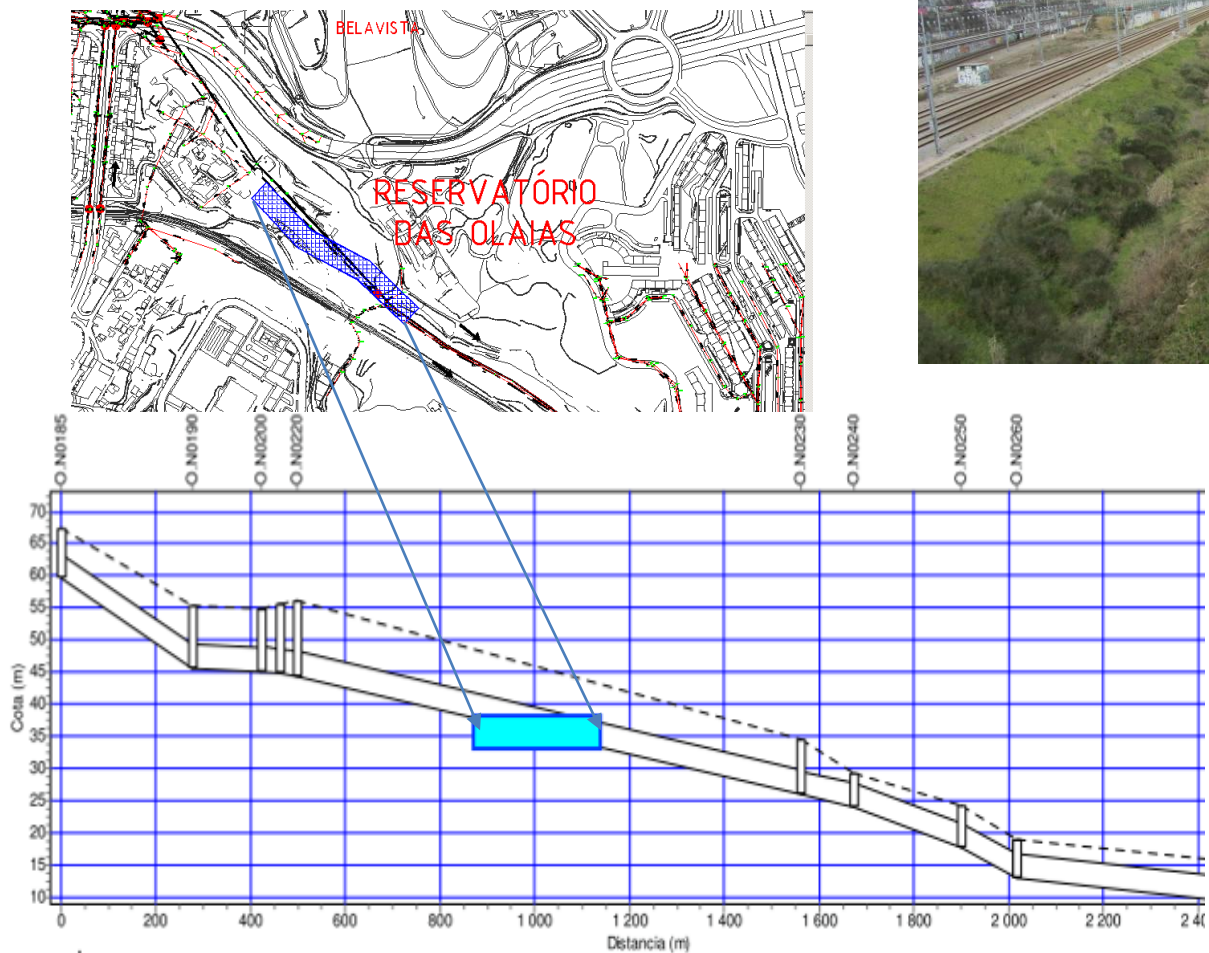
Storage tank of Olaias

Storage volume - 65 000m³



Storage Tank Olaias

- Implantanting area = 11 400 m²
- Total Volume = 65 000m³



Storage tank of Olaias

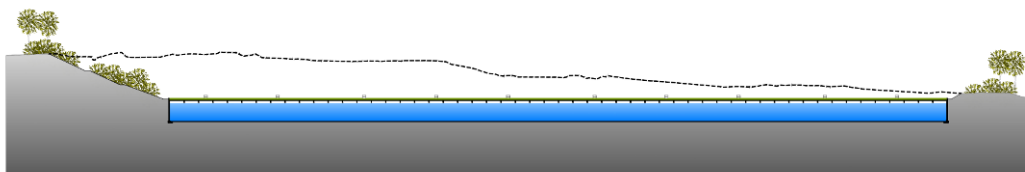
Local de implantação do Plano da Quinta da Montanha

Advantage:

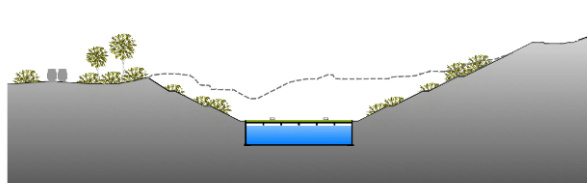
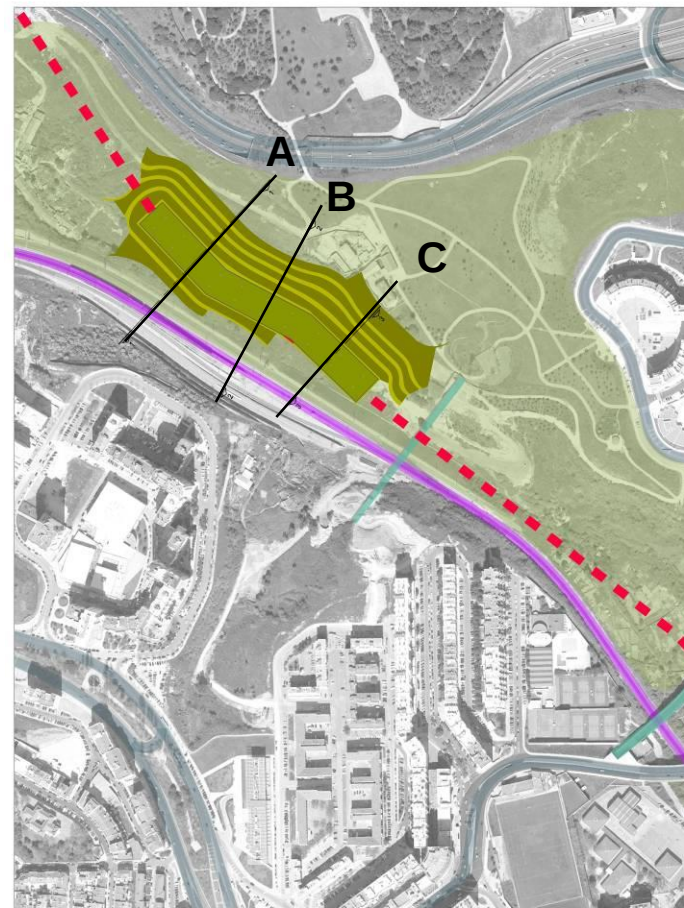
- implantating in municipality land;

Disadvantage:

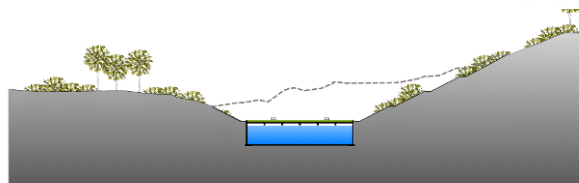
- Excavation volume (421 000m³);
- Change of land use of Quinta da Montanha.



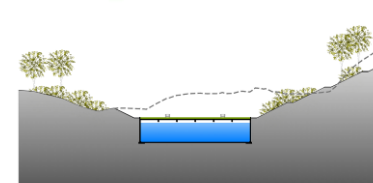
Perfil longitudinal



Corte A



Corte B



Corte C

Storage Tank Olaias

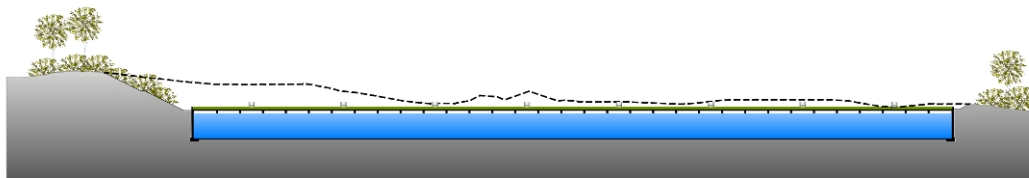
Implanting at South of Quinta da Montanha

Advantage:

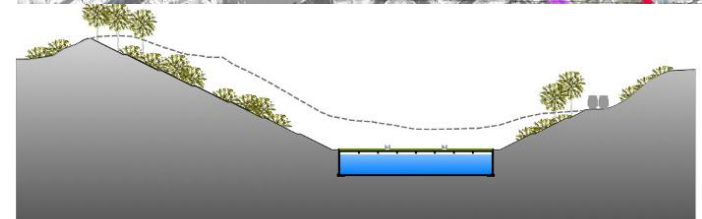
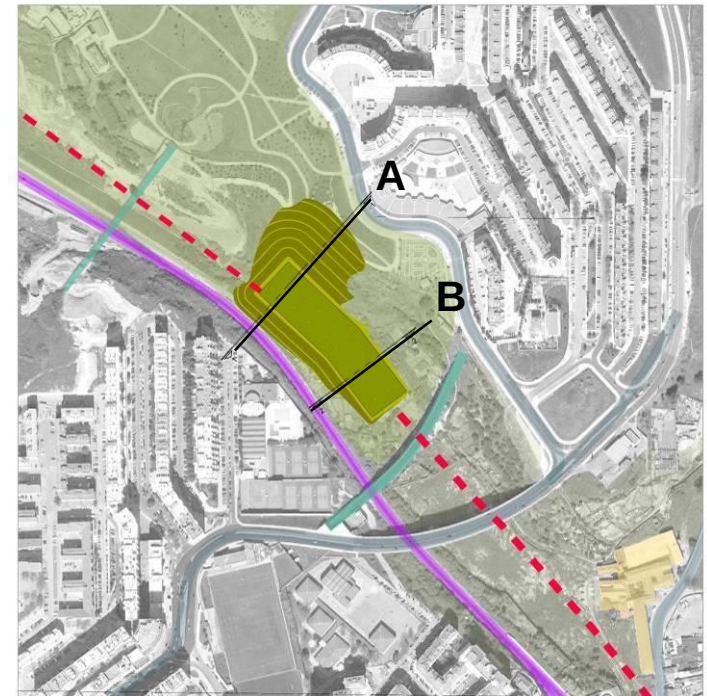
- Excavation volume (215 600m³);
- No need to change the land use of Quinta da Montanha

Disadvantage:

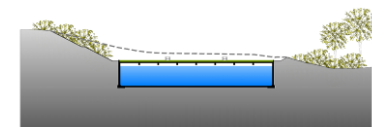
- implanting in private lands, with associated costs



Perfil longitudinal



Corte A



Corte B

Alternative Solution (Tunnel)

Bassin O: Campo Grande - Olaias

- **Alternative Proposal:**
 - Construction of a tunnel 3,8 m diameter Chelas – Beato for flow deviation

Critical issues: Crossing Lisbon Port area



Início do túnel



- Open trench aberta
- - - Tunnel
- - - Existent storm drainage sewer



Final do túnel

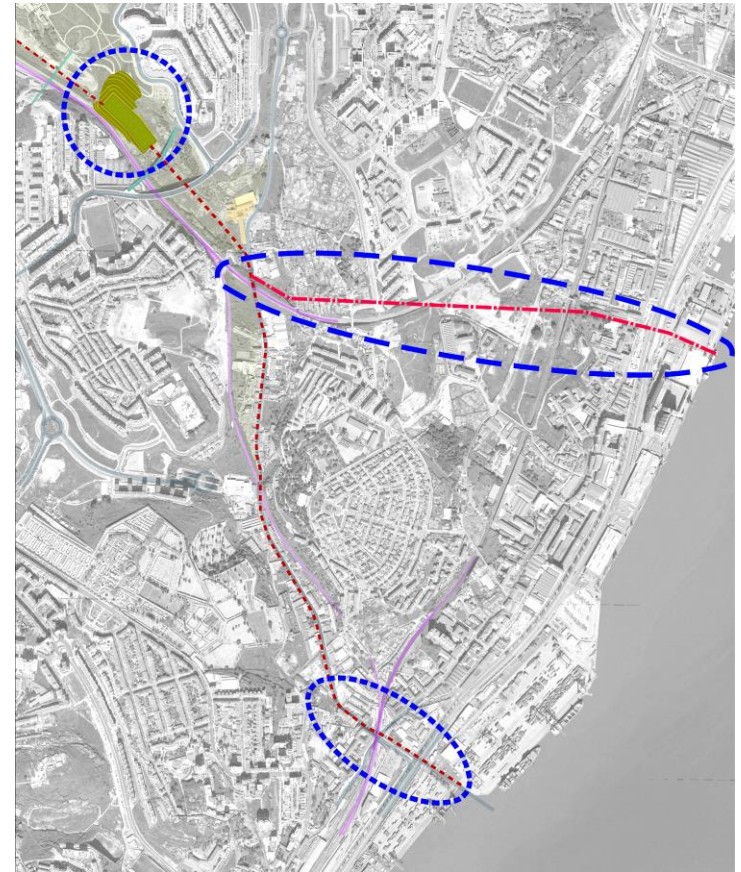
Summary of Alternative Solutions

Interventions

1. Disconnection with the construction of 500 m sewer and installation of monitoring the flow
2. Construction of a storage tank of Olaias with 65 000m³

Alternative

- Construction of tunnel Chelas - Beato with 3,8m of diameter in about 1 km;



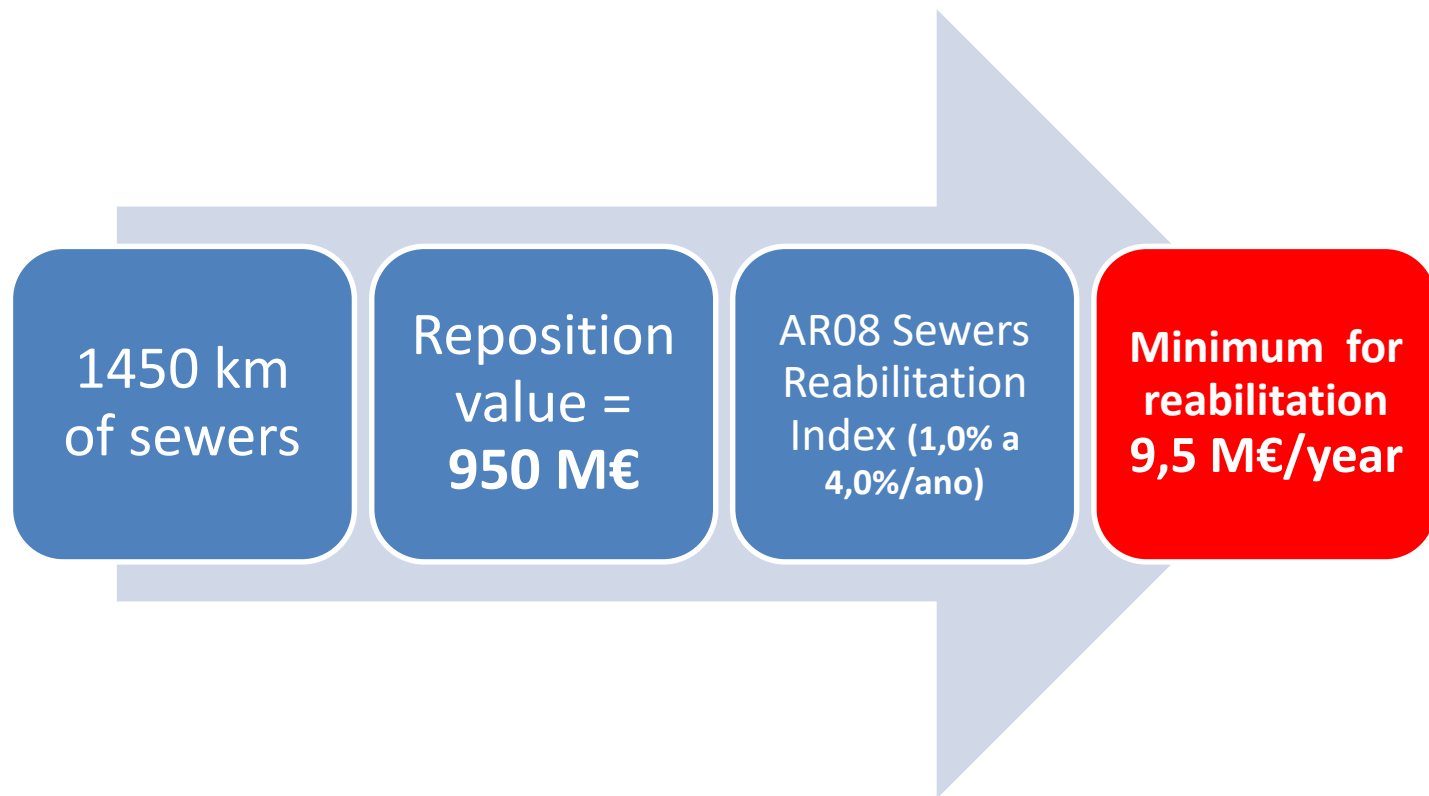
10 Structural Interventions

- 1. Tunnel Monsanto-Sta Marta-Sta Apolónia**
- 2. Tunnel Chelas-Beato**
- 3. Reinforce of sewer of Bassin Av. de Berlim**
- 4. Retention ponds (i.e. , Alto da Ajuda e Ameixoeira)**
- 5. Rehabilitation/reinforcement of sewer of primary and secondary system (ex. side sewers coletores of Caneiro de Alcântara, of Av. de Berna, of Traje Museum)**
- 6. Rehabilitation of final section of Caneiro de Alcântara**
- 7. Reduction of local head losses (Ex: Chambers of Rua de S. José/R. Telhal or chambers near Hotel Mundial)**
- 8. Rehabilitation and flow control in storm dischargers (ex. D16, D17, D8.1...)**
- 9. Surface flow catchment (inlets)**
- 10. Source control solutions (infiltration)**

Investments

Intervention	Cost (k€)	Cost (k€)	
	2016-2030	2016-2020	2021-2030
Deviation of flow (tunnels)	70 000	70 000	0
Detention ponds	495	365	130
Reinforcement and rehabilitation of sewers	75 000	30 000	45 000
Separation and control of flows	8 410	3 215	5 195
Minimization of local energy head losses	2 000	1 000	1 000
Source control solutions	1 585	85	1 500
Infrastructures inspections and survey	7 000	3 500	3 500
Aware and monitoring system	2 400	900	1 500
Capacitation and assets management	1000	500	500
Others interventions	10 350	4 100	6 250
Surface flow catchment	6 000	1 500	4 500
Urbanistic rearrangements of infrastructures	1 000	300	700
Beneficiation of river discharges	1350	300	1050
Beneficiation of maritim section of Can. de Alcântara	2000	2 000	0
TOTAL	178 240	113 665	64 575

Asset management



Recomendations for the implementation

Survey e CCTV = 1 M€ (1M€/year)

**Priority
Structural Works
70 M€**

Other structural works 5 M€

Other interventions

**Annual Renew =
5 M€/year**

**Annual Renew =
7 M€/year**

**Annual Renew =
10 M€/ano**

Additional Measures for a “Smart City”)

- ✓ **Update of assets registration and CCTV inspection**
- ✓ **Monitoring and Aware System** (sensor for water level and flow velocity and data transmission for aware, operation and management)
- ✓ **Capacitation** to optimize Assets management

