

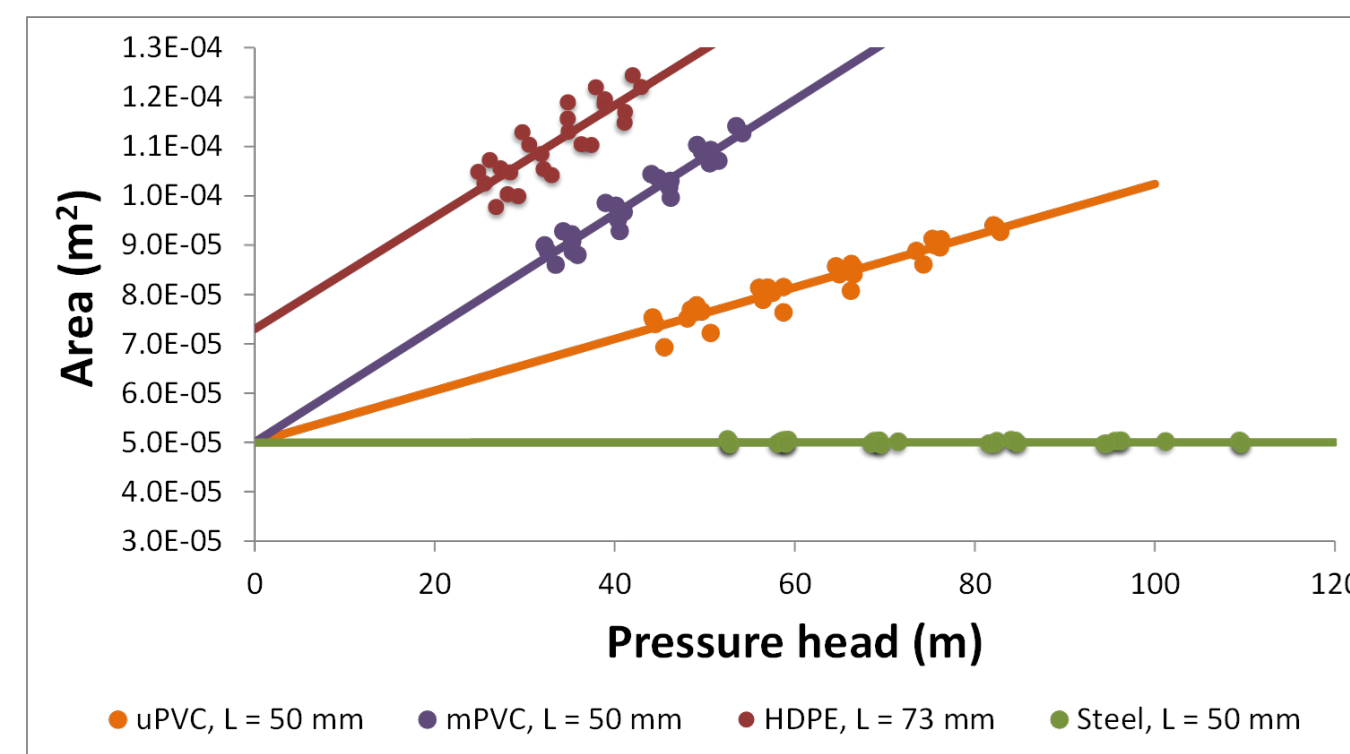
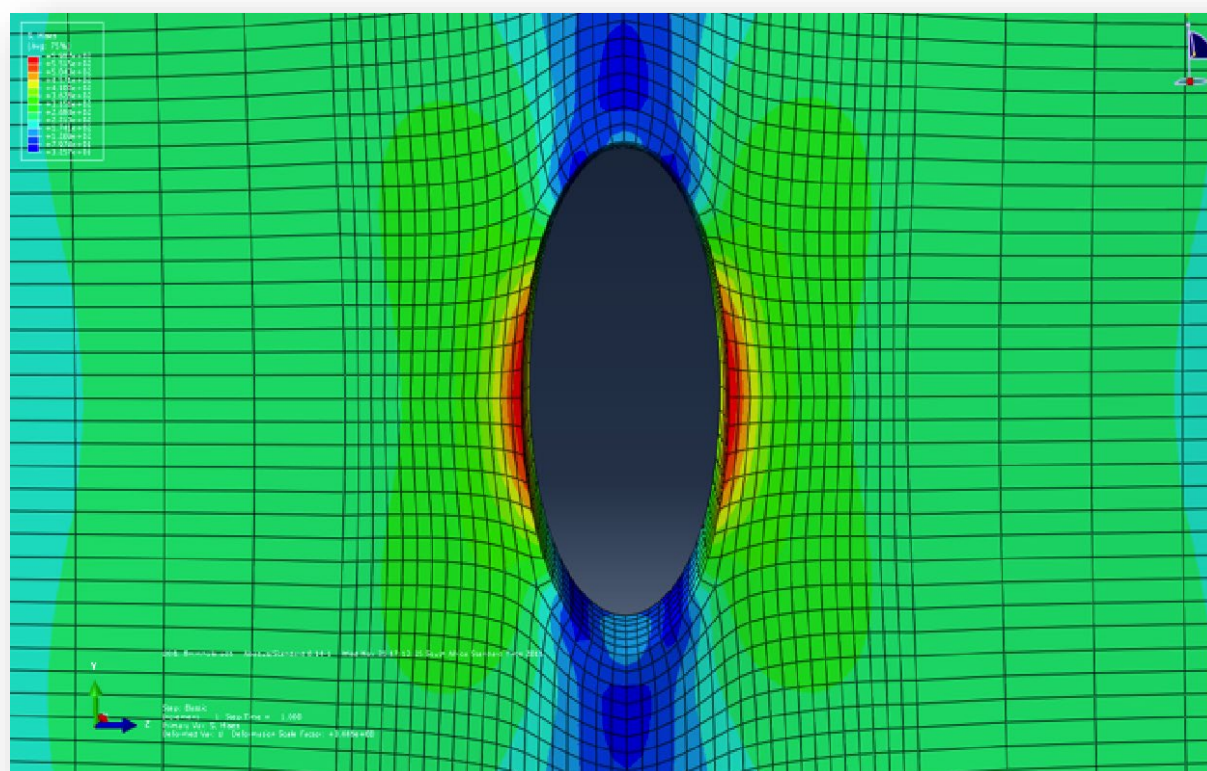
L'applicazione dell'indicatore di performance AMSI in diversi contesti gestionali

Prof. Ing. Luigi Berardi

Università «G. d'Annunzio» di Chieti Pescara



Fenomenologia delle perdite idriche

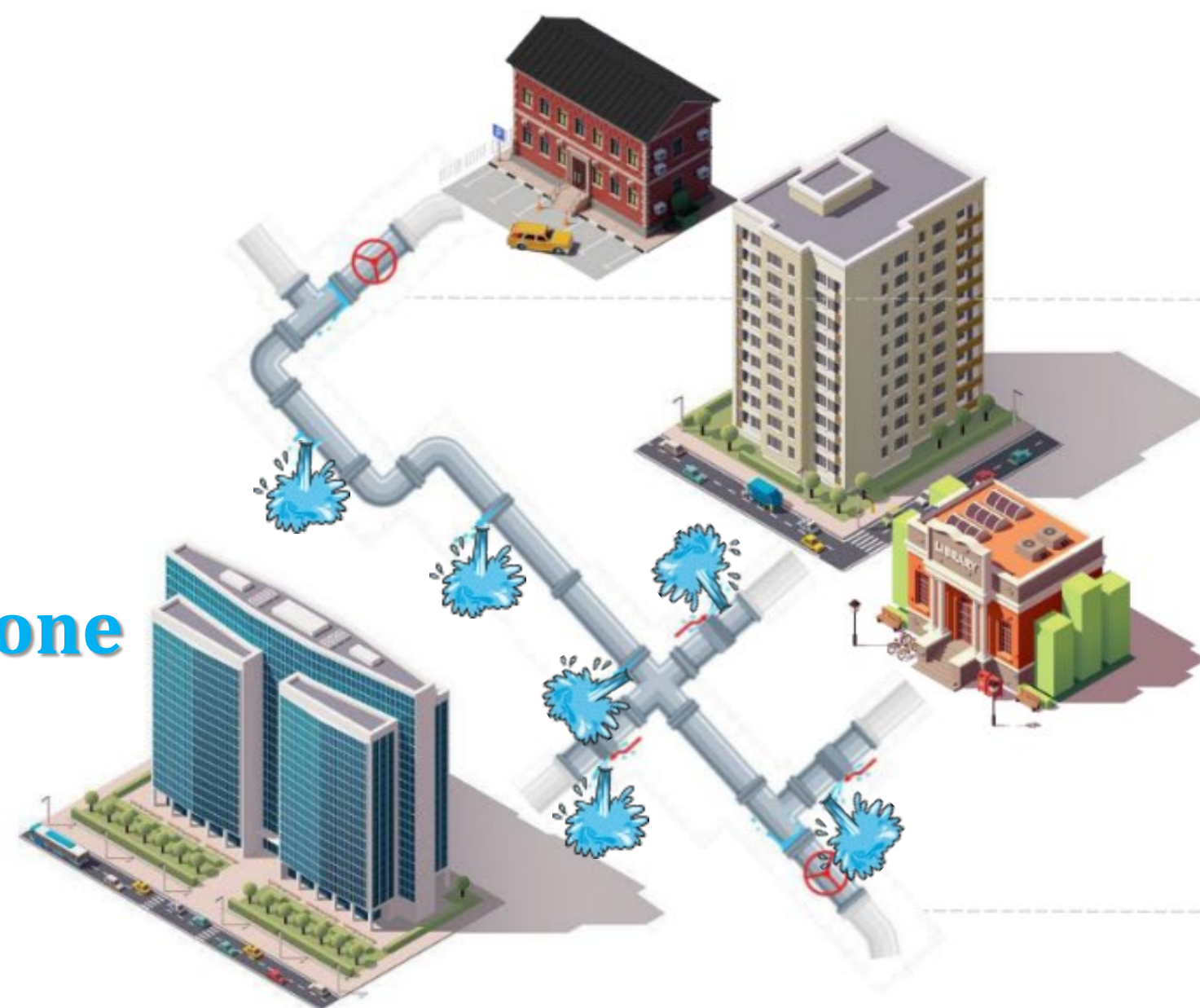


$$Q_{leak} \approx \beta \cdot P^{\alpha \approx 1}$$

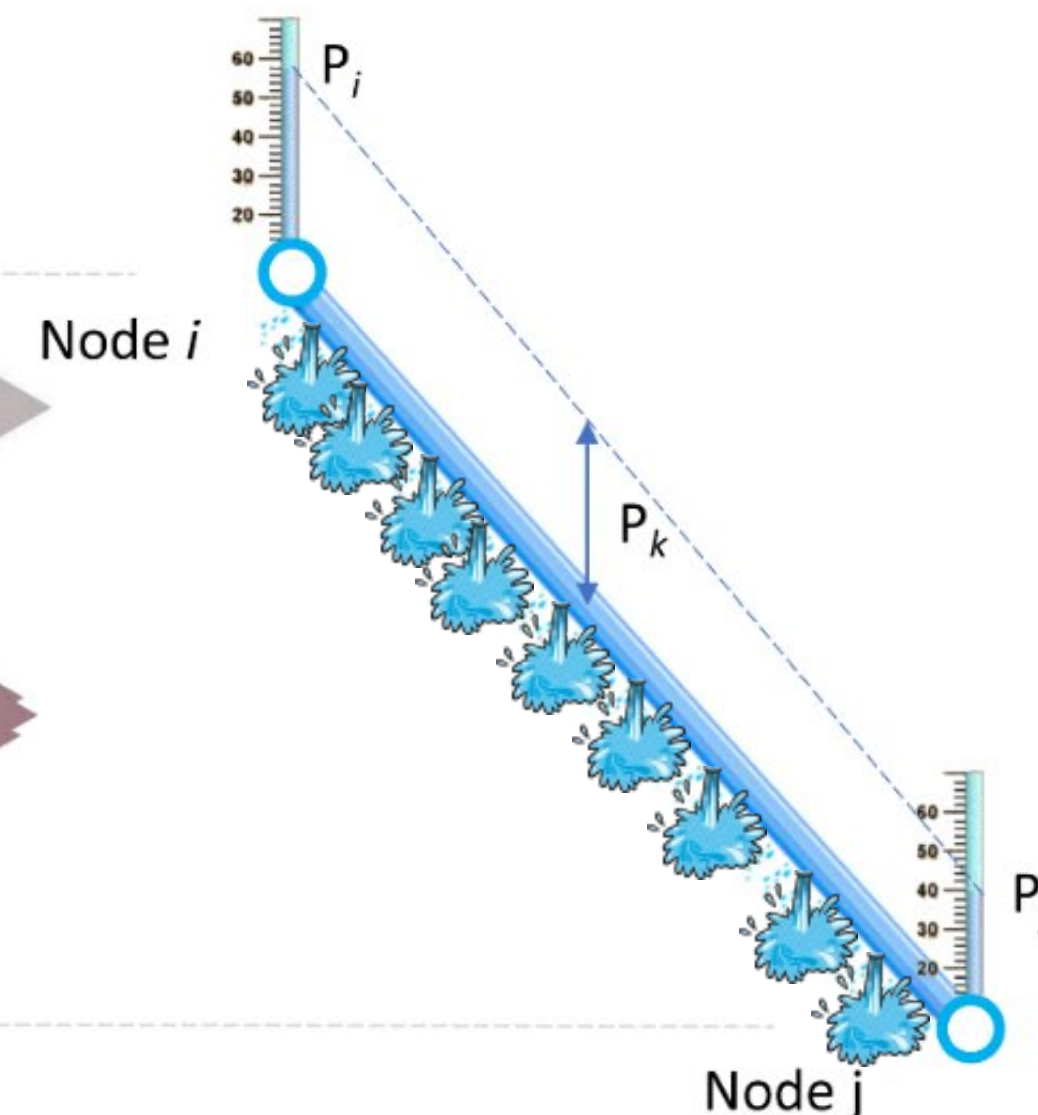


Analisi idraulica avanzata

Perdite idriche
modellate in funzione
della **pressione**
e del **deterioramento**
a **livello di singola tubazione**



Leakages in real system



Leakage representation in WDN model

Asset Management Support Indicator (AMSI)

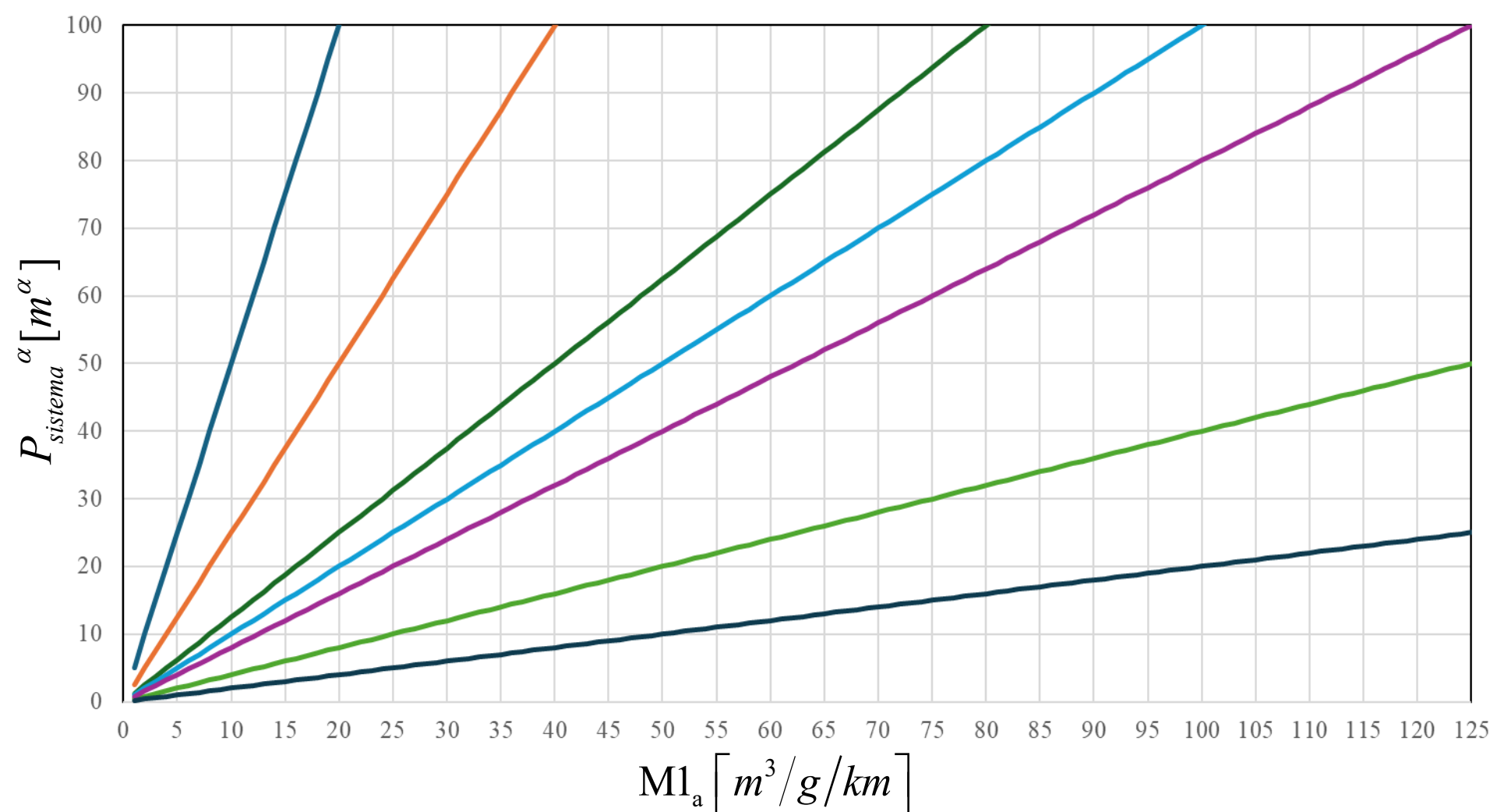
$$AMSI = \frac{M1_a}{\left(P_{media}^{sistema}\right)^\alpha}$$

Lo **stato di salute** (M1a) è determinato
Dalla **pressione media nel sistema** ($P_{media}^{sistema}$)
e dallo **stato di deterioramento** (AMSI).

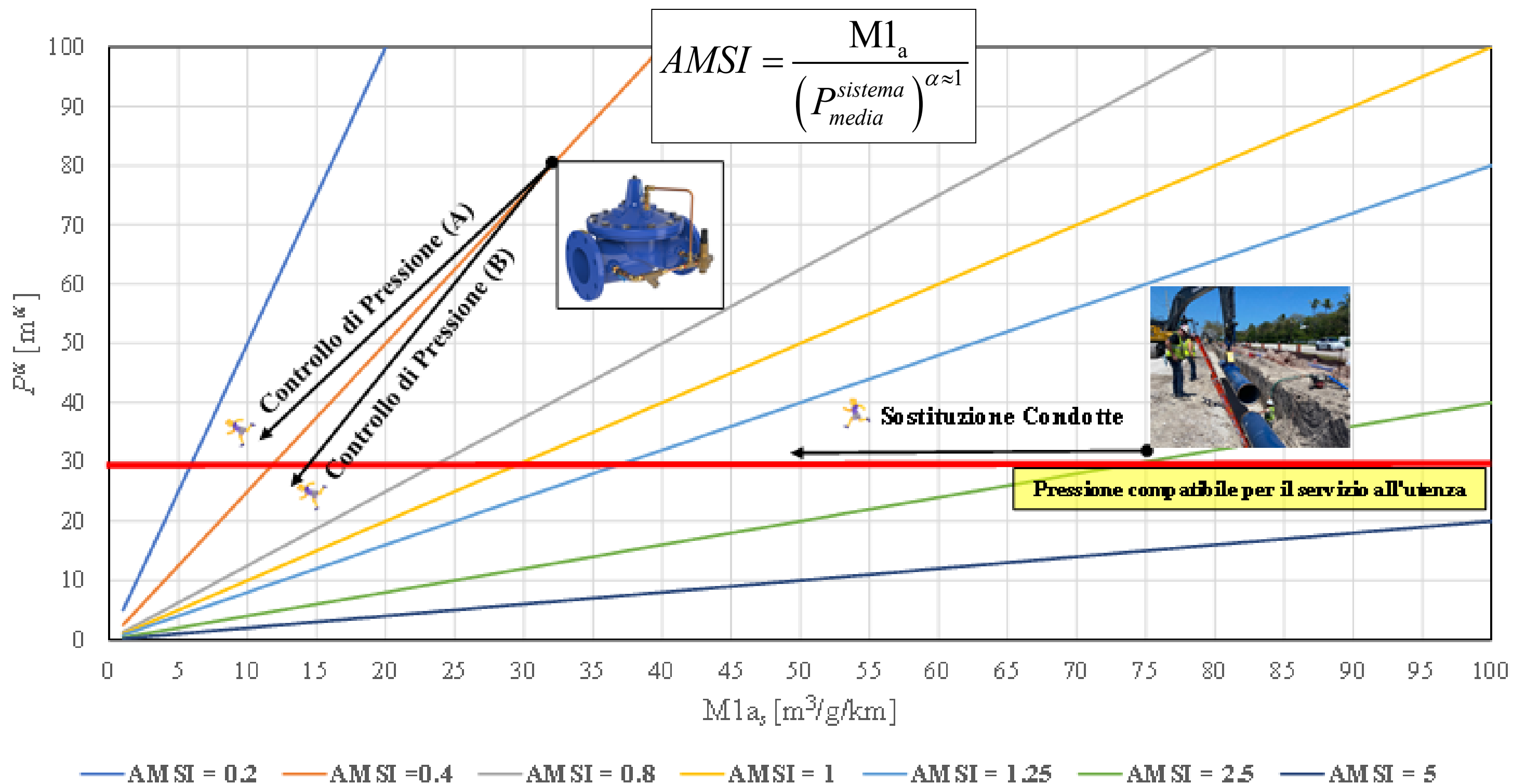
AMSI è una curva che indica lo stato di deterioramento del sistema

— AMSI = 0.2 — AMSI = 0.4 — AMSI = 0.8 — AMSI = 1 — AMSI = 2.5 — AMSI = 1.25 — AMSI = 5

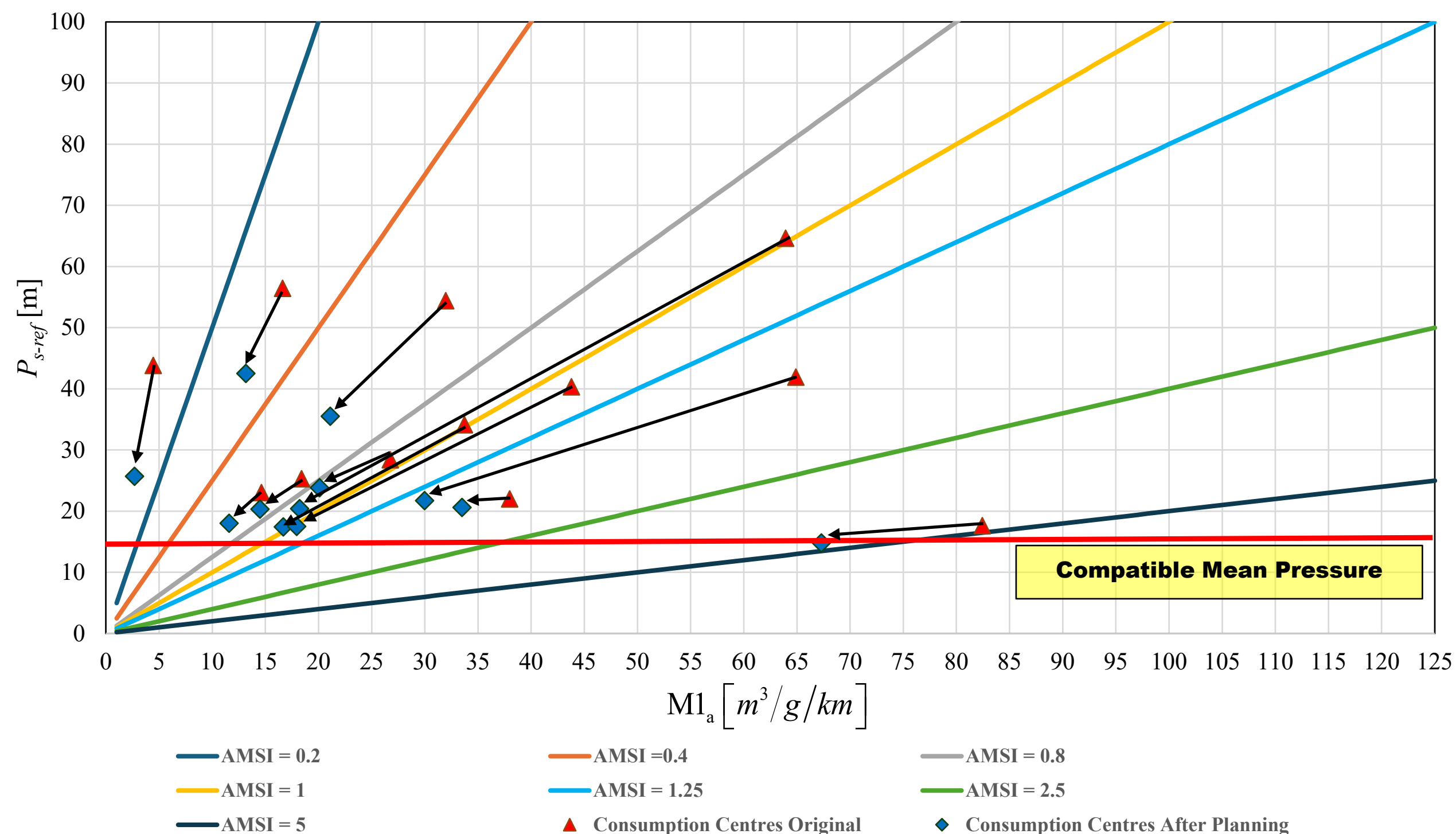
$\alpha = 1$



Supporto per l'asset management

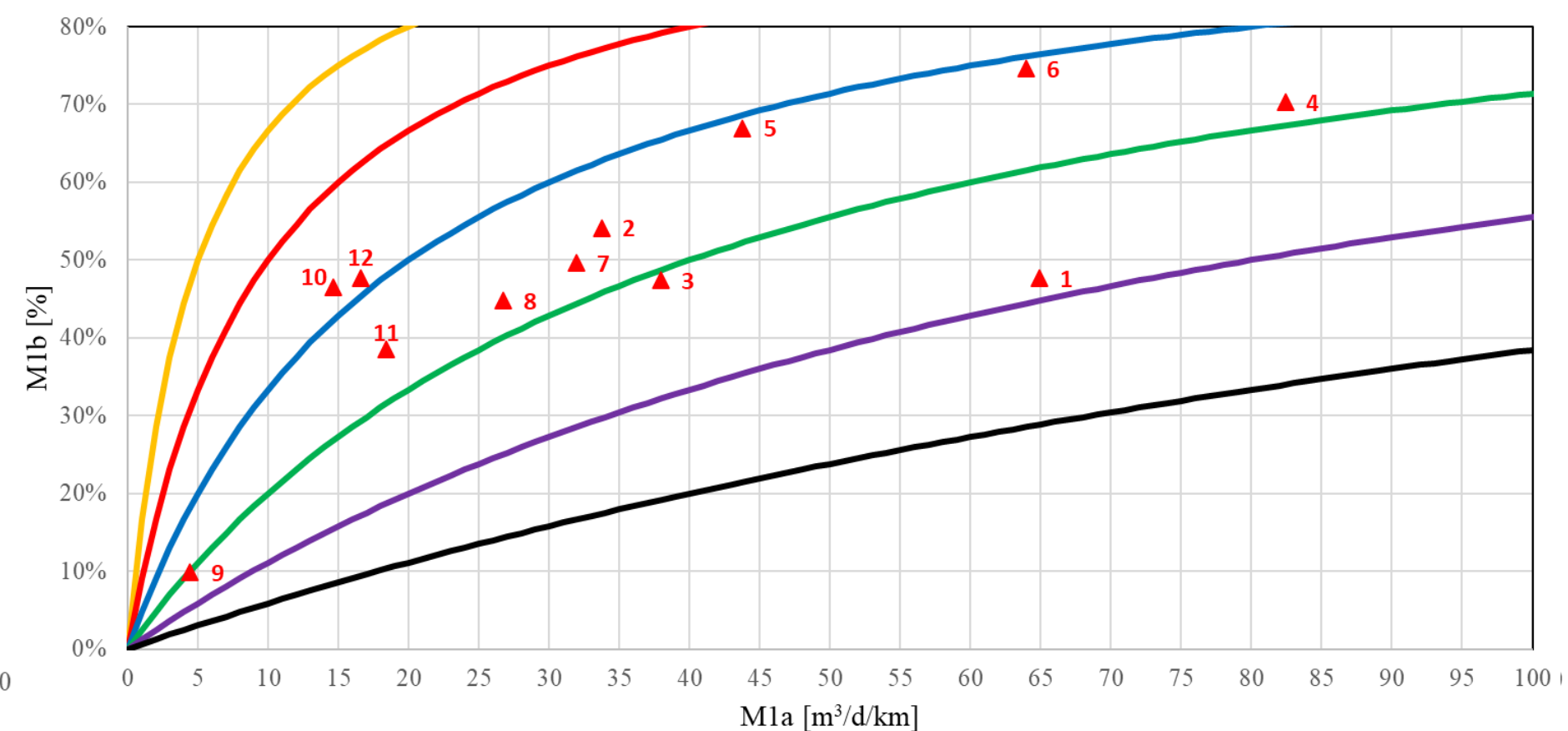
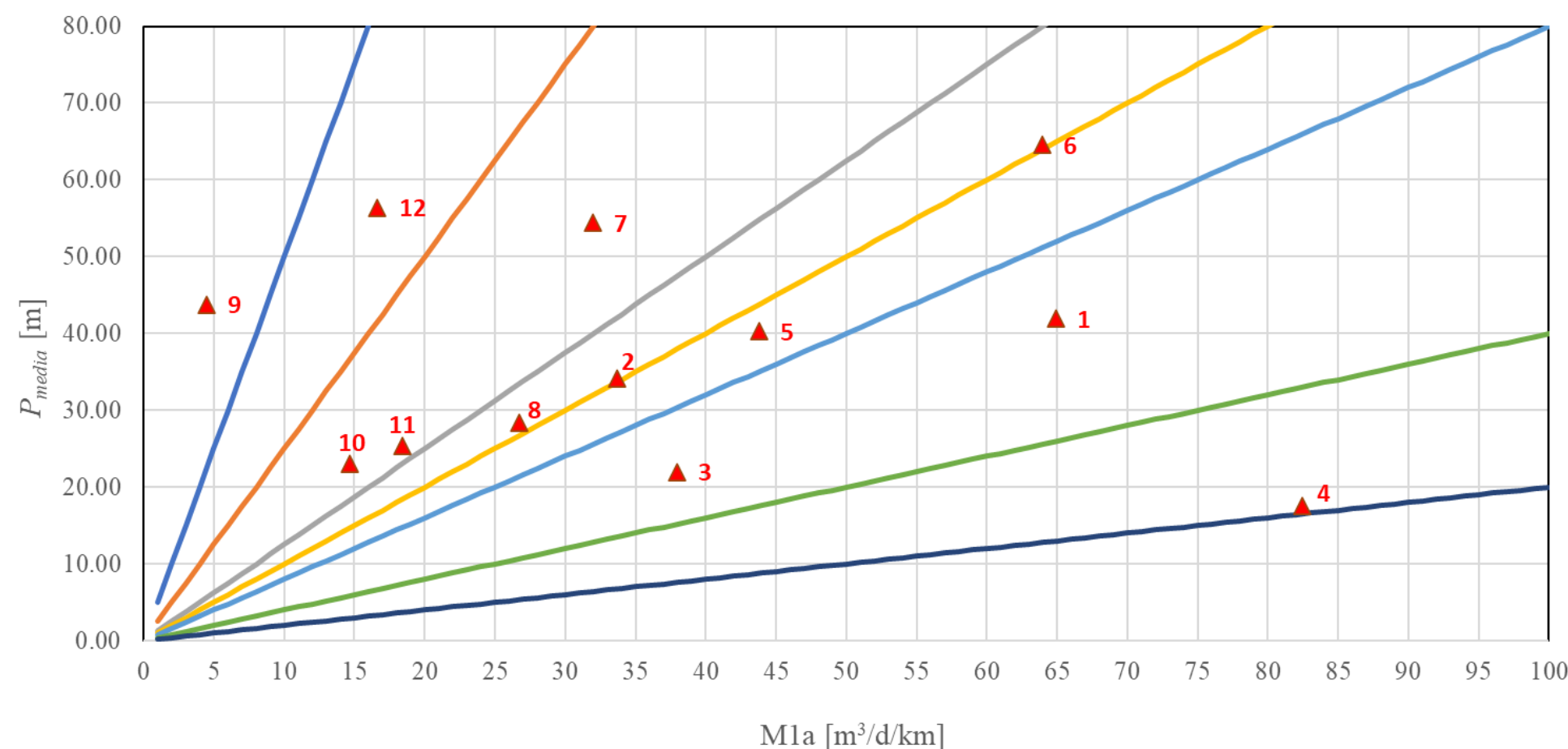


$\alpha = 1$



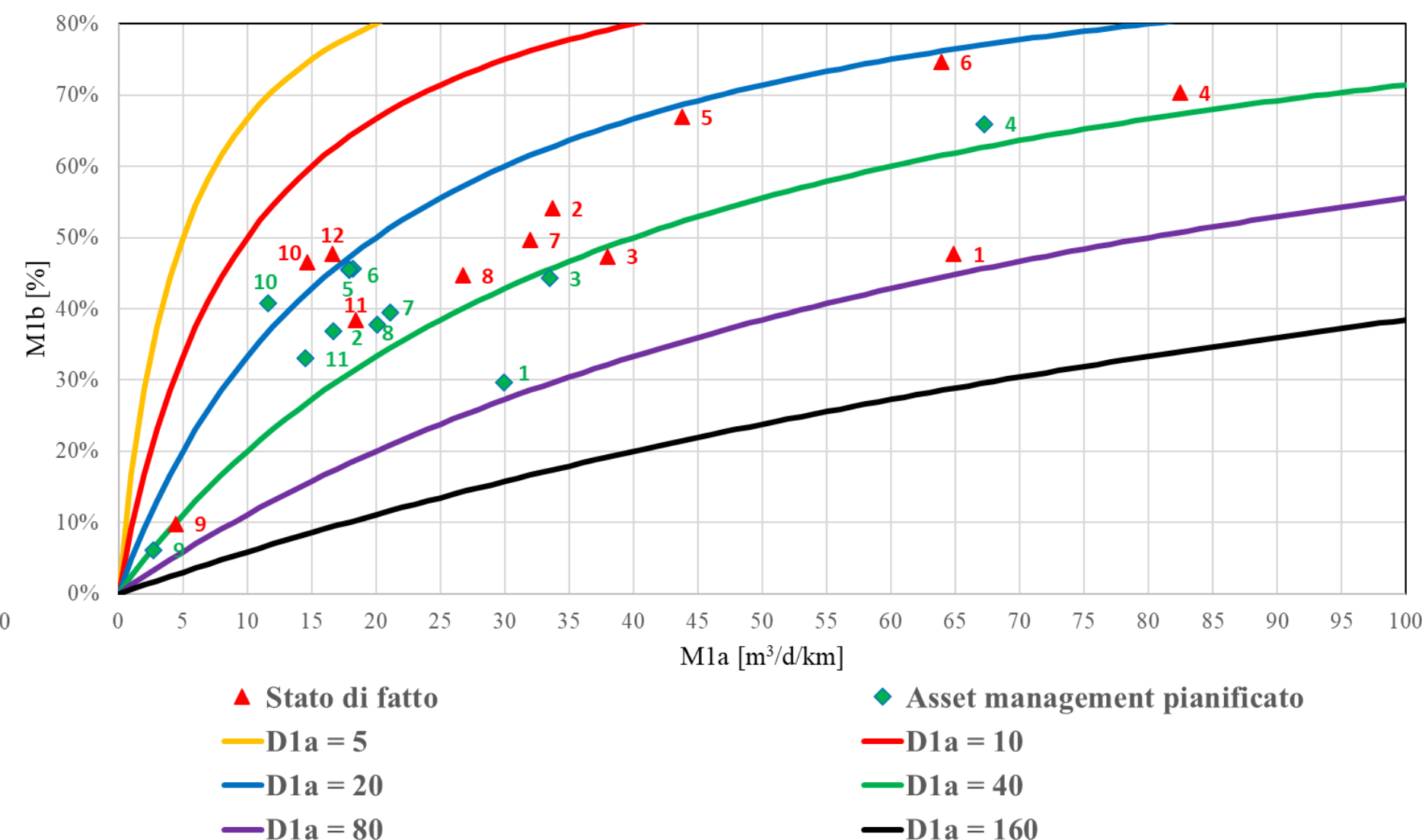
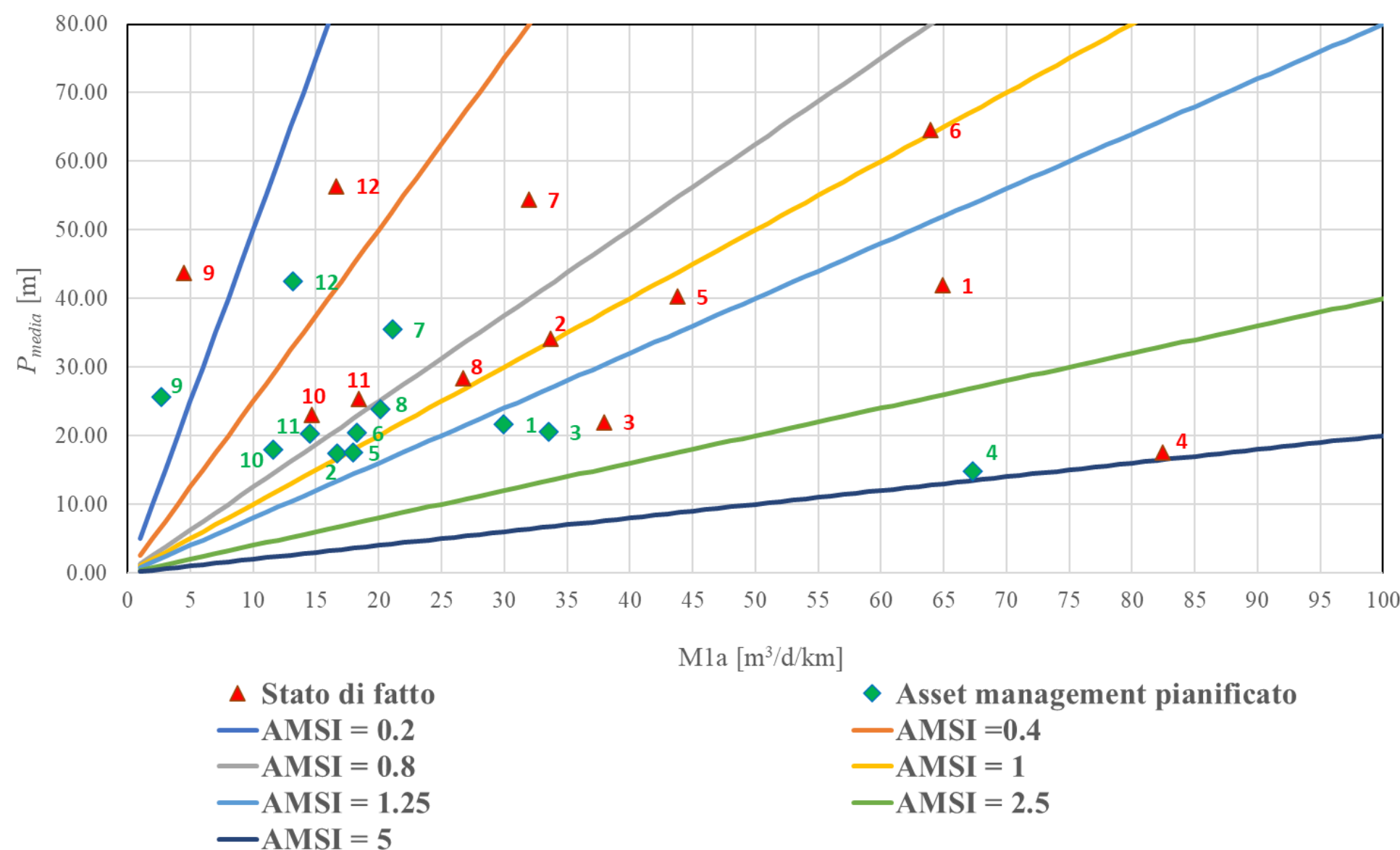
$$P_{s-ref} = P_{media}^{sistema}$$

Gestore (1)



Gestore (1)

Pianificazione asset management



WDN	L_s [m]	N_c [-]	P_{s-ref} [m]	W_{s-leak} [m³/d]	W_{s-con} [m³/d]	D_{s-leak} [m³/d/km]	D_{s-leak} [L/s/km]	$D_{s-\%}$ [%]	AMSI	D_{s-con} [m³/d/km]
1	66466	4773	41.90	4314	4728	64.90	0.75	47.71	1.549	71.13
2	49739	2312	34.10	1677	1420	33.72	0.39	54.16	0.989	28.55
3	103102	7936	22.00	3915	4349	37.97	0.44	47.37	1.726	42.18
4	112045	5324	17.60	9238	3893	82.45	0.95	70.35	4.685	34.75
5	48214	3194	40.30	2111	1041	43.79	0.51	66.98	1.087	21.59
6	35148	2385	64.60	2248	764	63.95	0.74	74.63	0.990	21.74
7	120841	8123	54.40	3862	3916	31.96	0.37	49.66	0.588	32.41
8	73127	4808	28.40	1957	2416	26.76	0.31	44.75	0.942	33.04
9	38198	3305	43.80	170	1562	4.46	0.05	9.83	0.102	40.89
10	33208	1619	23.00	486	558	14.63	0.17	46.55	0.636	16.80
11	229214	14525	25.30	4217	6738	18.40	0.21	38.50	0.727	29.40
12	101467	3149	56.40	1686	1847	16.61	0.19	47.72	0.295	18.20

$$P_{s-ref} = P_{sistema}^{media}$$

$$D_{s-leak} = M1_a$$

$$D_{s-\%} = M1_b$$

AMSI prima della progettazione dei DMA e controllo di pressione in 12 centri di consumo

W_{s-con} = daily volume of consumption; D_{s-con} = daily density of consumption; $D_{s-\%}$ = percentage of water loss.

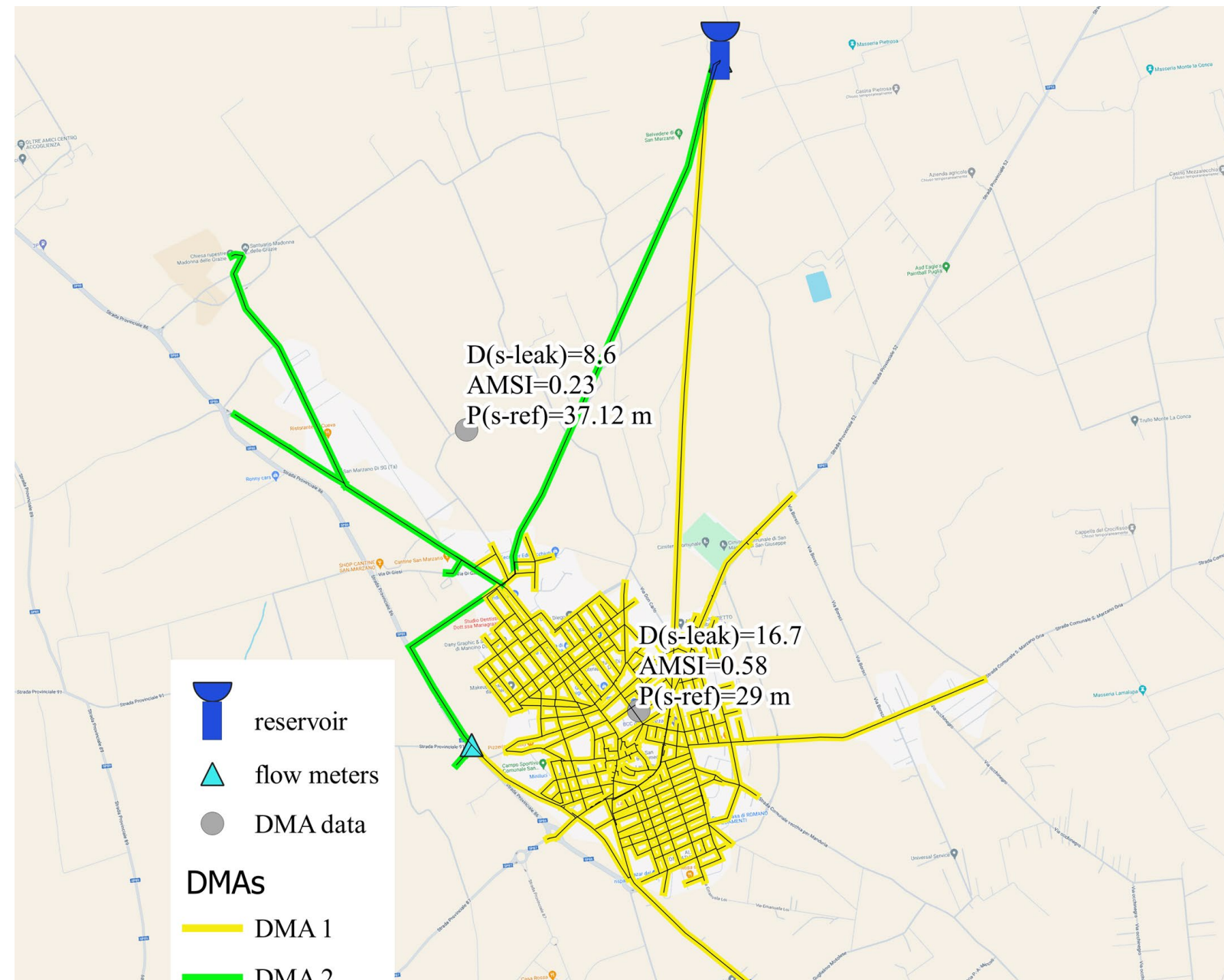
WDN	L_s [m]	N_c [-]	P_{s-ref} [m]	W_{s-leak} [m³/d]	W_{s-con} [m³/d]	D_{s-leak} [m³/d/km]	D_{s-leak} [L/s/km]	$D_{s-\%}$ [%]	AMSI	D_{s-con} [m³/d/km]
1	66466	4773	21.70	1992	4728	29.97	0.35	29.65	1.381↓	71.13
2	49739	2312	17.40	830	1420	13.68	0.16	36.89	0.959↓	23.40
3	103102	7936	20.60	3454	4349	27.46	0.32	44.27	1.626↓	34.57
4	112045	5324	14.80	7539	3893	55.16	0.64	65.95	4.547↓	28.48
5	48214	3194	17.50	865	1041	14.71	0.17	45.39	1.025↓	17.70
6	35148	2385	20.40	641	764	14.94	0.17	45.61	0.894↓	17.82
7	120841	8123	35.50	2550	3916	17.30	0.20	39.44	0.594↑	26.56
8	73127	4808	23.80	1470	2416	16.48	0.19	37.83	0.845↓	27.08
9	38198	3305	25.70	103	1562	2.21	0.03	6.19	0.105↑	33.52
10	33208	1619	18.00	385	558	9.50	0.11	40.83	0.644↑	13.77
11	229214	14525	20.30	3322	6738	11.88	0.14	33.02	0.714↓	24.10
12	101467	3149	42.50	1336	1847	10.79	0.12	41.97	0.310↑	14.92

AMSI dopo la progettazione dei DMA e controllo di pressione in 12 centri di consumo

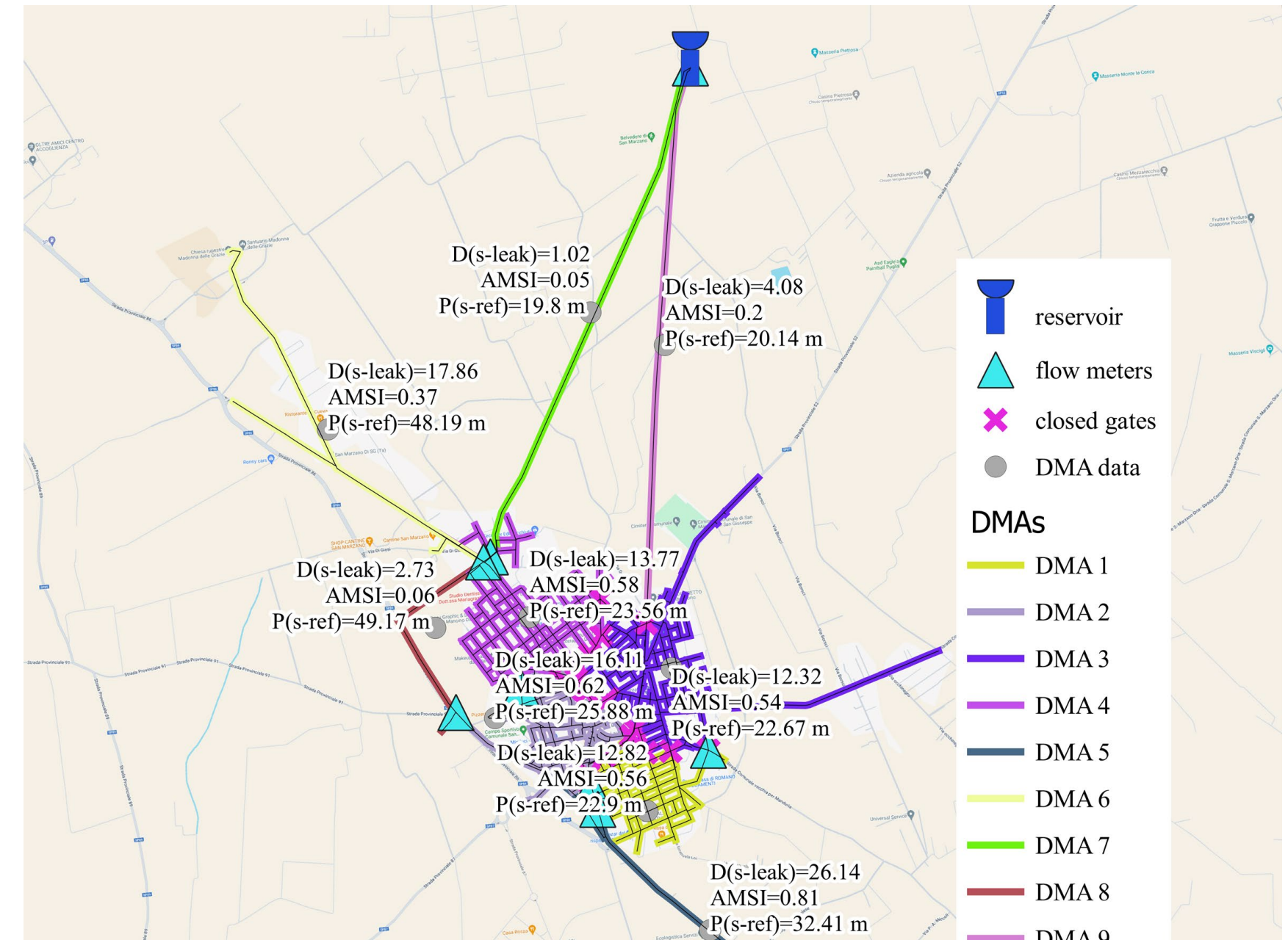
W_{s-con} = daily volume of consumption; D_{s-con} = daily density of consumption; $D_{s-\%}$ = percentage of water loss.

AMSI & la Progettazione dei DMA

AMSI prima della progettazione dei DMA



AMSI dopo la progettazione dei DMA

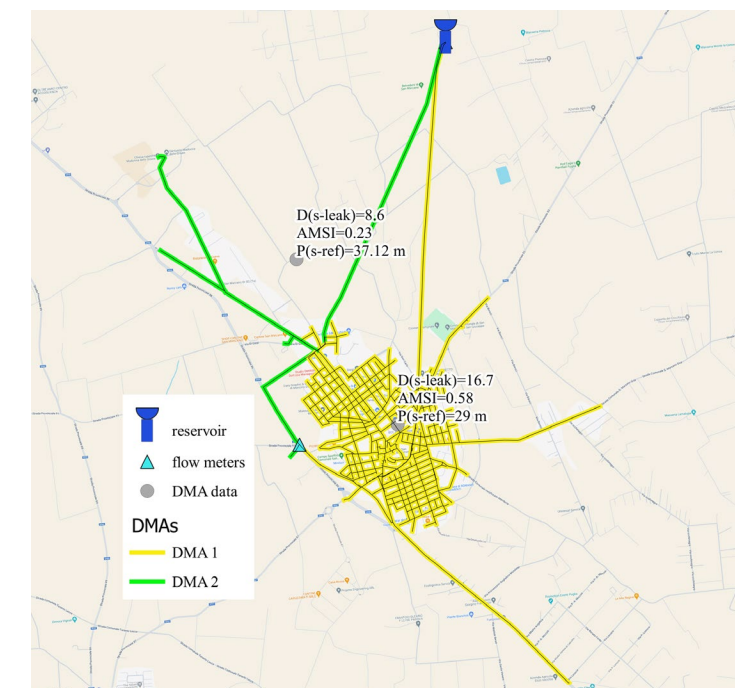


AMSI & la Progettazione dei DMA

$$P_{s-ref} = P_{sistema}^{media} \quad D_{s-leak} = M1_a \quad D_{s-\%} = M1_b$$

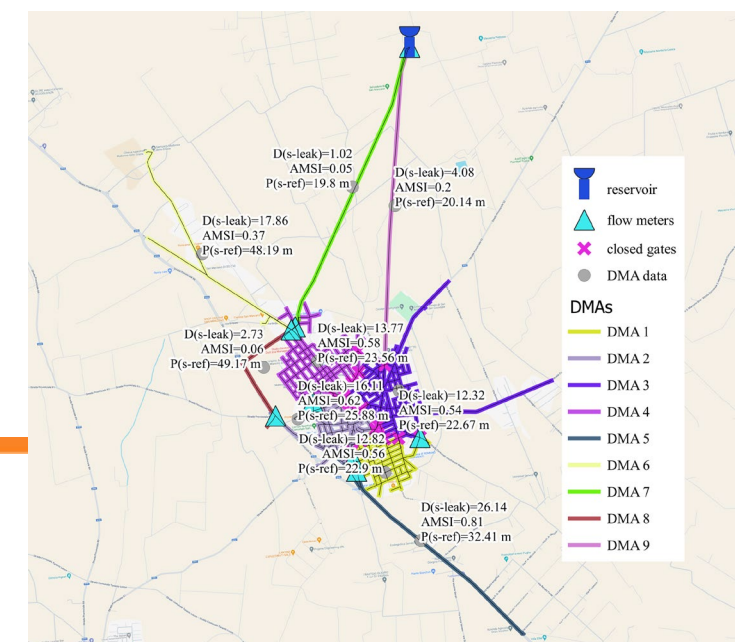
DMA	L_s [m]	N_c [-]	P_{s-ref} [m]	W_{s-leak} [m³/d]	W_{s-con} [m³/d]	D_{s-leak} [m³/d/km]	D_{s-leak} [L/s/km]	$D_{s-\%}$ [%]	AMSI	D_{s-con} [m³/d/km]
1	54362	2702	29.00	908	907	16.70	0.19	50.03	0.576	16.68
2	8557	12	37.12	74	8	8.60	0.10	90.74	0.232	0.88
WDN	62919	2714	30.10	982	914	15.60	0.18	51.78	0.518	14.53

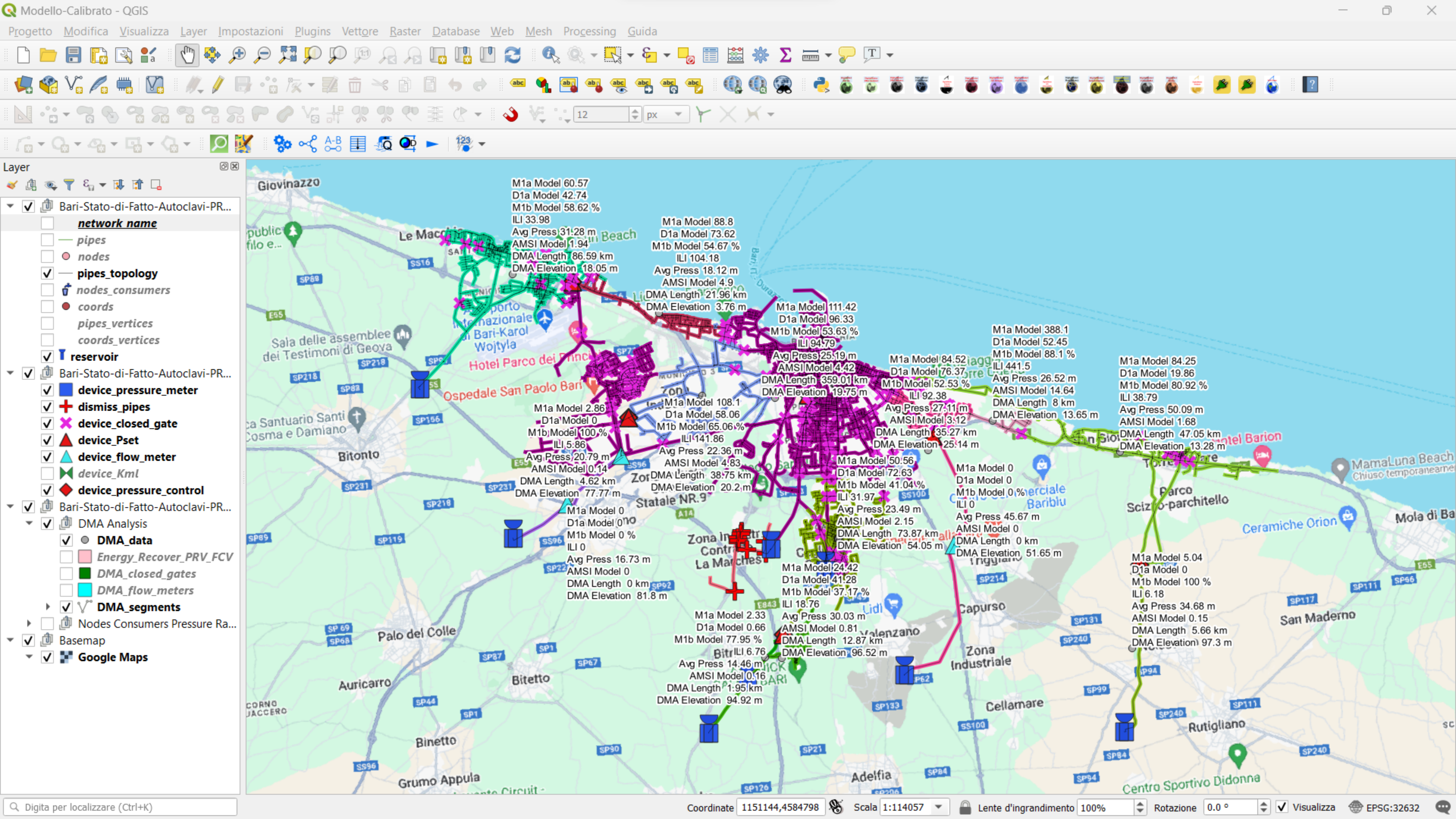
W_{s-con} = daily volume of consumption; D_{s-con} = daily density of consumption; $D_{s-\%}$ = percentage of water loss.



DMA	L_s [m]	N_c [-]	P_{s-ref} [m]	W_{s-leak} [m³/d]	W_{s-con} [m³/d]	D_{s-leak} [m³/d/km]	D_{s-leak} [L/s/km]	$D_{s-\%}$ [%]	AMSI	D_{s-con} [m³/d/km]
1	8687	508	22.90	111	176	12.82	0.15	38.69	0.560	20.31
2	9821	687	25.88	158	194	16.11	0.19	44.95	0.623	19.73
3	15440	717	22.67	190	267	12.32	0.14	41.60	0.543	17.29
4	13628	766	23.56	188	259	13.77	0.16	42.00	0.585	19.02
5	3192	20	32.41	83	8	26.14	0.30	91.59	0.807	2.40
6	3693	12	48.19	66	8	17.86	0.21	89.77	0.371	2.04
7	3433	0	19.80	3	0	1.02	0.01	100.00	0.051	0.00
8	1431	0	49.17	4	0	2.73	0.03	100.00	0.055	0.00
9	3594	4	20.14	15	3	4.08	0.05	84.03	0.203	0.78
WDN	62919	2714	25.69	819	914	13.02	0.15	47.25	0.507	14.53

W_{s-con} = daily volume of consumption; D_{s-con} = daily density of consumption; $D_{s-\%}$ = percentage of water loss.

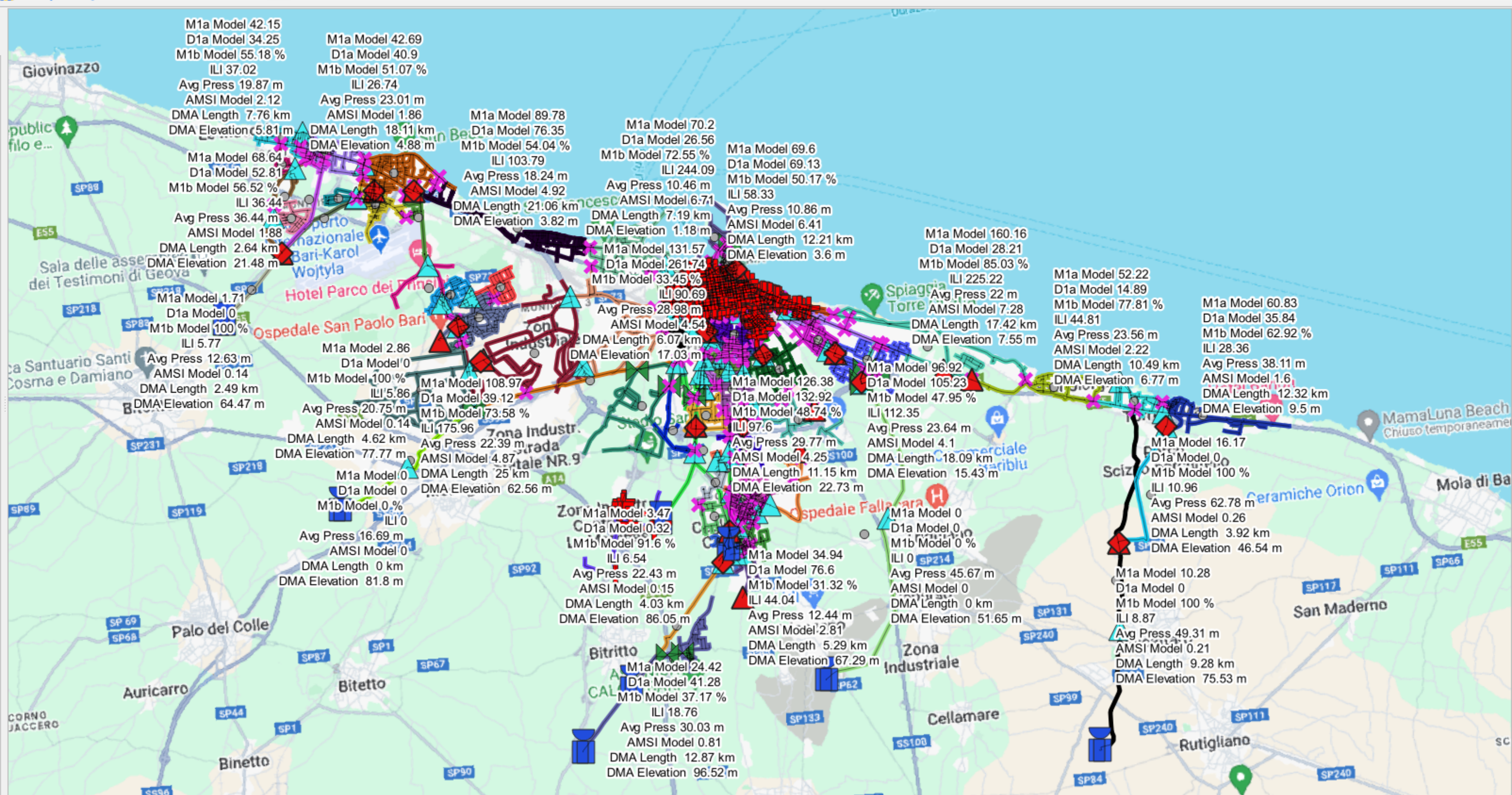






Layer

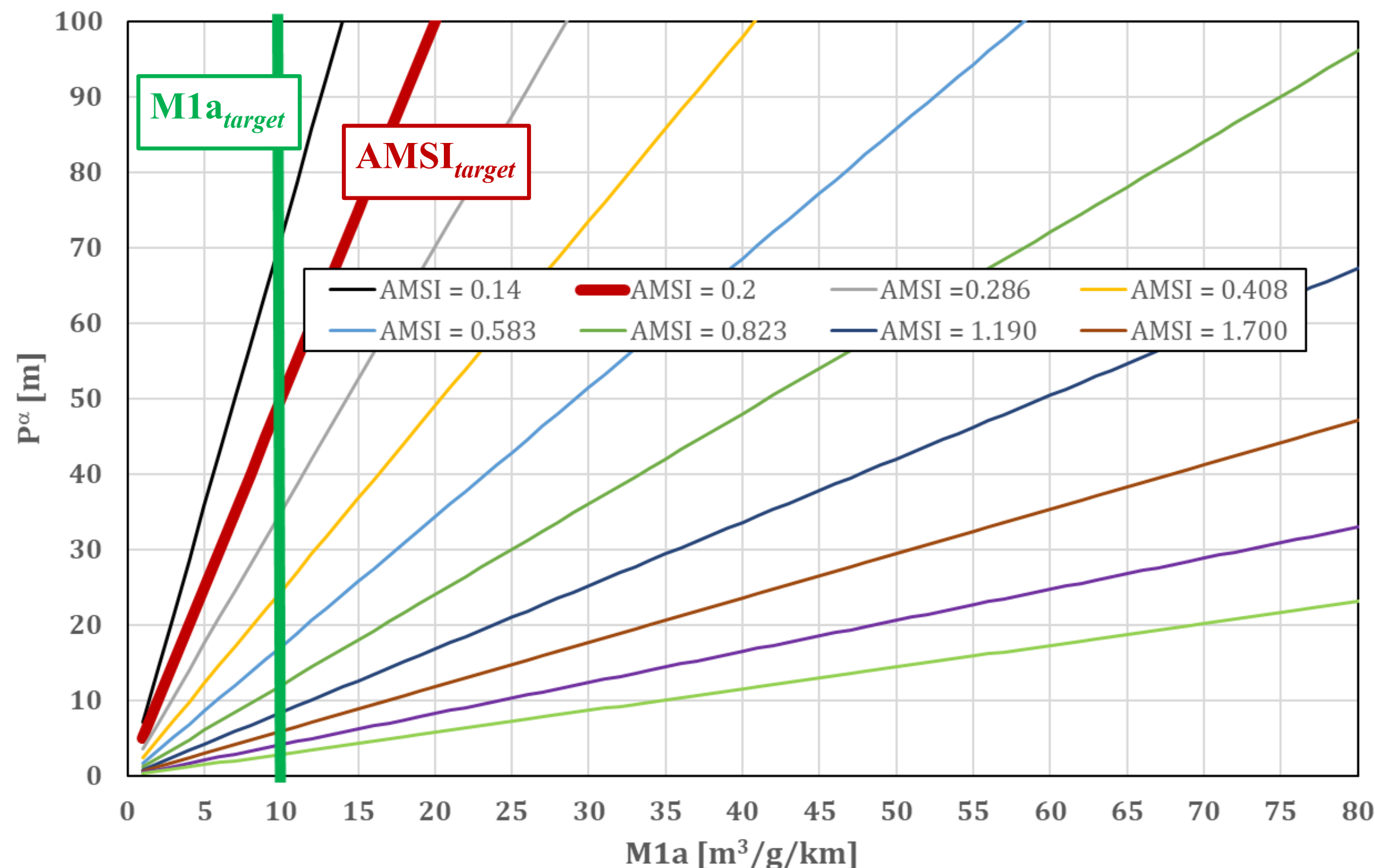
- ☒ Bari-Progetto-Autoclavi Digital T...
 - ☐ network_name
 - ☐ pipes
 - ☐ nodes
 - ☒ pipes topology
 - ☐ nodes_consumers
 - ☐ coords
 - ☐ pipes_vertices
 - ☐ coords_vertices
 - ☒ reservoir
- ☒ Bari-Progetto-Autoclavi_Devices
 - ☒ device_pressure_control
 - ☒ device_Pset
 - ☒ dismiss_pipes
 - ☒ device_pressure_meter
 - ☒ device_closed_gate
 - ☒ device_Kml
 - ☒ device_flow_meter
- ☒ Bari-Progetto-Autoclavi DigitalW...
 - ☒ DMA Analysis
 - ☒ DMA_data
 - ☐ Energy_Recover_PRV_FCV
 - ☐ DMA_closed_gates
 - ☐ DMA_flow_meters
 - ☒ DMA_segments
 - ☐ Nodes Consumers Pressure Ra...
 - ☐ Min Pressure [m]
 - ☐ Max Pressure [m]
 - ☒ Mean Pressure [m]
- ☒ Basemap
 - ☒ Google Maps



AMSI_{target} = 0.2 garantisce un obiettivo di **sostenibilità socioeconomica e contemporaneamente incrocia la sostenibilità ambientale e della risorsa** attraverso i valori M1a generalmente minori di 10 m³/g/km.

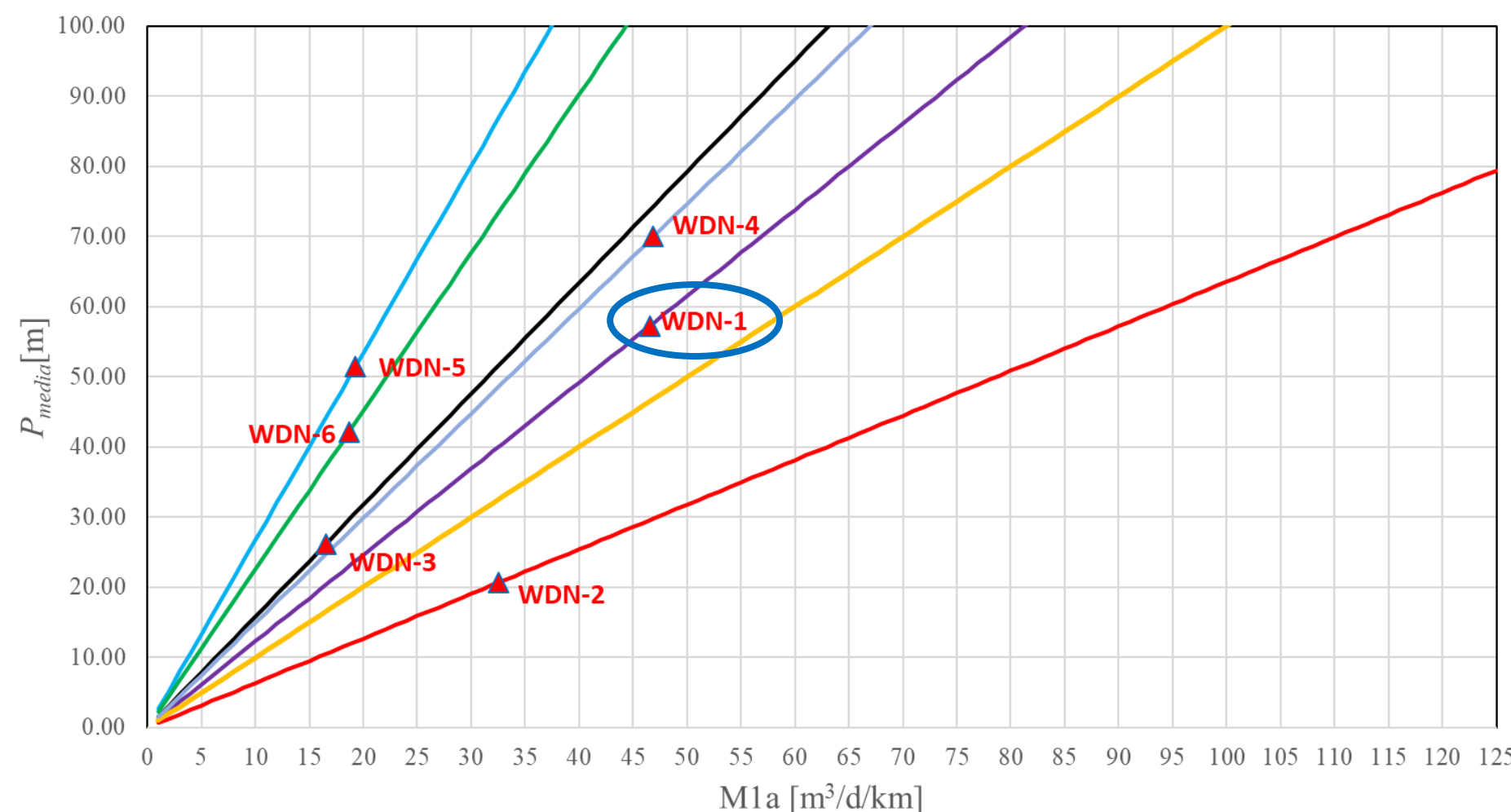
M1a_{target} = 10 m³/g/km **rafforza il vincolo di sostenibilità ambientale e della risorsa** attraverso l'**indicazione ai sistemi con pressioni più elevate di ridurre AMSI a valori minori di 0.2** quindi si va **oltre la sola** per la **sostenibilità socioeconomica**

M1a_{target} = 10 m³/g/km da solo non è congruo perché consente ai sistemi a pressioni più basse di non considerare l'obiettivo di sostenibilità socioeconomica ovvero di non avere le azioni di asset management utili a rinnovare il sistema per le generazioni future a prescindere dai volumi delle perdite.

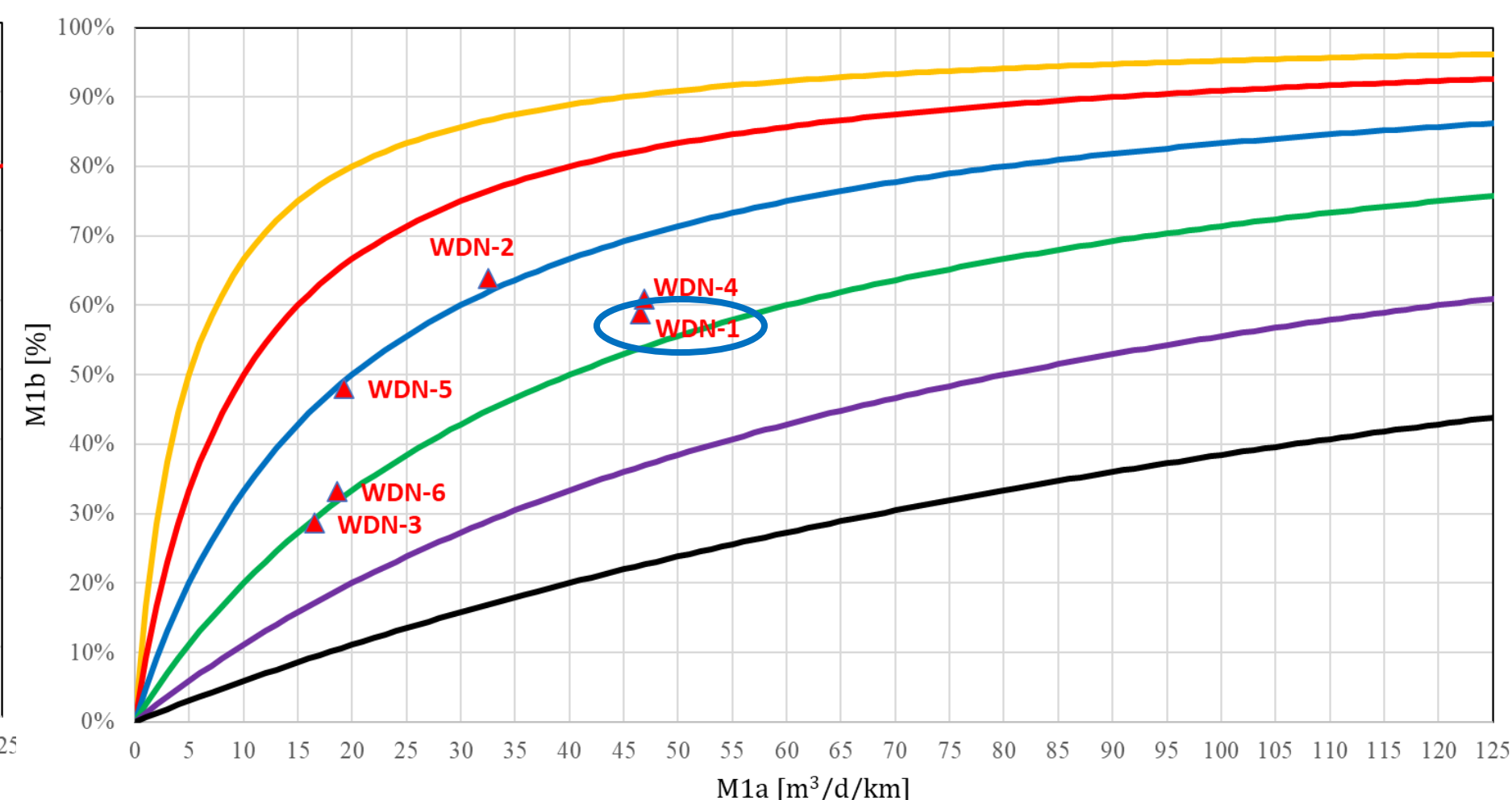


Gestore (2)

Pianificazione asset management



▲ Stato di fatto
AMS I = 1
AMS I = 1.57
AMS I = 0.67
AMS I = 0.63
AMS I = 0.37
AMS I = 0.44
AMS I = 0.81

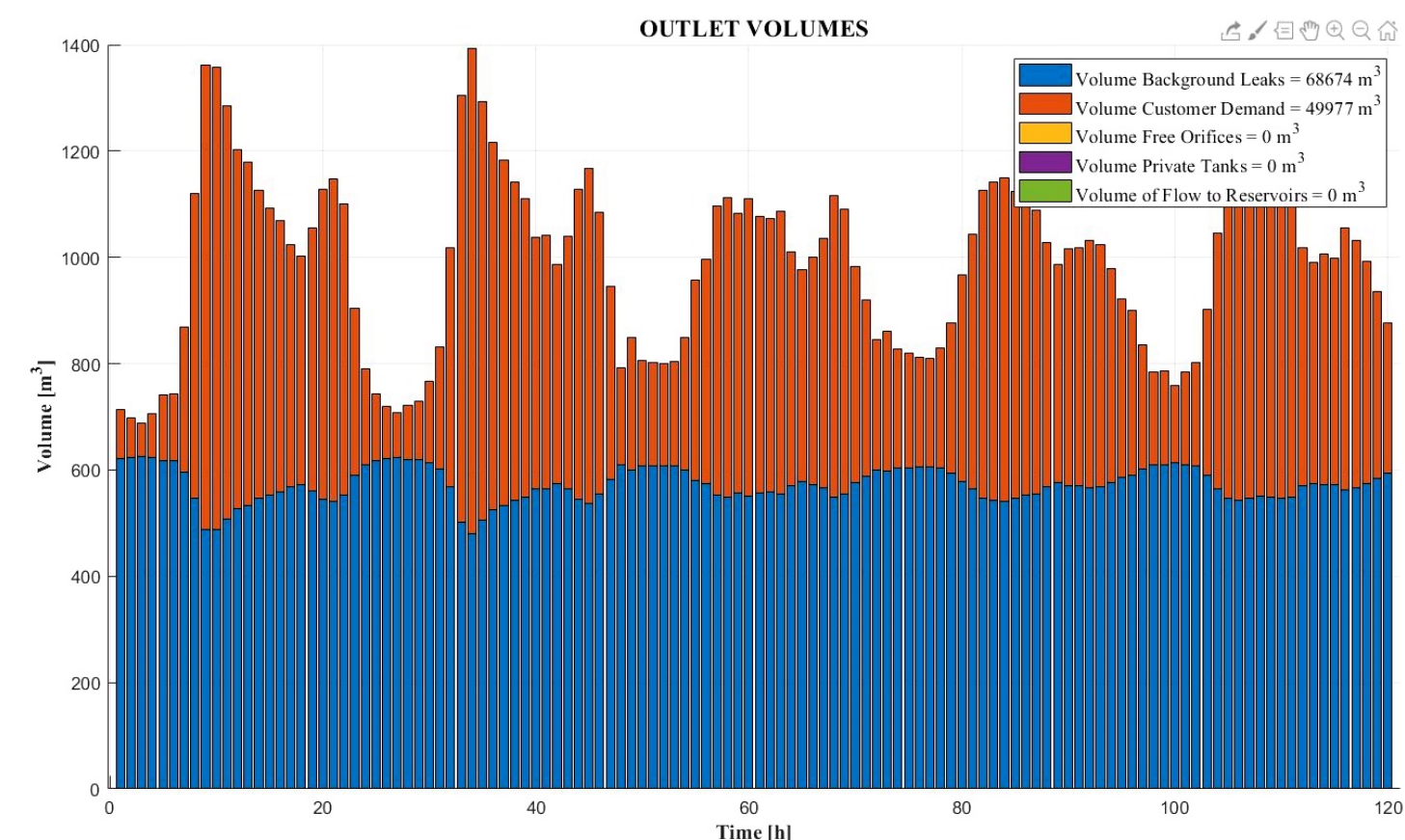
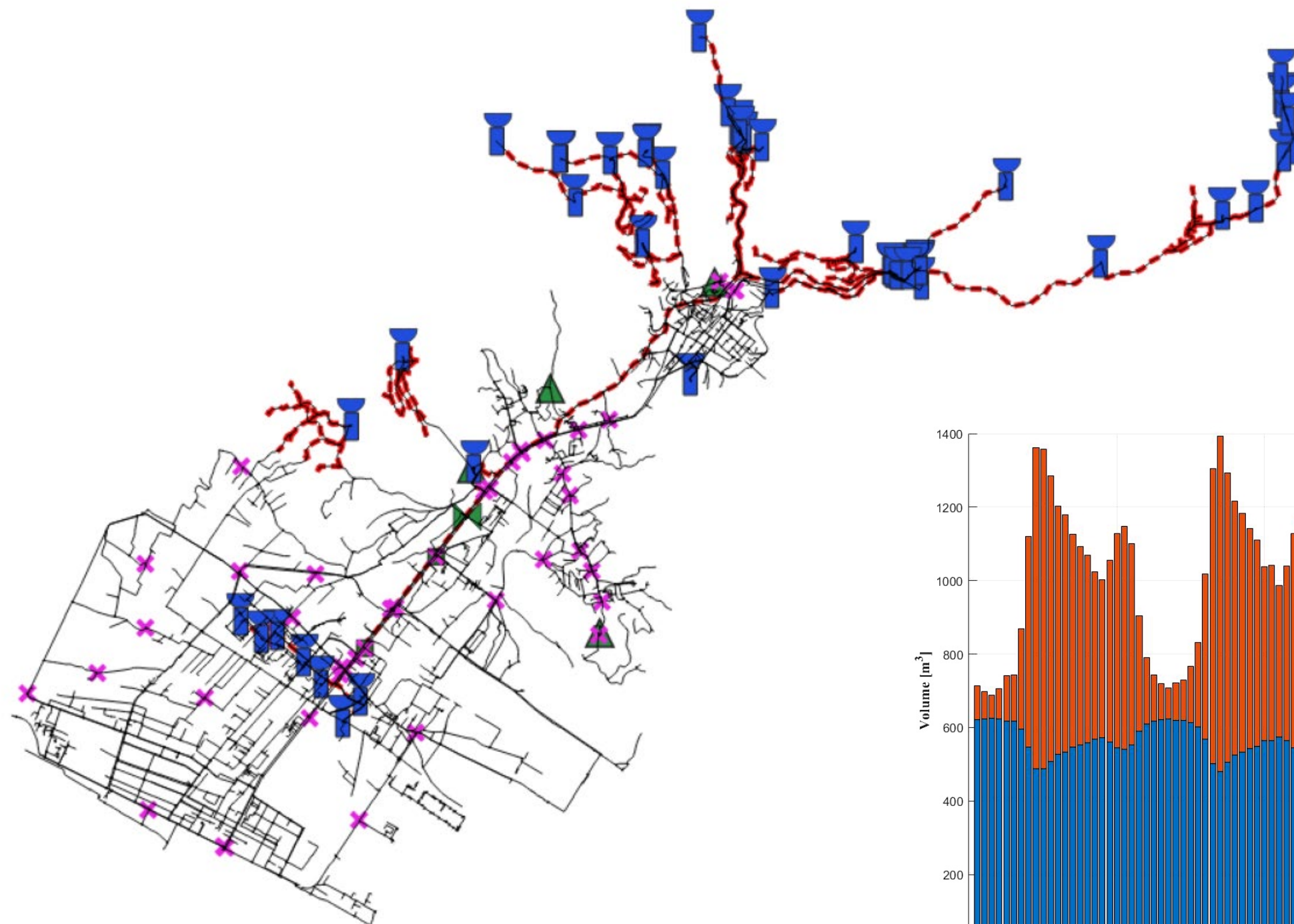


▲ Stato di fatto
D1a = 5
D1a = 10
D1a = 20
D1a = 40
D1a = 80
D1a = 160

M1a = 46.5 m³/d/km

P_{media} = 57.3 m

P_{compatibile} = 40 m



ORGANIZZATO DA

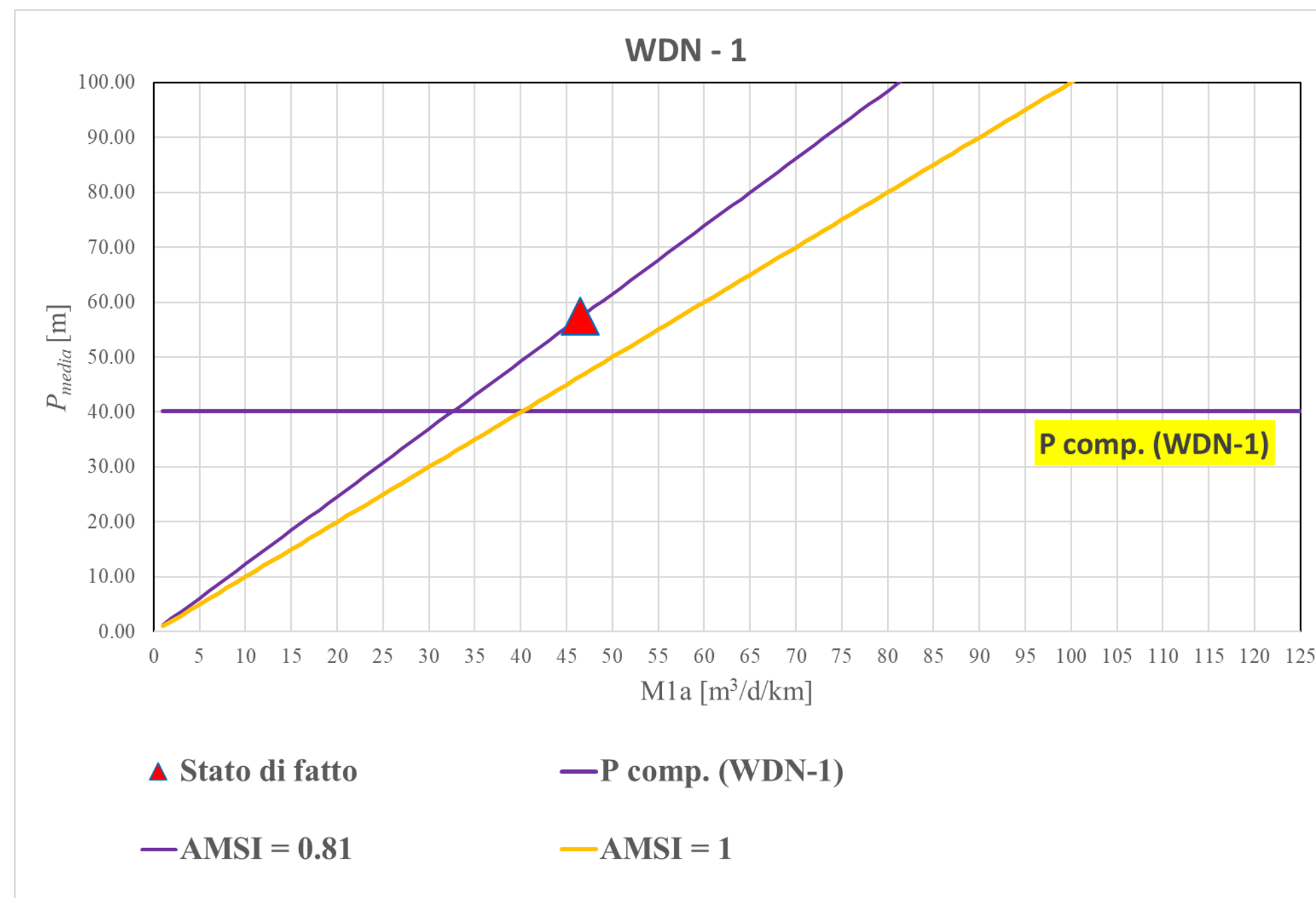
IN COLLABORAZIONE CON

M1a = 46.5 m³/d/km

P_{media} = 57.3 m

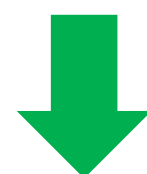
P_{compatibile} = 40 m

$$AMSI = \frac{M1_a}{\left(P_{media}^{sistema}\right)^{\alpha \approx 1}}$$



M1a = 46.5 m³/d/km

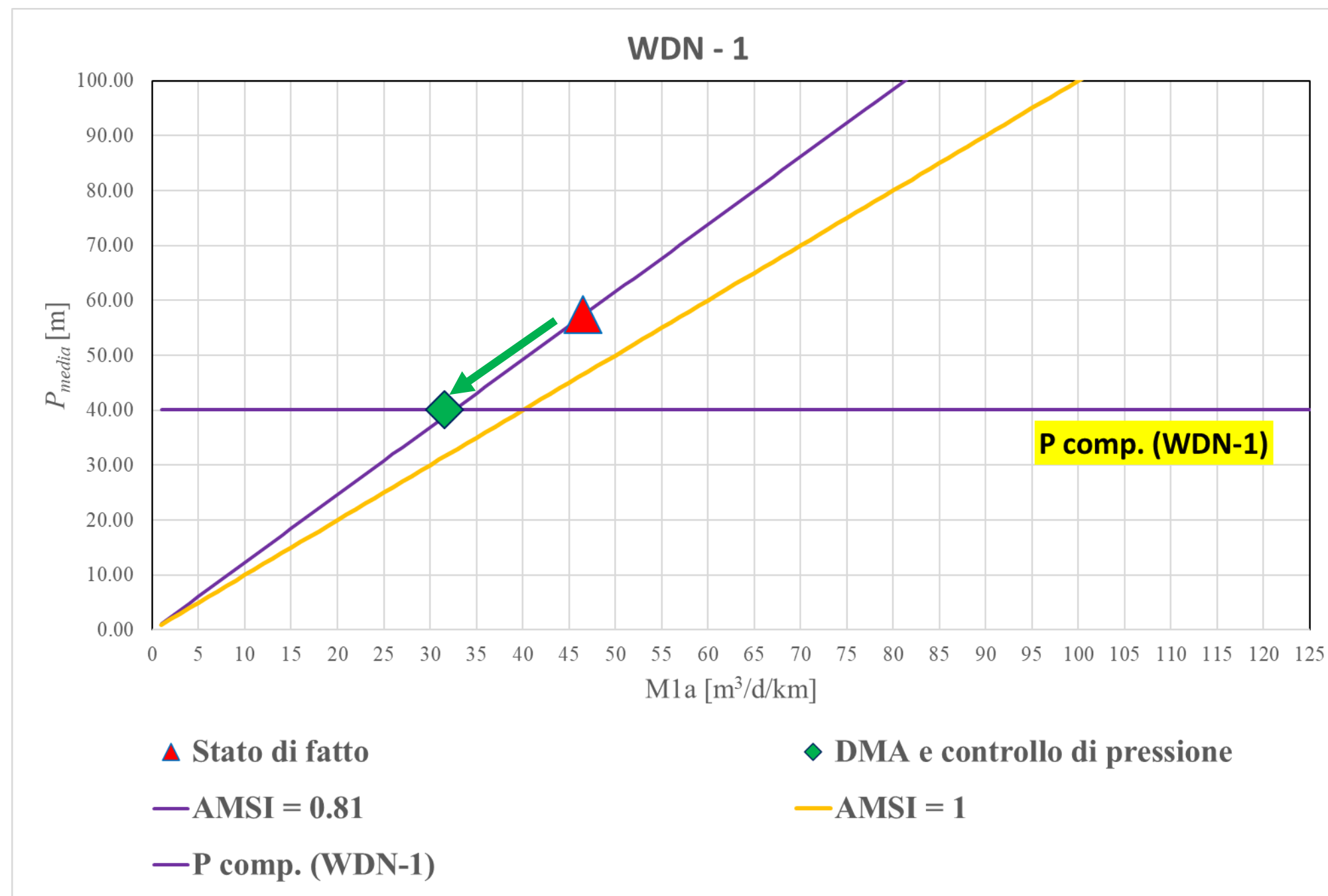
P_{media} = 57.3 m



**DMA e controllo
di pressione**

M1a = 31.6 m³/d/km

P_{media} = 40.1 m



$$AMSI = \frac{M1_a}{(P_{media}^{sistema})^{\alpha \approx 1}}$$

M1a = 46.5 m³/d/km

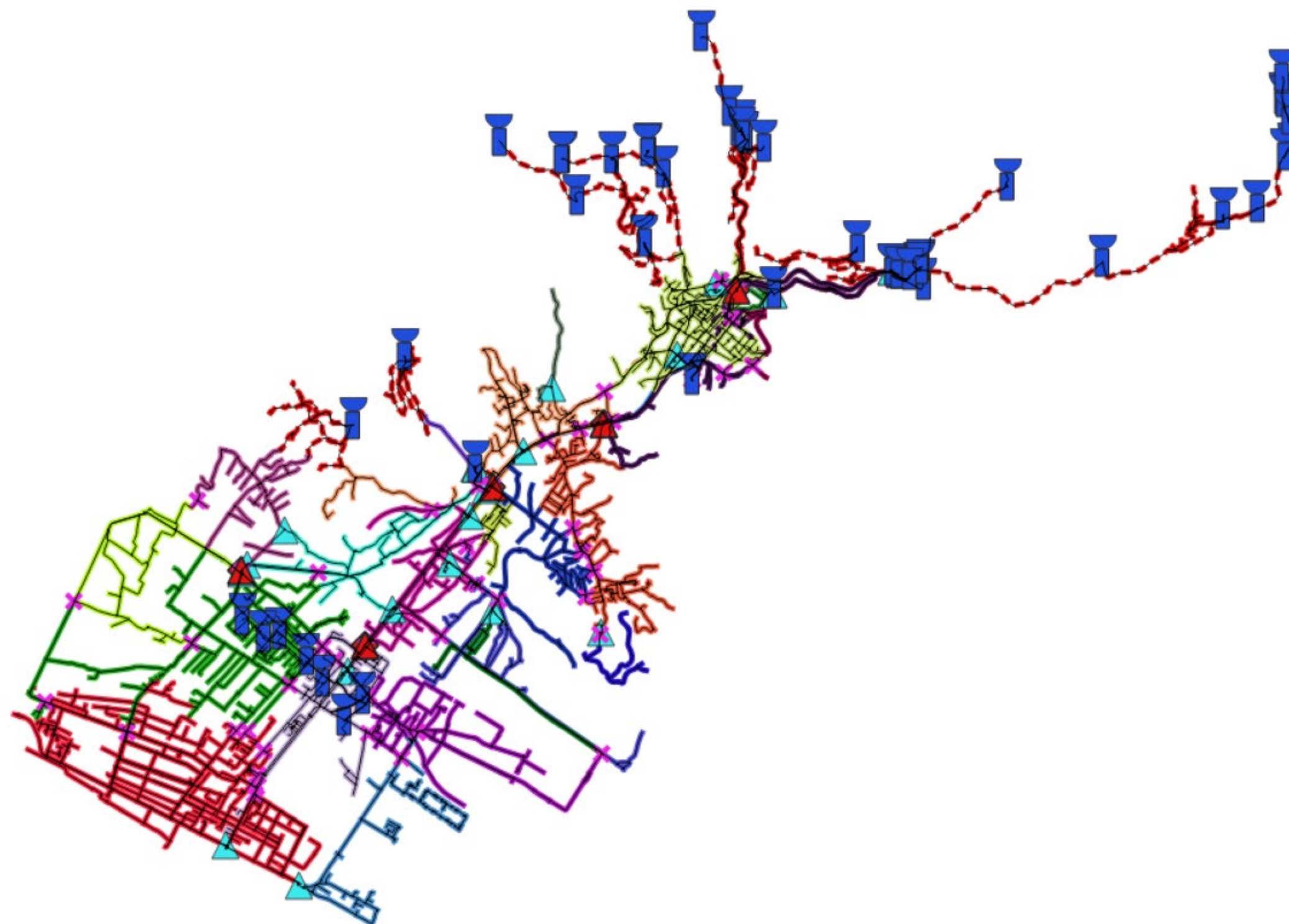
P_{media} = 57.3 m



**DMA e controllo
di pressione**

M1a = 31.6 m³/d/km

P_{media} = 40.1 m



ORGANIZZATO DA

IN COLLABORAZIONE CON

M1a = 46.5 m³/d/km

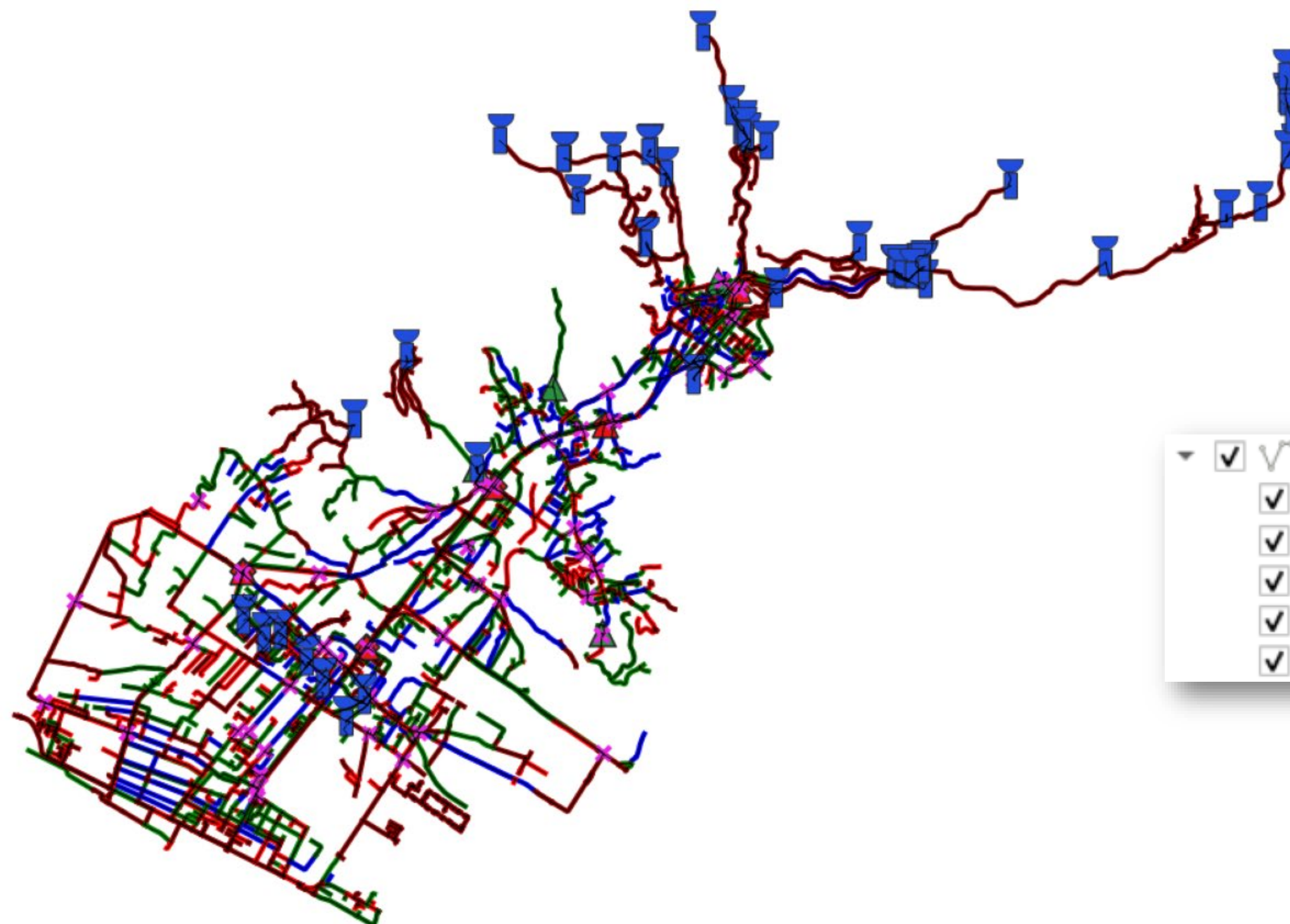
P_{media} = 57.3 m



**DMA e controllo
di pressione**

M1a = 31.6 m³/d/km

P_{media} = 40.1 m



<input checked="" type="checkbox"/>	<input type="checkbox"/>	asset data
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	M1a < 15
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	15 < M1a < 25
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	25 < M1a < 40
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	40 < M1a < 60
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	M1a > 60

M1a = 46.5 m³/d/km

P_{media} = 57.3 m



**DMA e controllo
di pressione**

M1a = 31.6 m³/d/km

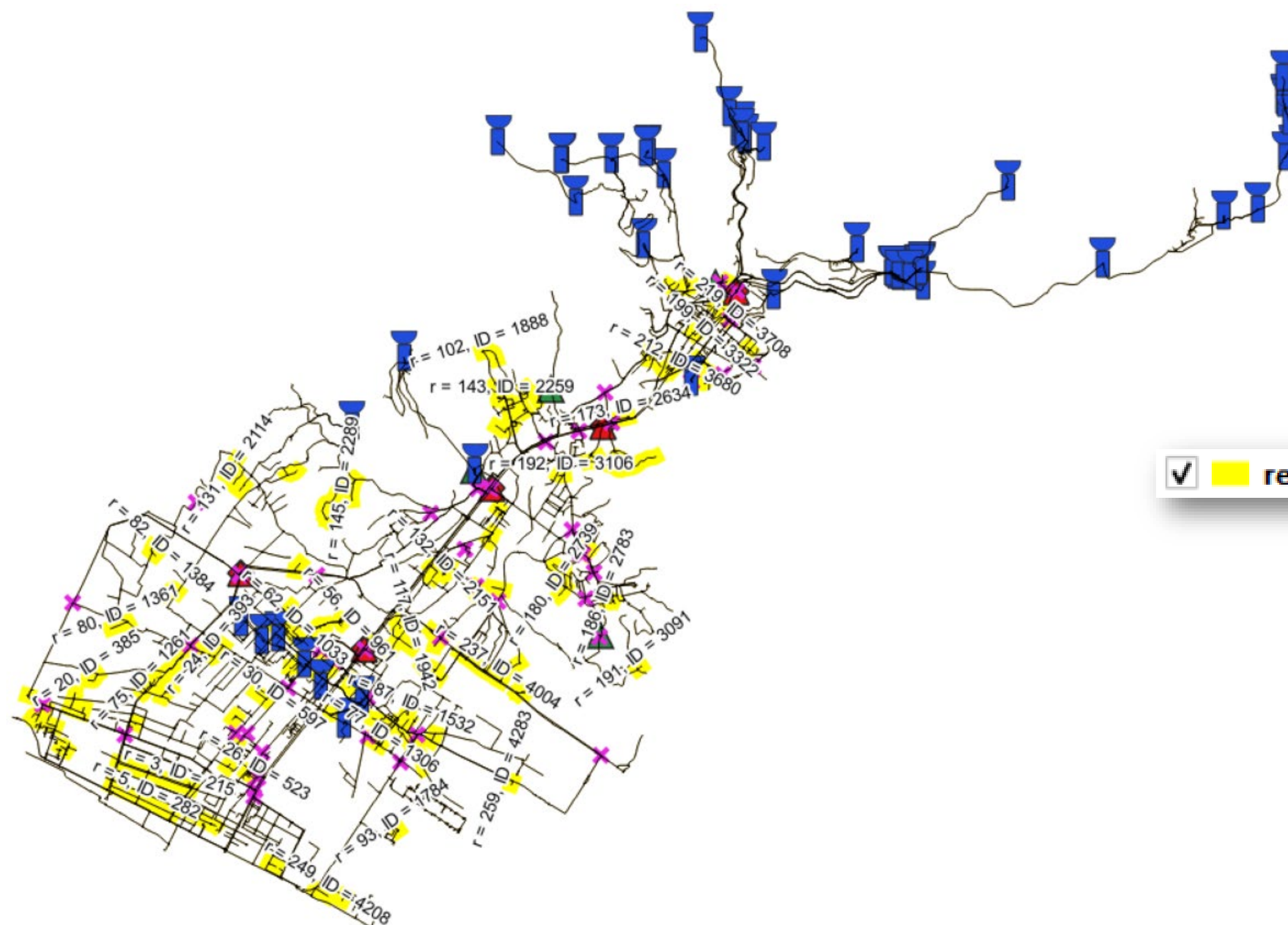
P_{media} = 40.1 m



**Sostituzione 5%
in lunghezza
(DN<40mm)**

M1a = 30.0 m³/d/km

P_{media} = 40.5 m



✓ **replaced_pipes**

$M1a = 46.5 \text{ m}^3/\text{d}/\text{km}$

$P_{\text{media}} = 57.3 \text{ m}$



DMA e controllo
di pressione

$M1a = 31.6 \text{ m}^3/\text{d}/\text{km}$

$P_{\text{media}} = 40.1 \text{ m}$



Sostituzione 5%
in lunghezza
(DN<40mm)

$M1a = 30.0 \text{ m}^3/\text{d}/\text{km}$

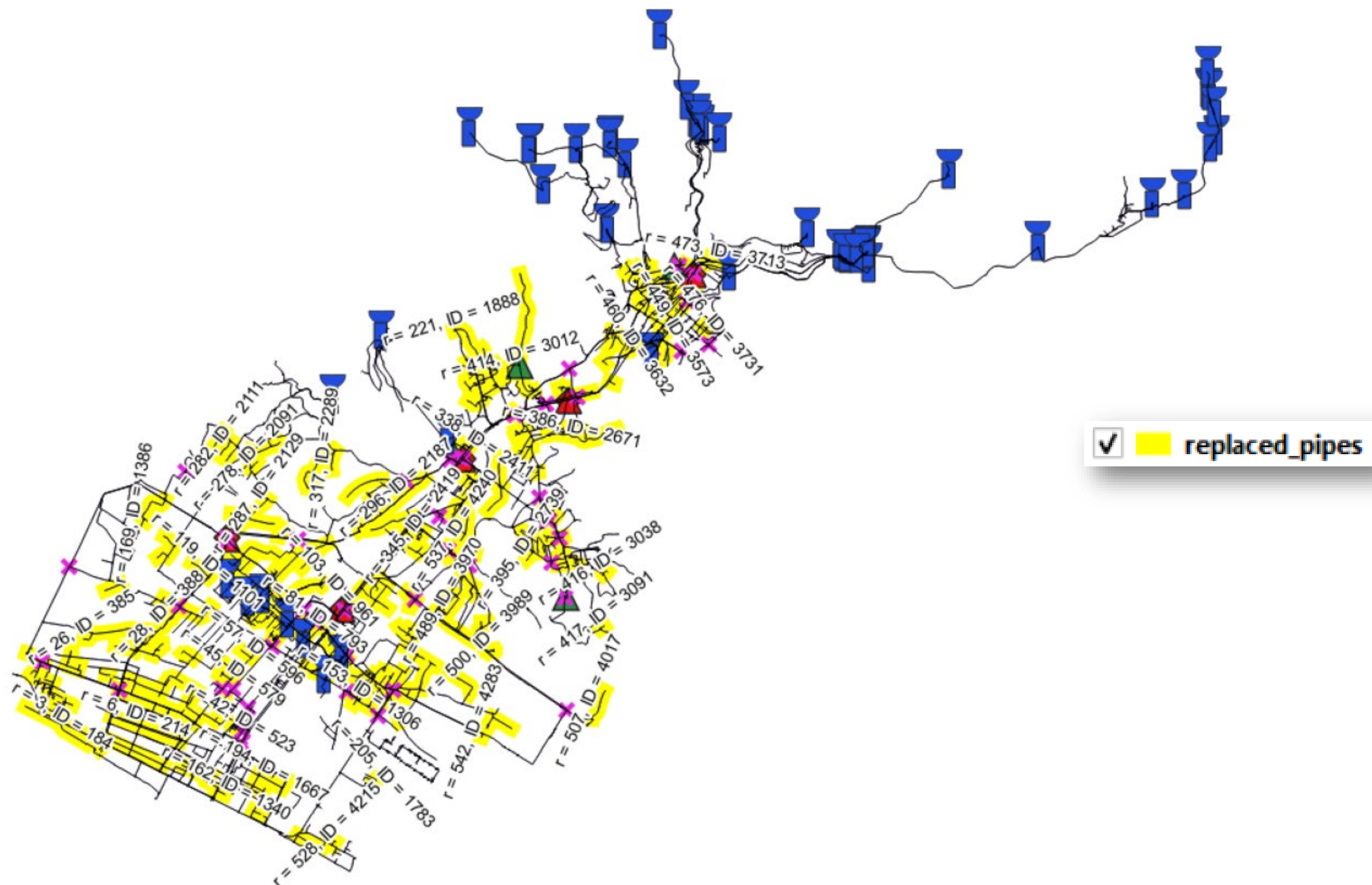
$P_{\text{media}} = 40.5 \text{ m}$



Sostituzione 15%
in lunghezza
(DN<50mm)

$M1a = 27.5 \text{ m}^3/\text{d}/\text{km}$

$P_{\text{media}} = 40.9 \text{ m}$



✓ replaced_pipes

M1a = 46.5 m³/d/km

P_{media} = 57.3 m



DMA e controllo di pressione

M1a = 31.6 m³/d/km

P_{media} = 40.1 m



Sostituzione 5% in lunghezza (DN<40mm)

M1a = 30.0 m³/d/km

P_{media} = 40.5 m

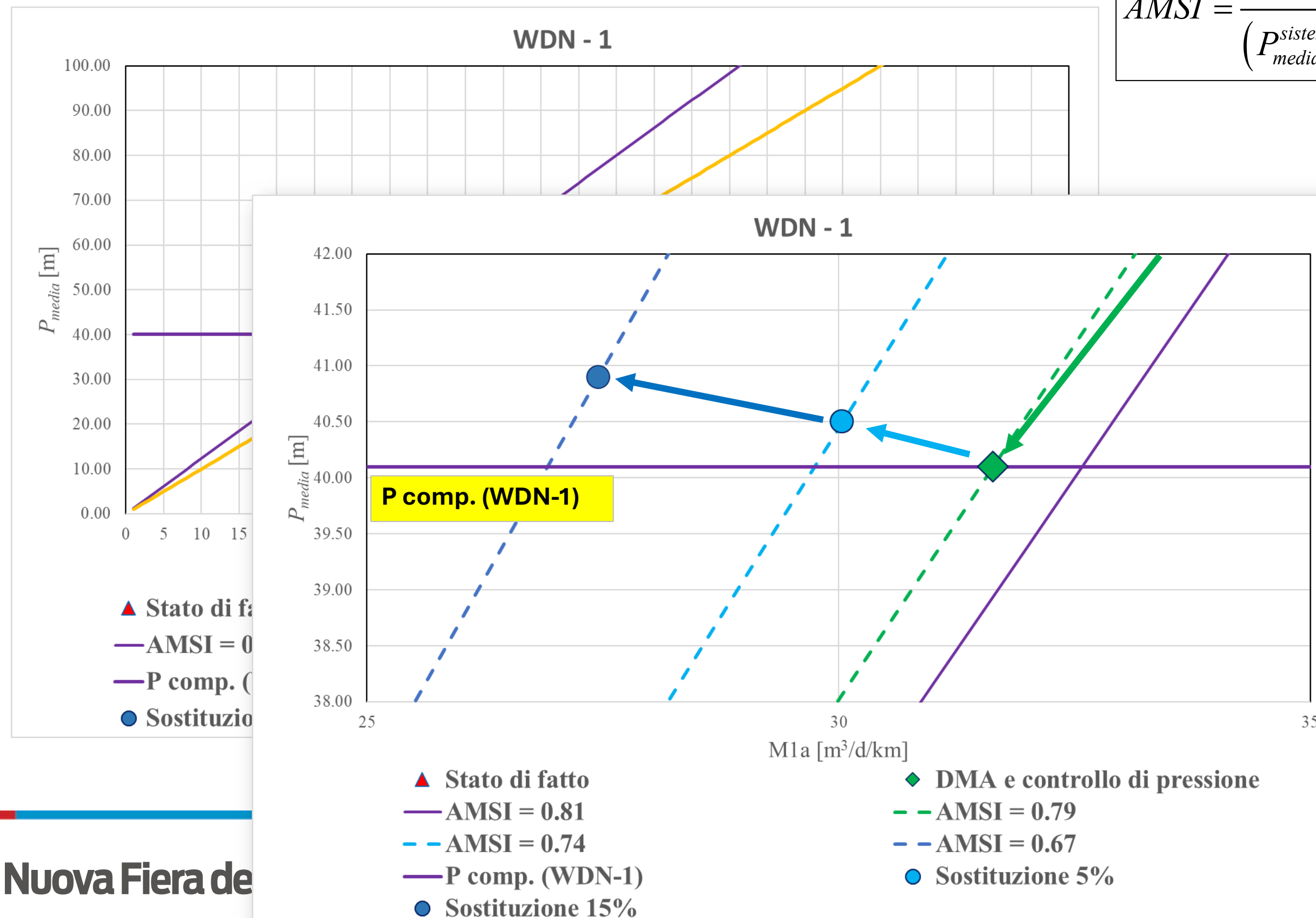


Sostituzione 15% in lunghezza (DN<50mm)

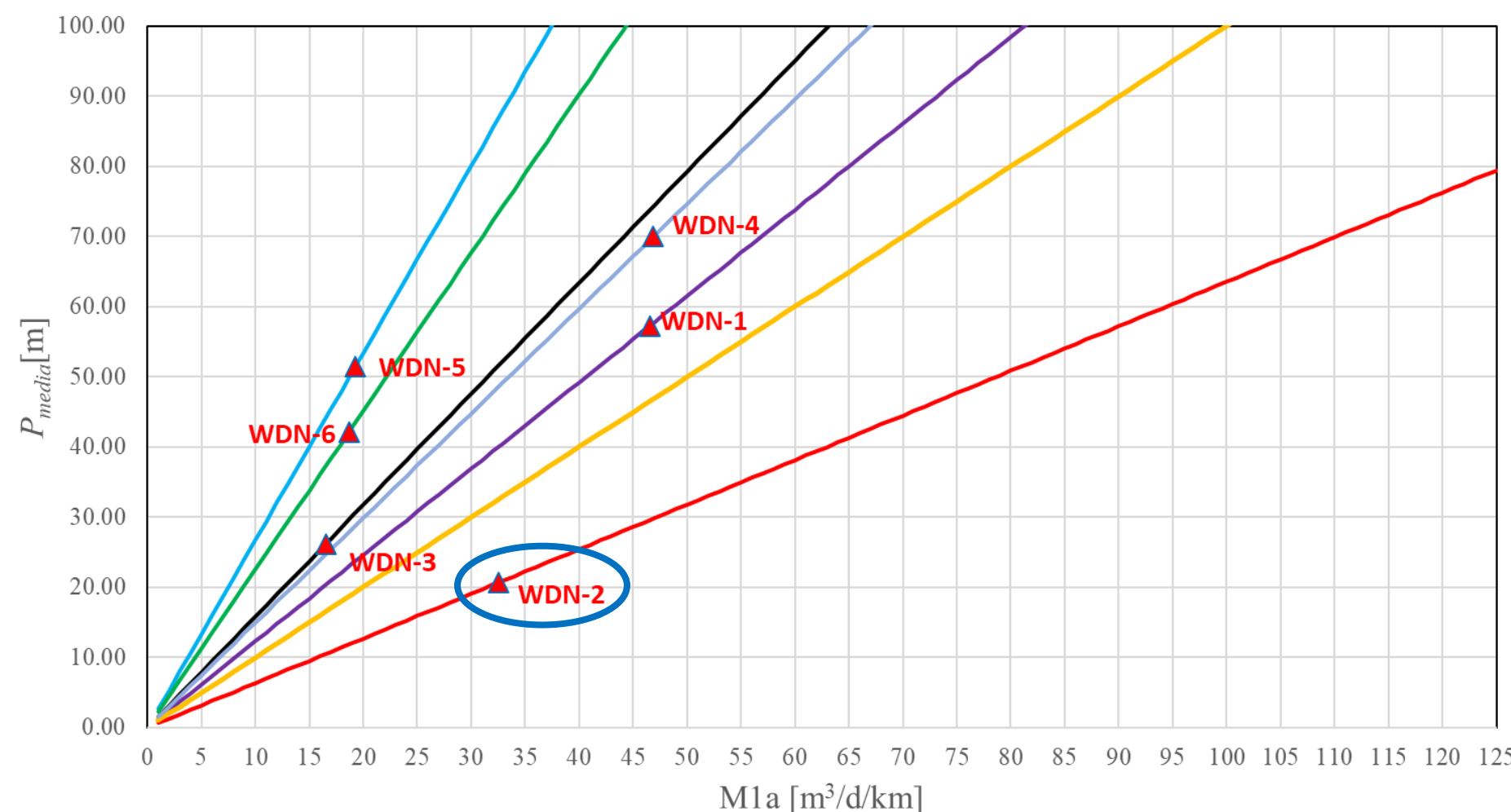
M1a = 27.5 m³/d/km

P_{media} = 40.9 m

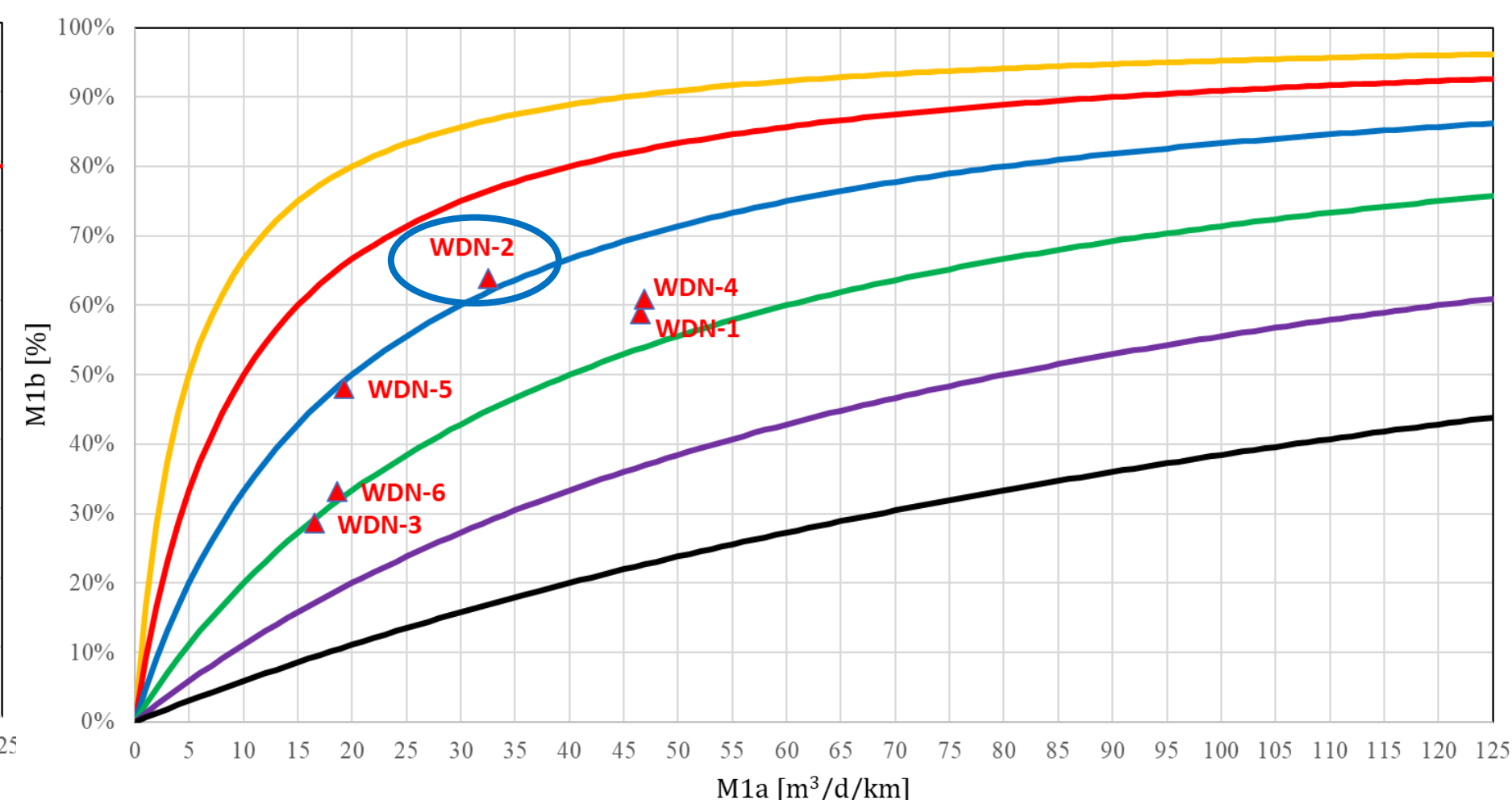
$$AMSI = \frac{M1_a}{(P_{media}^{sistema})^{\alpha \approx 1}}$$



Gestore (2)



▲ Stato di fatto
 — AMSI = 1.57 — AMSI = 0.63 — AMSI = 0.81
 — AMSI = 1 — AMSI = 0.67 — AMSI = 0.37 — AMSI = 0.44



▲ Stato di fatto
 — D1a = 5 — D1a = 10 — D1a = 20
 — D1a = 40 — D1a = 80 — D1a = 160

ORGANIZZATO DA



Nuova Fiera del Levante, 27-28 novembre 2024

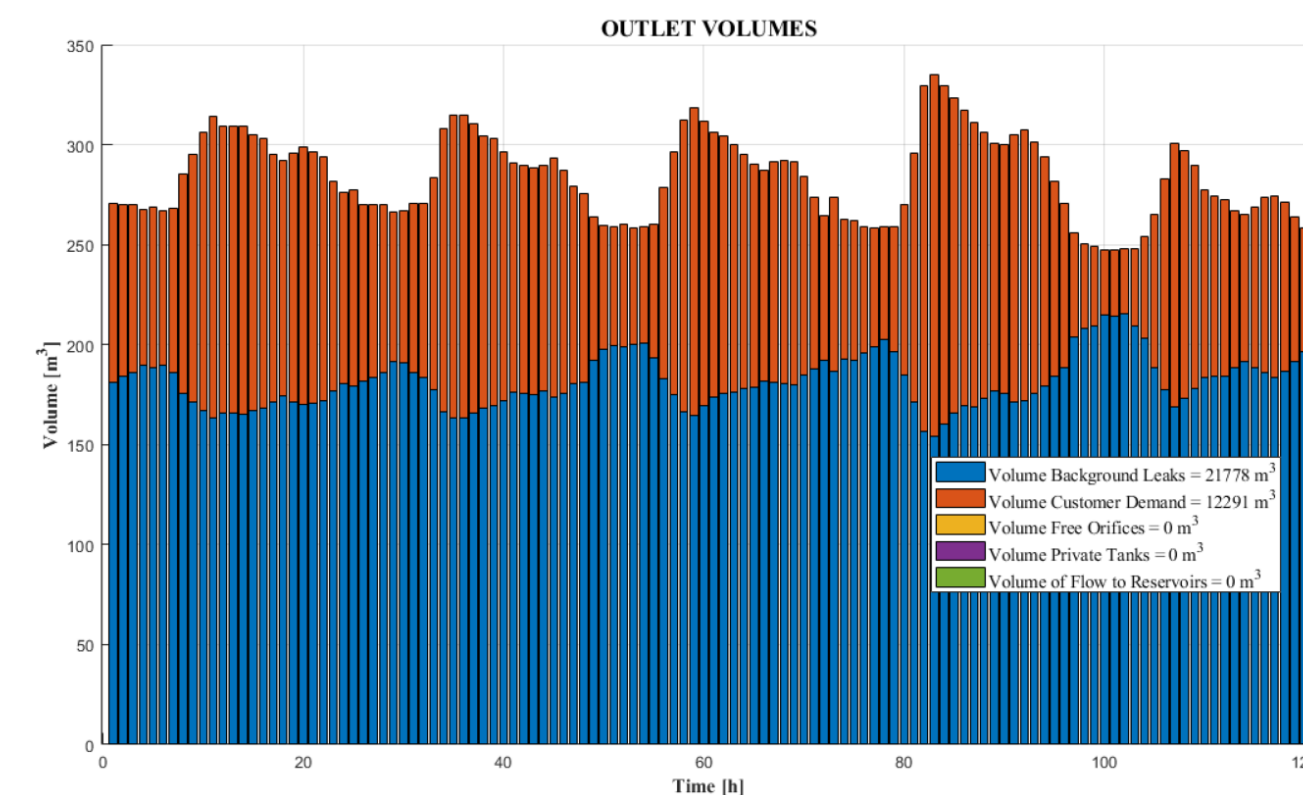
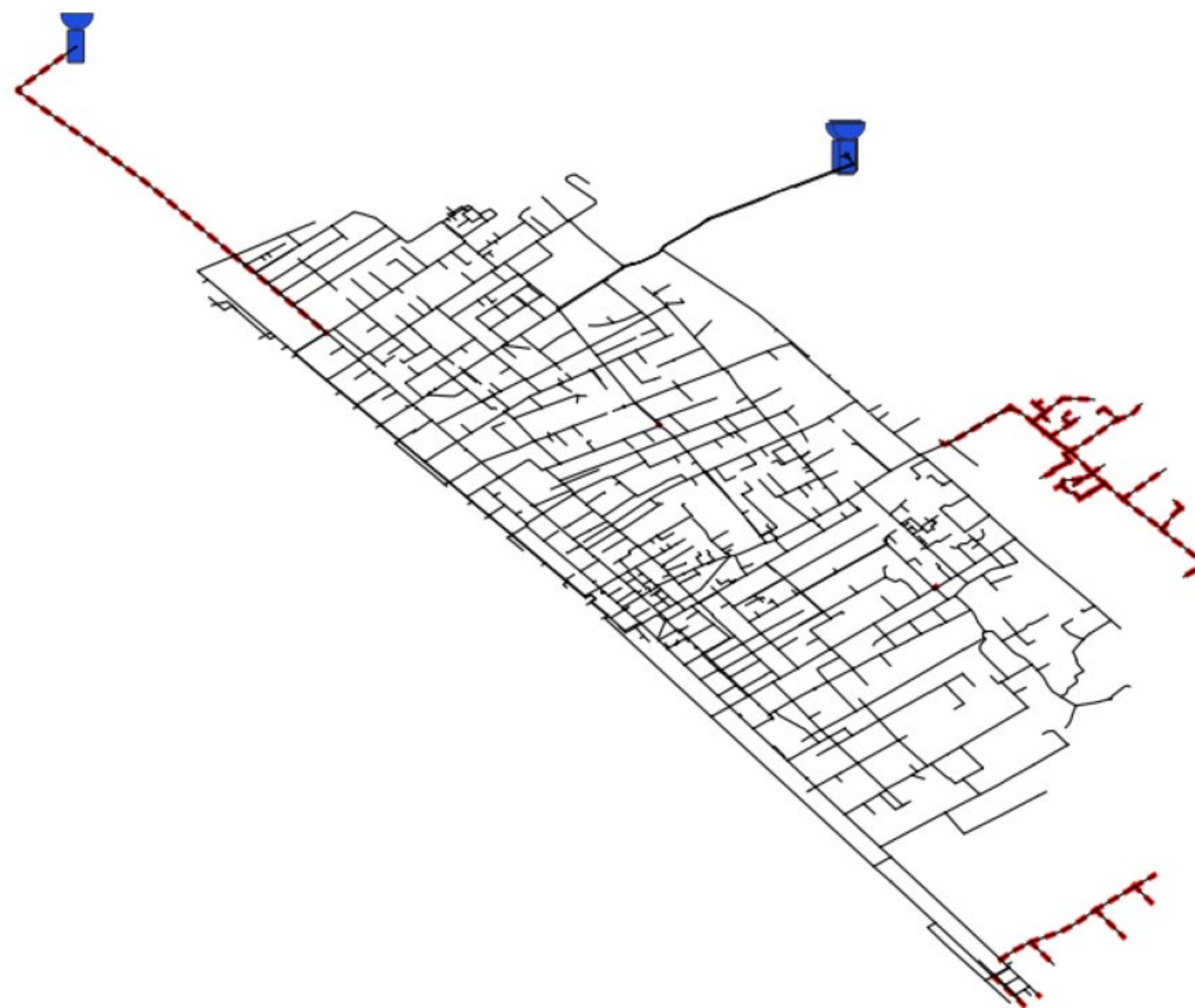
IN COLLABORAZIONE CON



$M1a = 32.5 \text{ m}^3/\text{d}/\text{km}$

$P_{\text{media}} = 20.7 \text{ m}$

$P_{\text{compatibile}} = 19.9 \text{ m}$

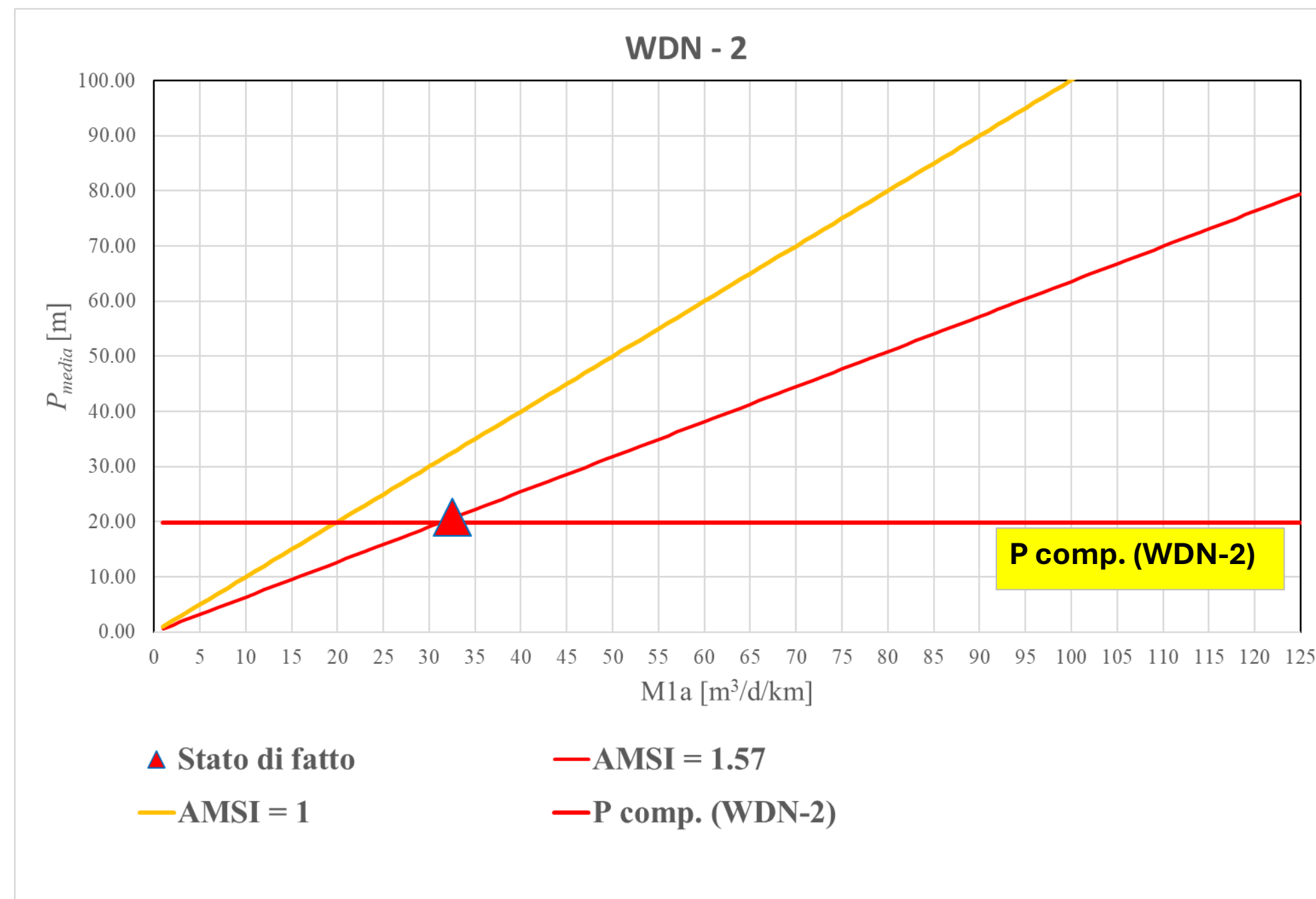


M1a = 32.5 m³/d/km

P_{media} = 20.7 m

P_{compatibile} = 19.9 m

$$AMSI = \frac{M1_a}{\left(P_{media}^{sistema}\right)^{\alpha \approx 1}}$$



M1a = 32.5 m³/d/km

P_{media} = 20.7 m

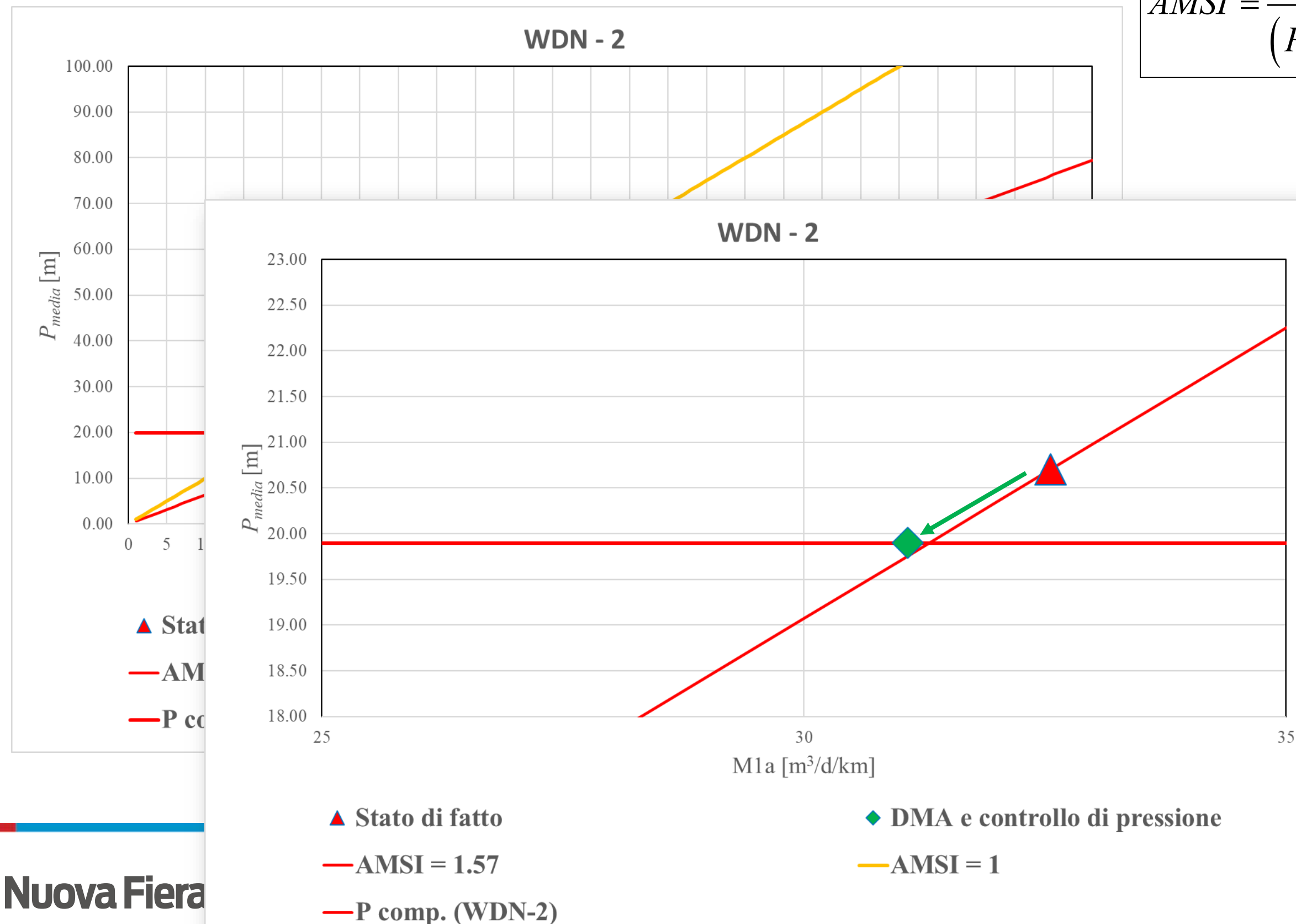


**DMA e controllo
di pressione**

M1a = 31.1 m³/d/km

P_{media} = 19.9 m

$$AMSI = \frac{M1_a}{(P_{media}^{sistema})^{\alpha \approx 1}}$$



M1a = 32.5 m³/d/km

P_{media} = 20.7 m



DMA e controllo di pressione

M1a = 31.1 m³/d/km

P_{media} = 19.9 m



Sostituzione 5% in lunghezza

M1a = 28.1 m³/d/km

P_{media} = 20.9 m

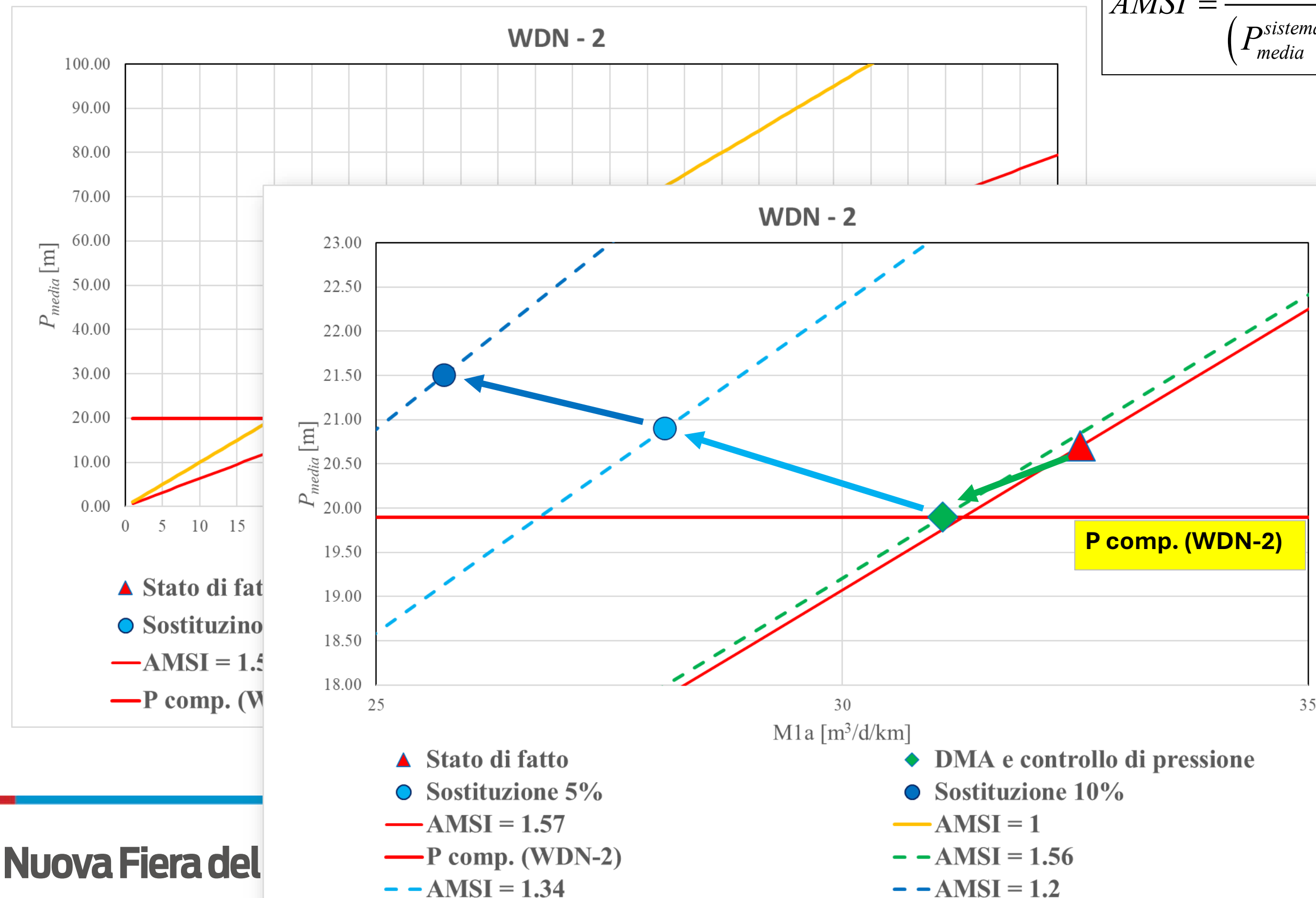


Sostituzione 10% in lunghezza

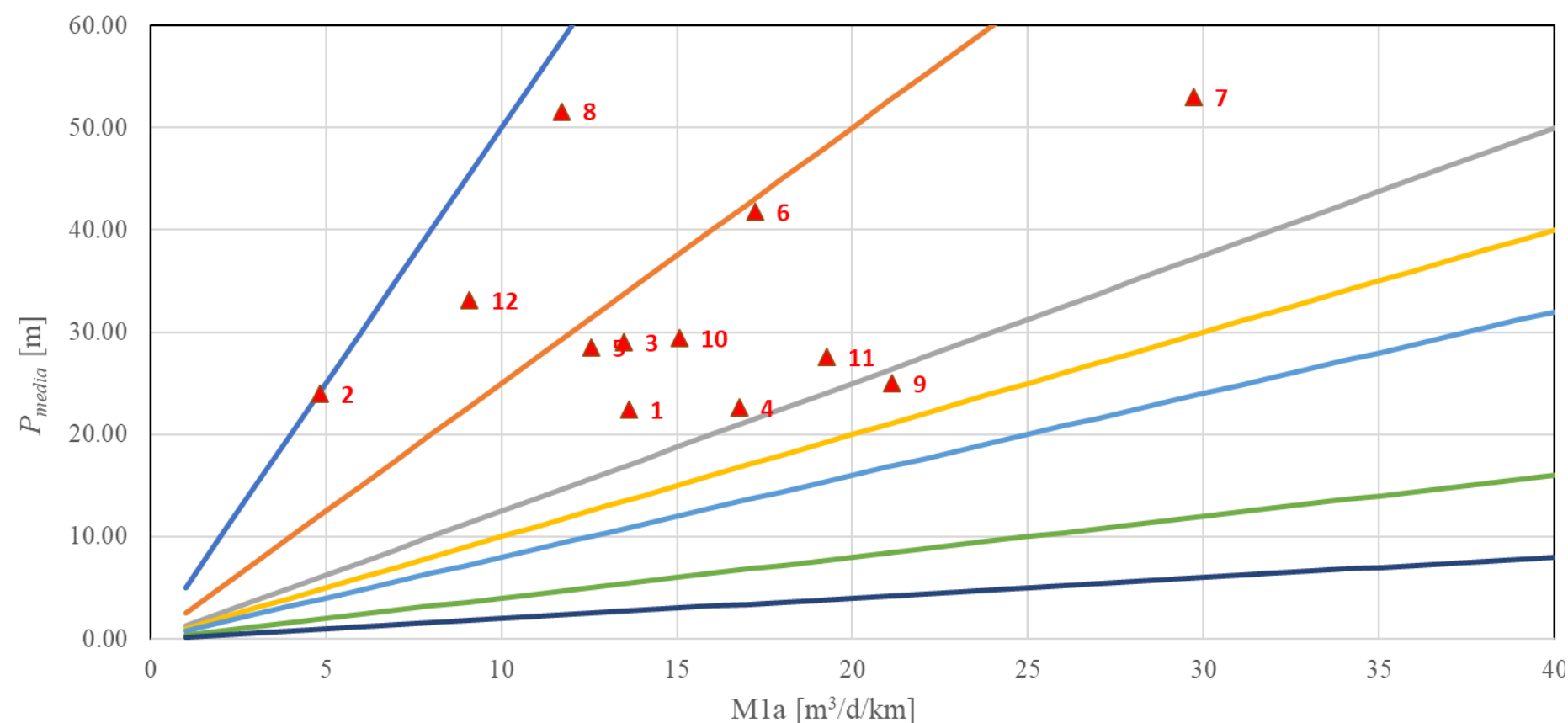
M1a = 25.7 m³/d/km

P_{media} = 21.5 m

$$AMSI = \frac{M1_a}{(P_{media}^{sistema})^{\alpha \approx 1}}$$



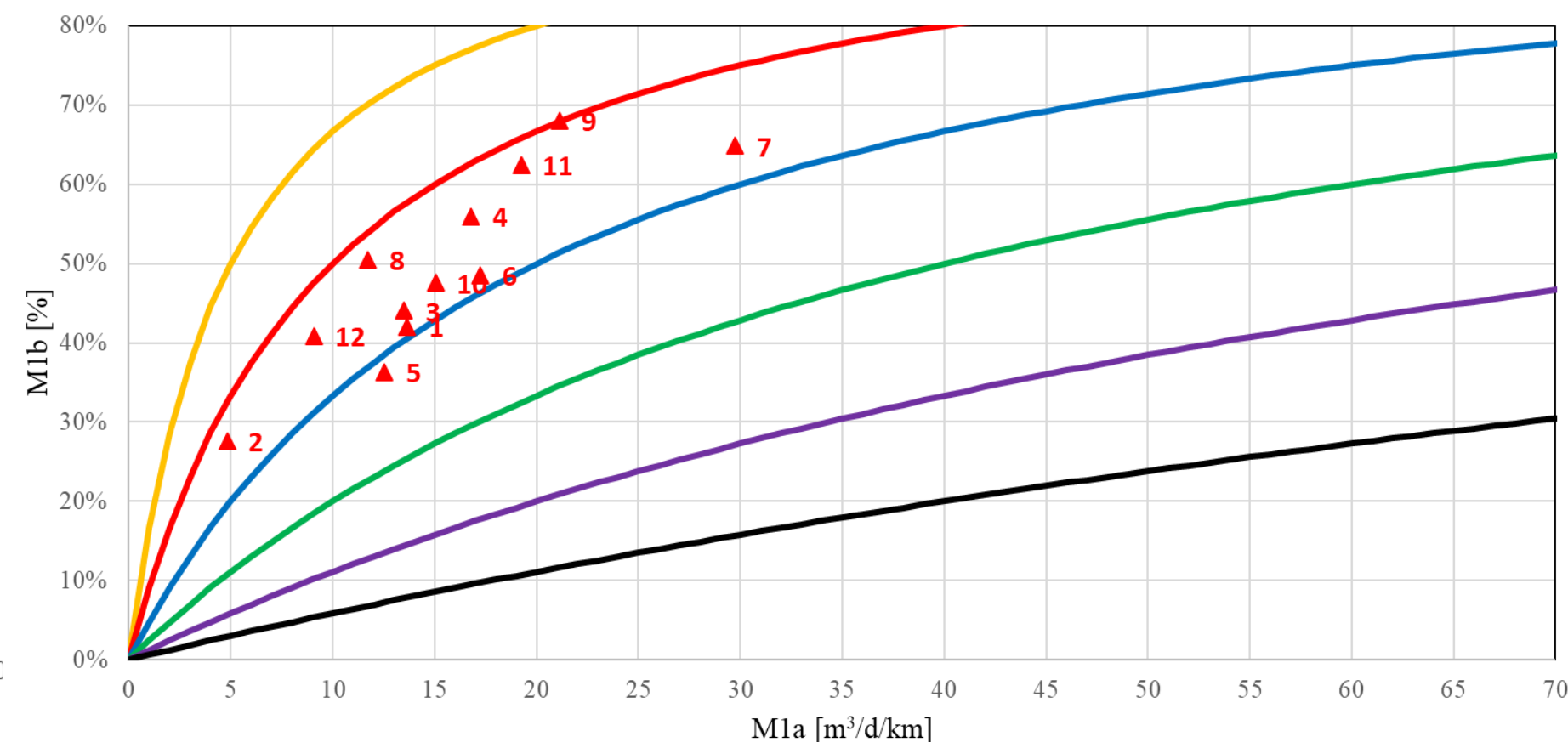
Gestore (3)



▲ Stato di fatto

— AMSI = 0.2 — AMSI = 0.4 — AMSI = 0.8

— AMSI = 1 — AMSI = 1.25 — AMSI = 2.5 — AMSI = 5



▲ Stato di fatto — $D1a = 5$ — $D1a = 10$ — $D1a = 20$

— $D1a = 40$ — $D1a = 80$ — $D1a = 160$

ORGANIZZATO DA



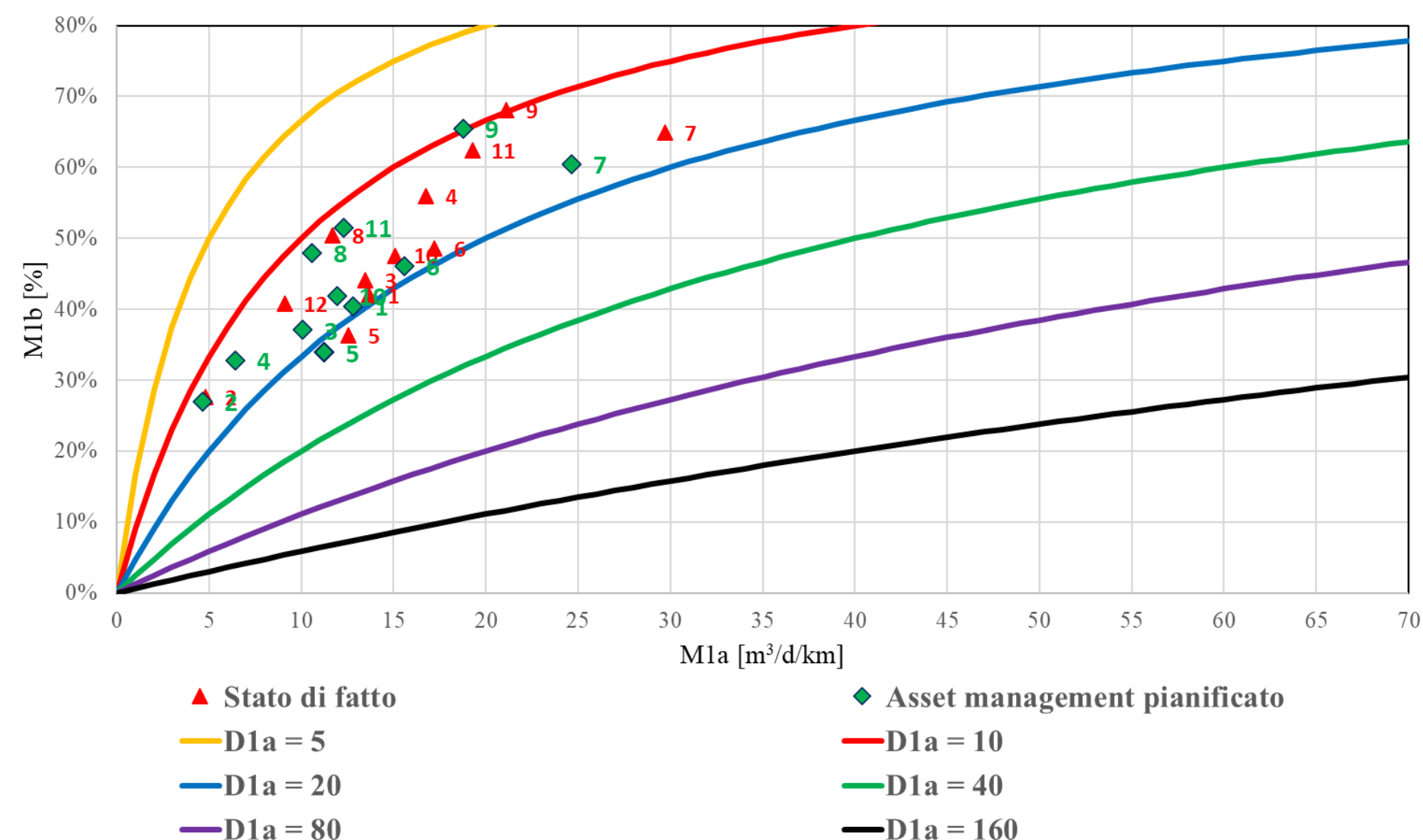
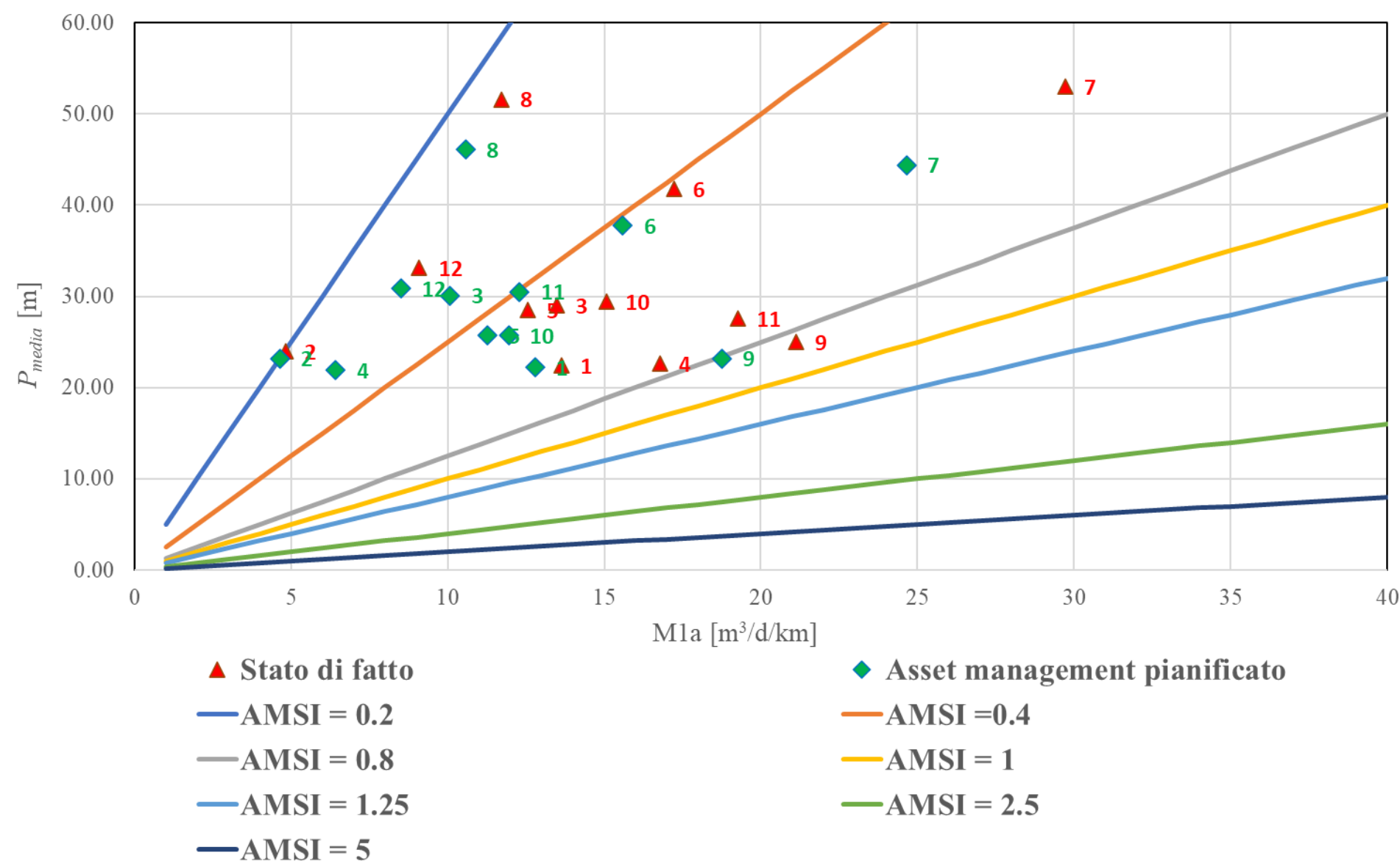
Nuova Fiera del Levante, 27-28 novembre 2024

IN COLLABORAZIONE CON



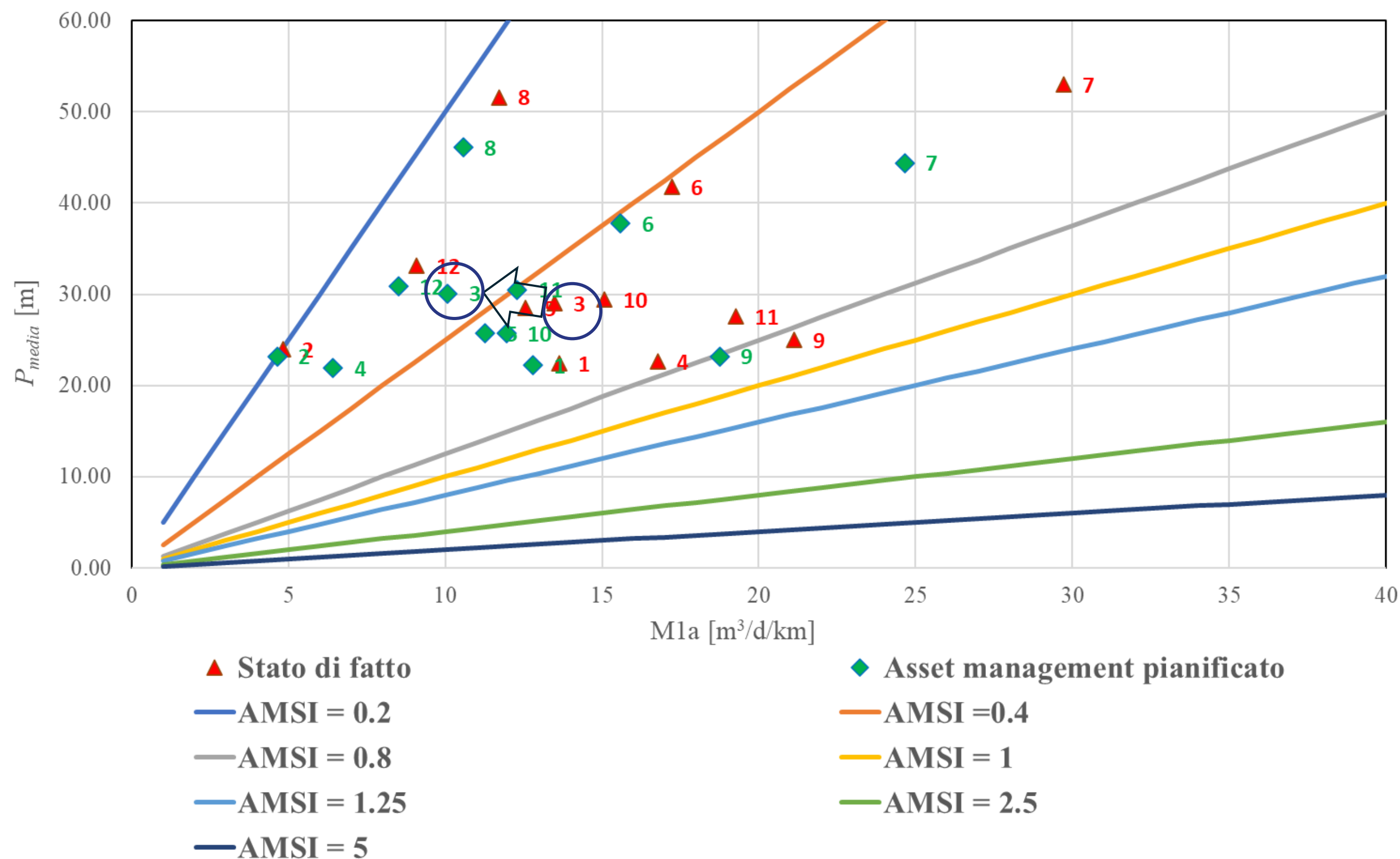
Gestore (3)

Pianificazione asset management



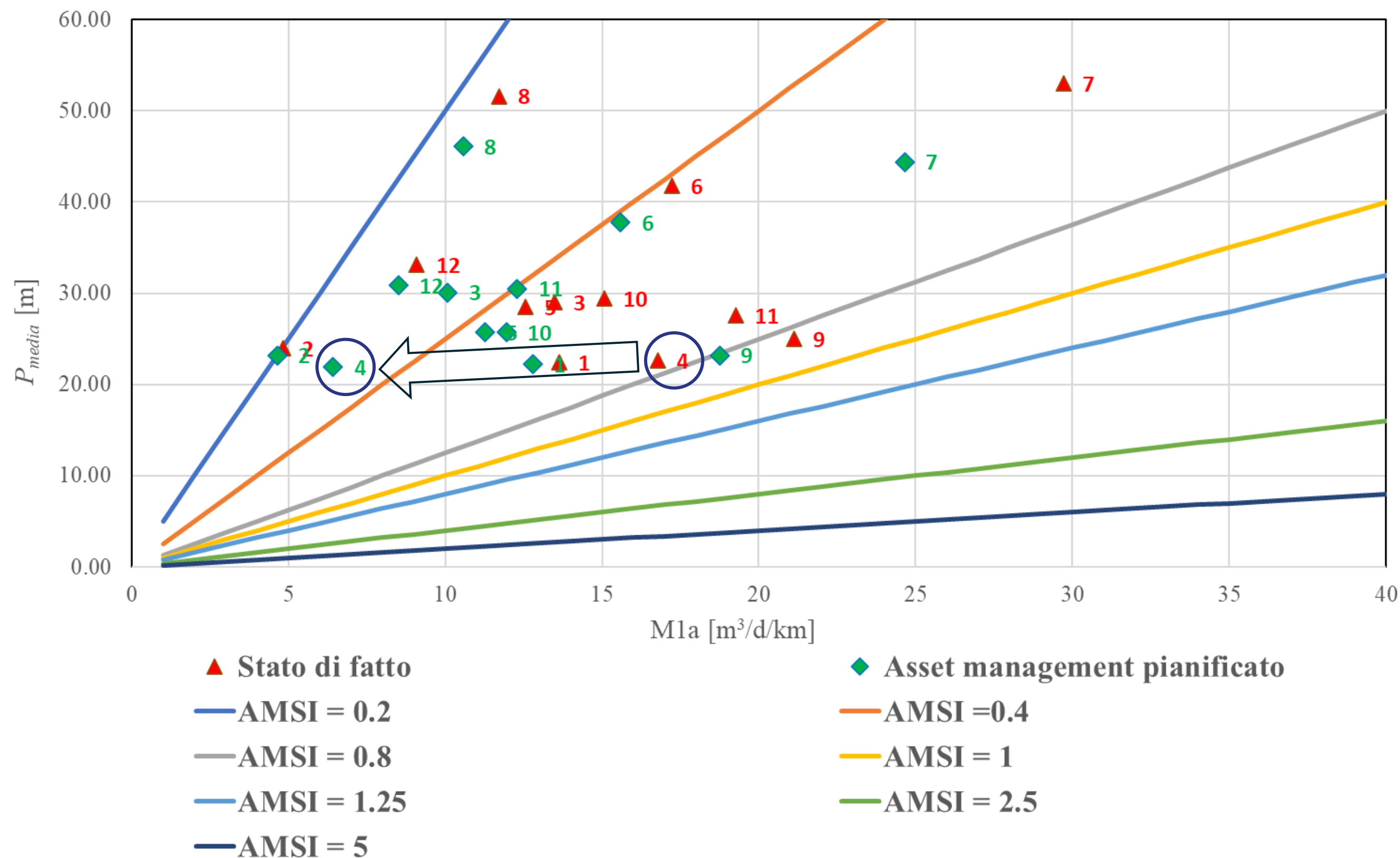
Gestore (3)

Pianificazione asset management



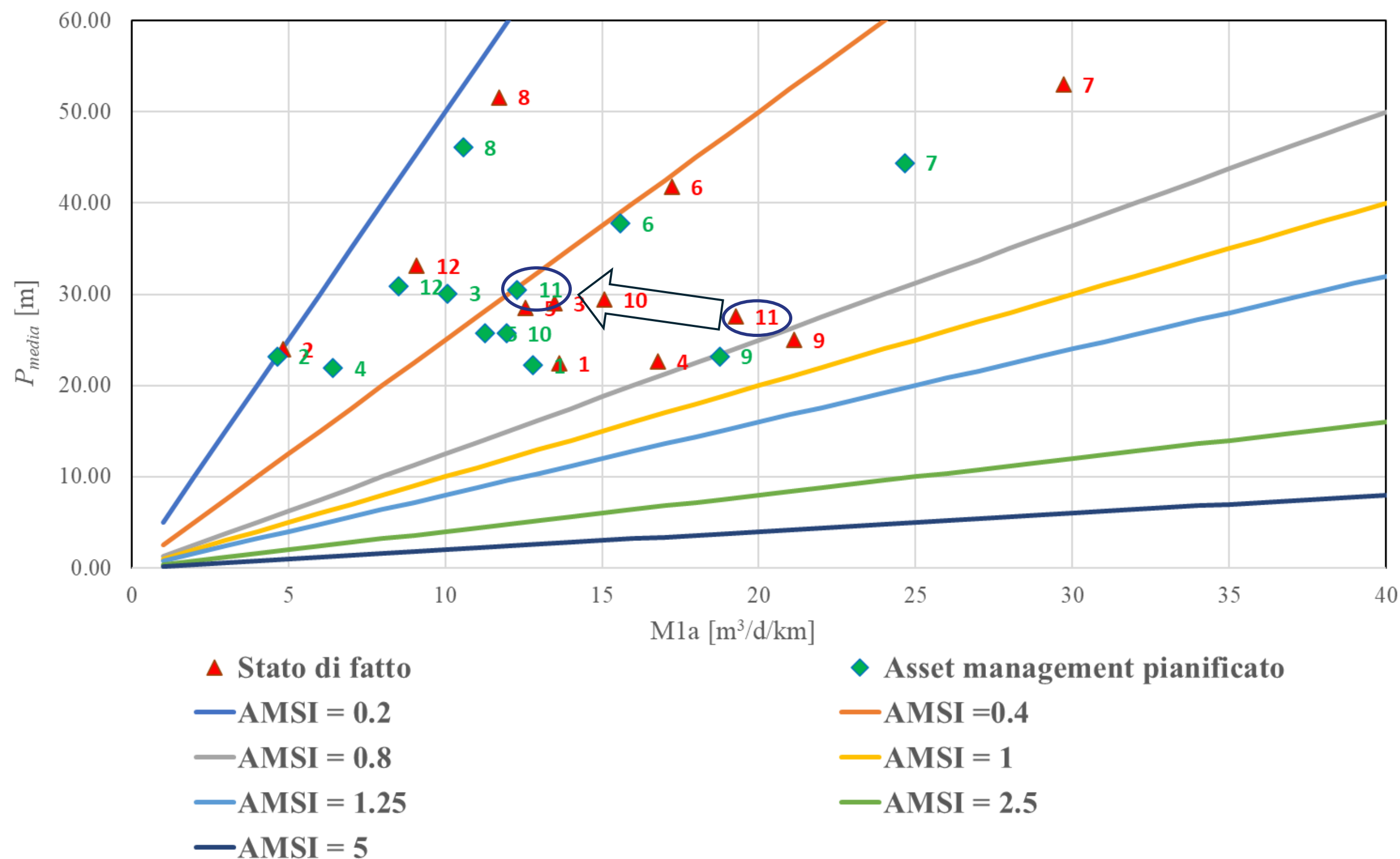
Gestore (3)

Pianificazione asset management



Gestore (3)

Pianificazione asset management



Conclusioni

- ✓ AMSI valorizza le opportunità della **Transizione Digitale** integrando la **modellazione idraulica avanzata** con la disponibilità di **dati** per migliorare l'**efficienza del processo di asset management per la gestione delle perdite**
- ✓ AMSI è **razionale** e basato sull'idraulica dei sistemi
- ✓ AMSI è **scalabile**: supporta valutazioni dalla scala della rete a quella dei DMA
- ✓ AMSI permette di eseguire un **benchmarking** utile ai gestori e ai regolatori
- ✓ AMSI permette di supportare i gestori nella pianificazione della attività di gestione delle perdite massimizzando l'**efficienza degli investimenti**

Grazie per l'attenzione

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