Riduzione dell'inquinamento dell'acquifero della Piana di Arborea da nitrati di origine agro-zootecnica mediante TECNOLOGIE DIFFUSE DI BIO-RISANAMENTO IN SITU

Problematiche connesse alle interazioni agricoltura - ambiente

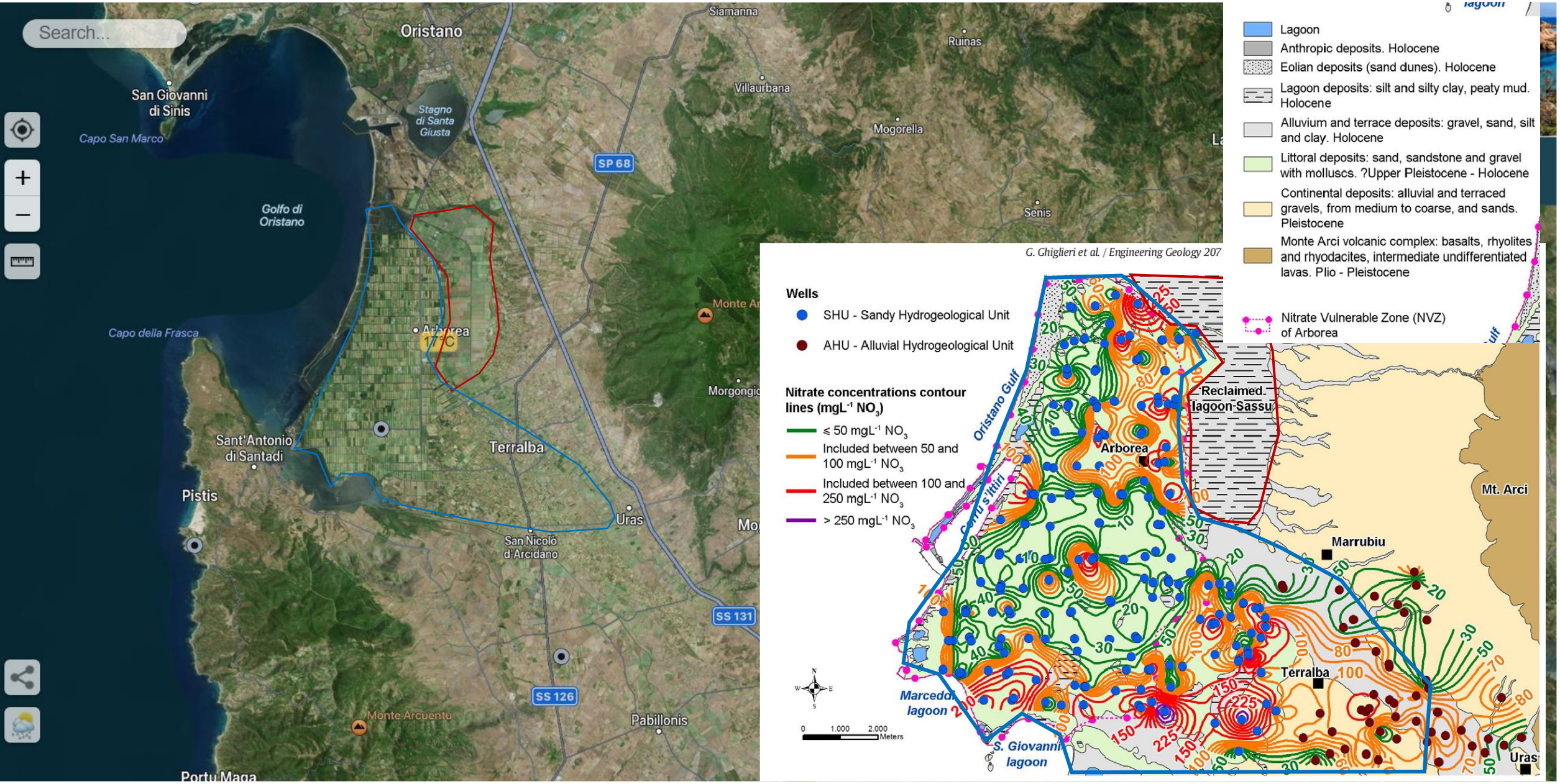
- Volumi irrigui

2000/60/EC - *Water Framework Directive*

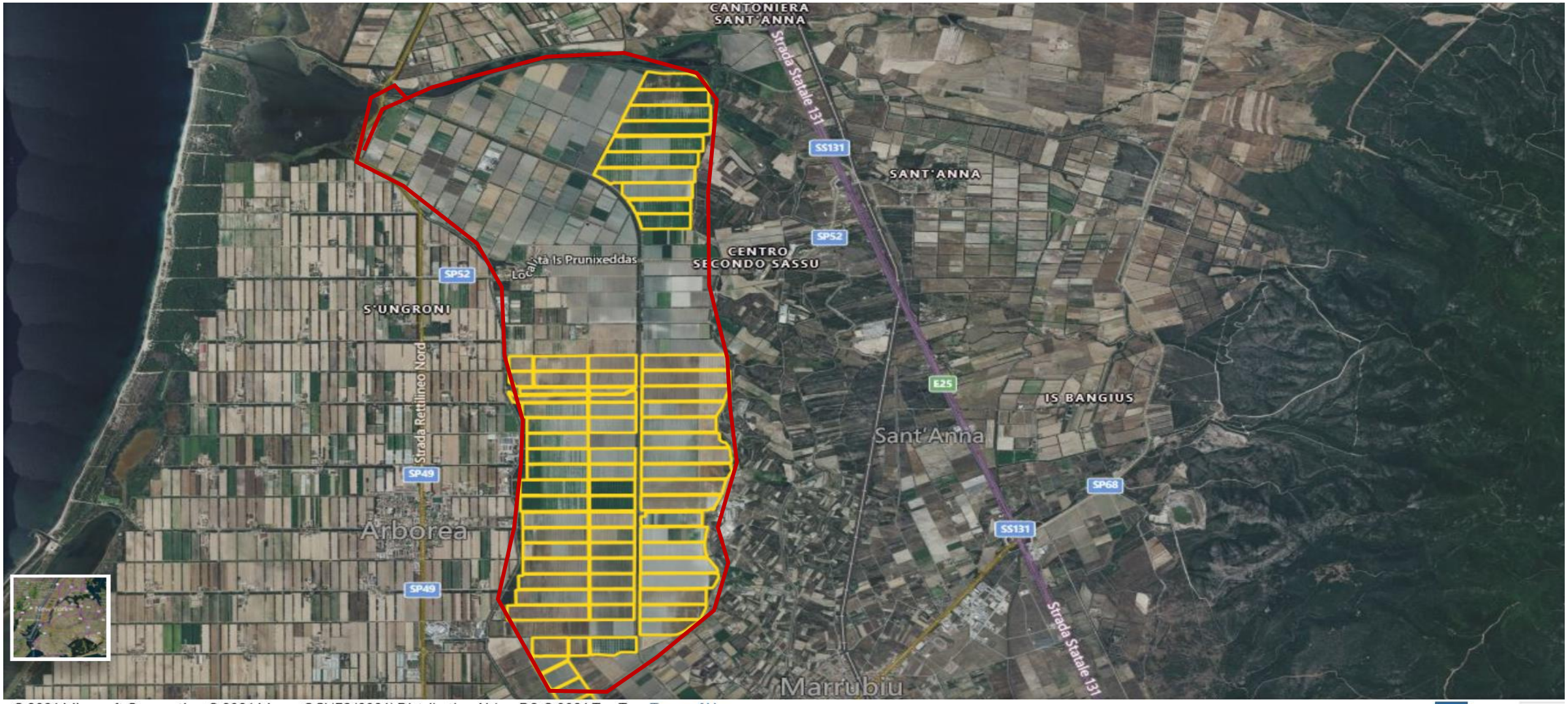
91/676/EEC -*Nitrate Directive*

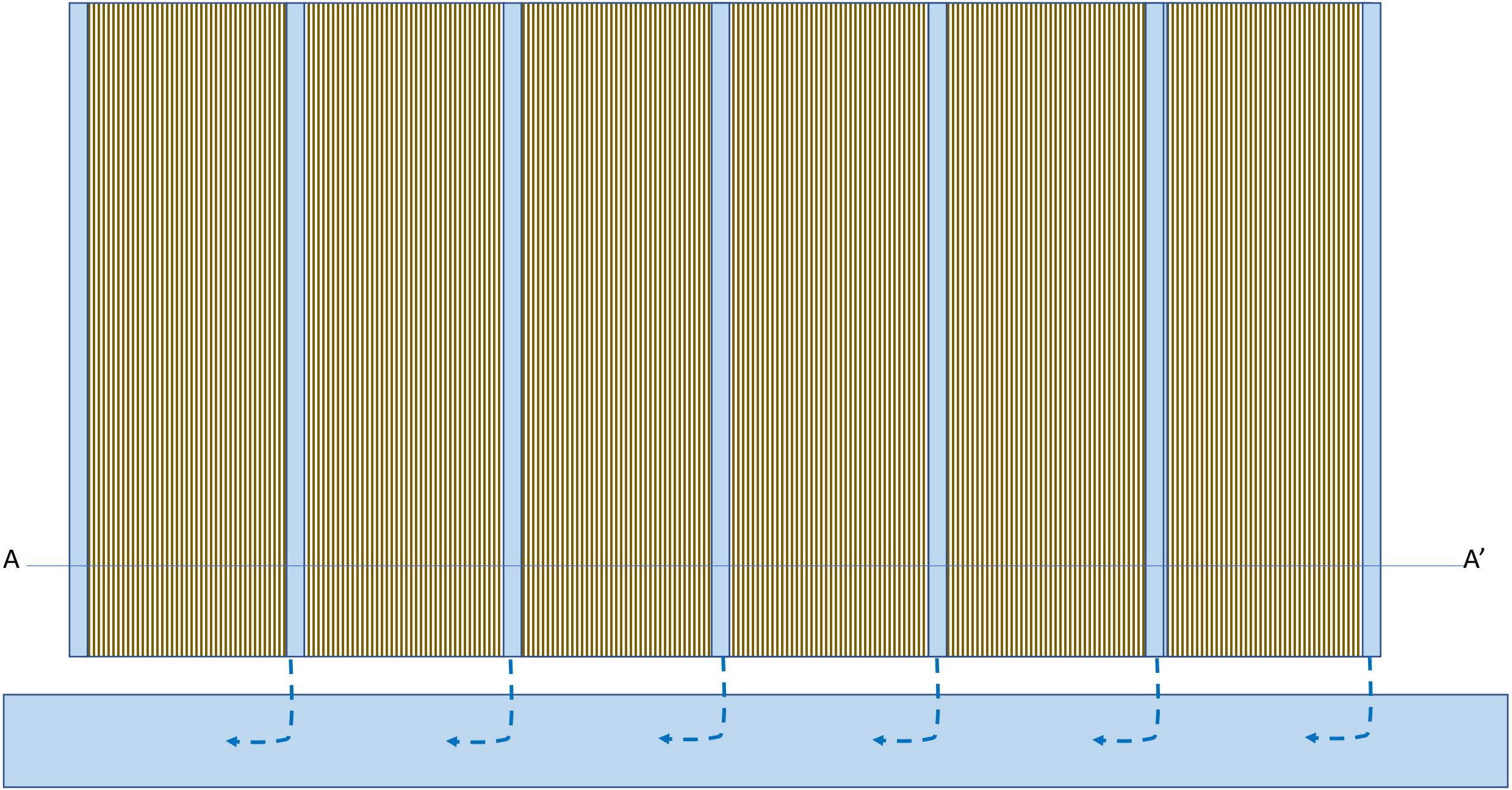
128/2009/EC-*Pesticide Directive*

- Restituzioni (di acqua) al reticolo superficiale e alla falda (ricarica)
- Peggioramento qualitativo delle acque dovuto a flussi di nutrienti e agrofarmaci alla falda e al reticolo connessi all'irrigazione e in generale alla gestione dei nutrienti
- Deflussi minimi al reticolo e alla falda
- ……

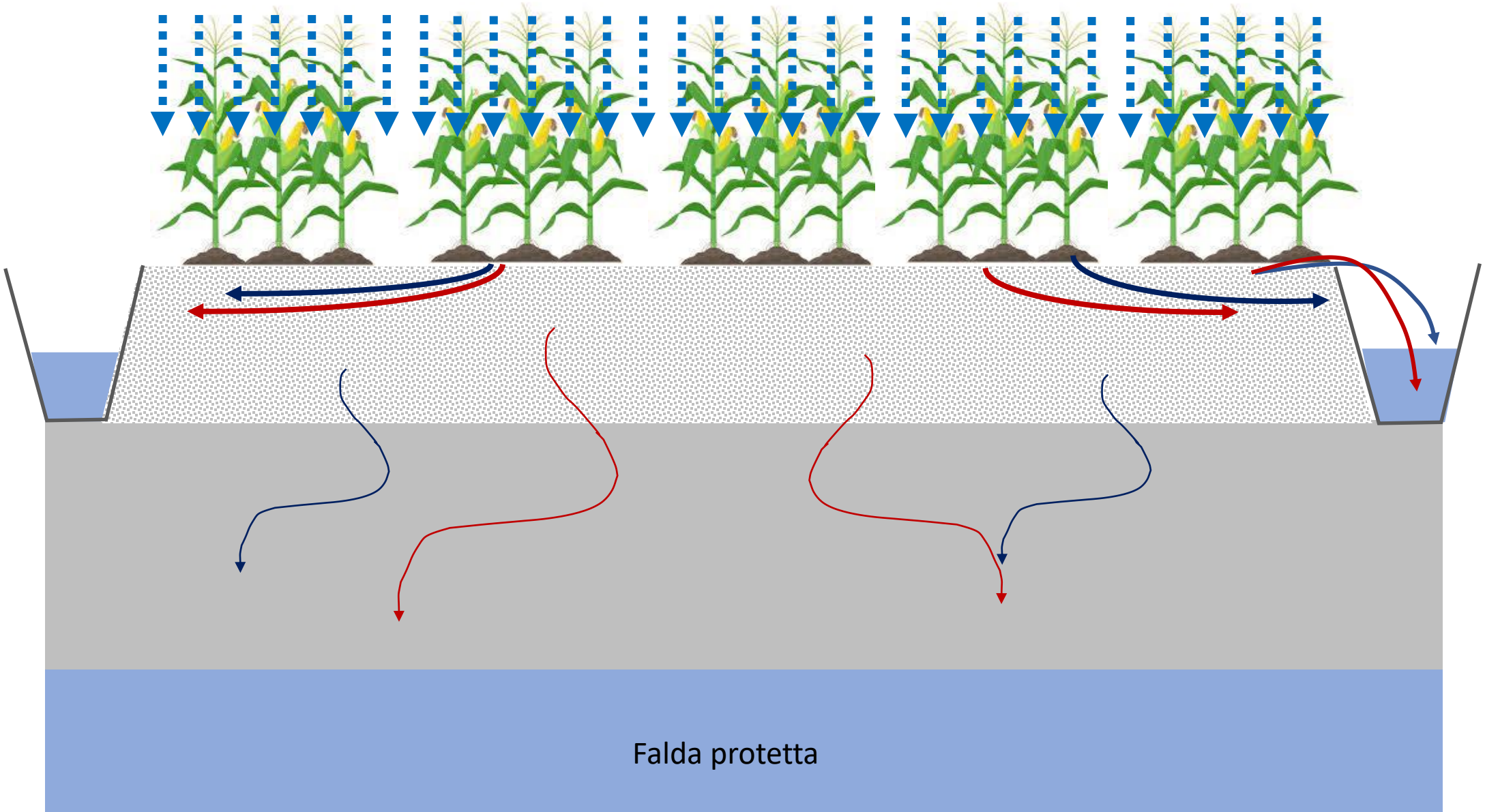

Search...
Oristano
Siamanna
Ruinas
Villaurbana
Mogorella
Senis
San Giovanni di Sinis
Capo San Marco
Stagno di Santa Giusta
SP 68
Golfo di Oristano
Capo della Frasca
Arborea
17°C
Monte Ar
Morgongio
Sant'Antonio di Santadi
Terralba
Pistis
Uras
San Nicolò d'Arcidano
SS 131
SS 126
Monte Arcuentu
Pabillonis
Portu Maga
Lagoon
Anthropic deposits. Holocene
Eolian deposits (sand dunes). Holocene
Lagoon deposits: silt and silty clay, peaty mud. Holocene
Alluvium and terrace deposits: gravel, sand, silt and clay. Holocene
Littoral deposits: sand, sandstone and gravel with molluscs. ?Upper Pleistocene - Holocene
Continental deposits: alluvial and terraced gravels, from medium to coarse, and sands. Pleistocene
Monte Arci volcanic complex: basalts, rhyolites and rhyodacites, intermediate undifferentiated lavas. Plio - Pleistocene
Nitrate Vulnerable Zone (NVZ) of Arborea
G. Ghiglieri et al. / Engineering Geology 207
Wells
SHU - Sandy Hydrogeological Unit
AHU - Alluvial Hydrogeological Unit
Nitrate concentrations contour lines (mgL-1 NO3)
≤ 50 mgL-1 NO3
Included between 50 and 100 mgL-1 NO3
Included between 100 and 250 mgL-1 NO3
> 250 mgL-1 NO3
Oristano Gulf
Reclaimed lagoon Sassu
Arborea
Mt. Arci
Marrubiu
Terralba
Marcedo lagoon
S. Giovanni lagoon
Uras
0 1.000 2.000 Meters

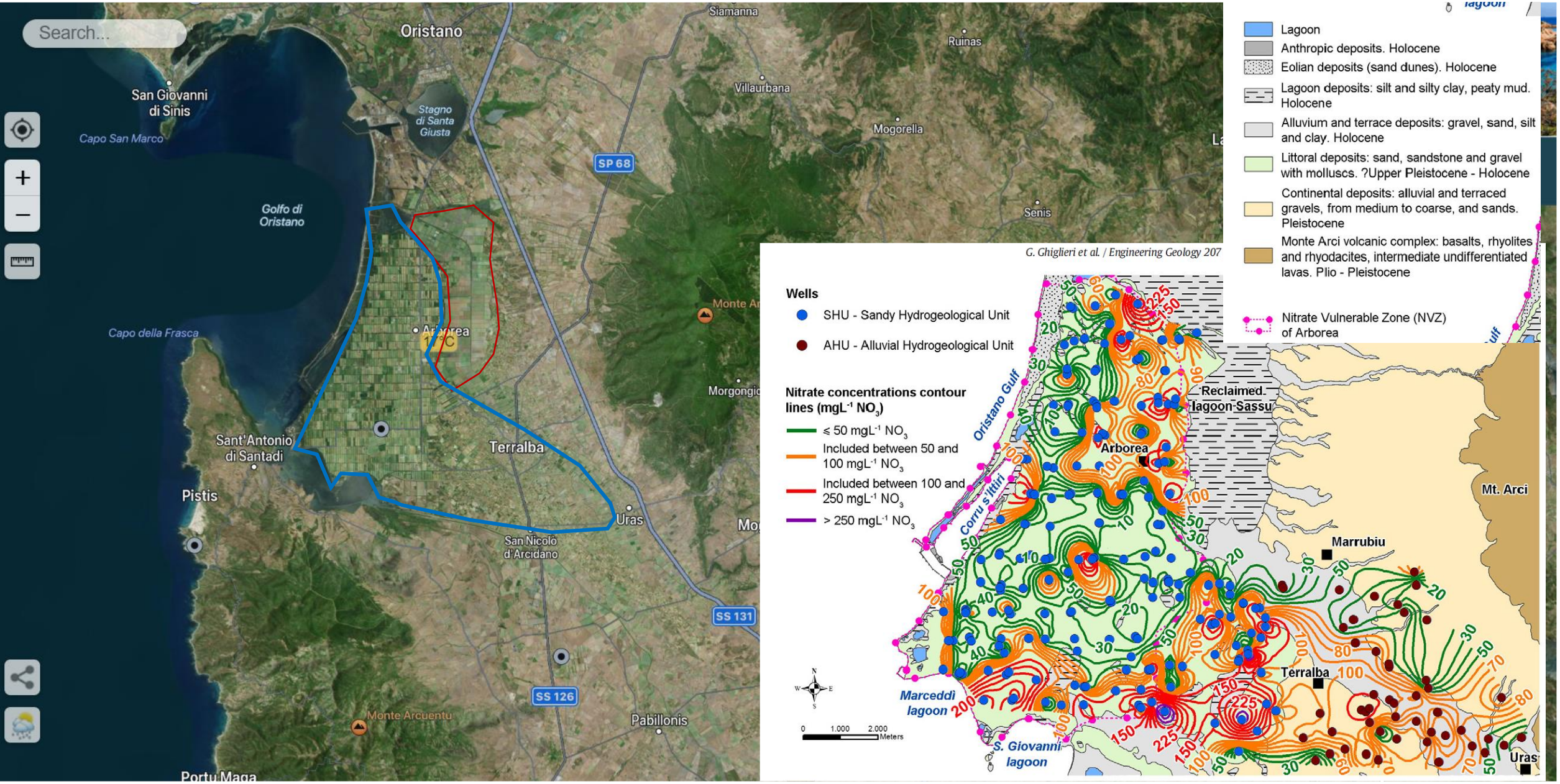
Stagno Sassu




A
A’

Prevalente restituzione al reticolo superficiale

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S. Giovanni lagoon
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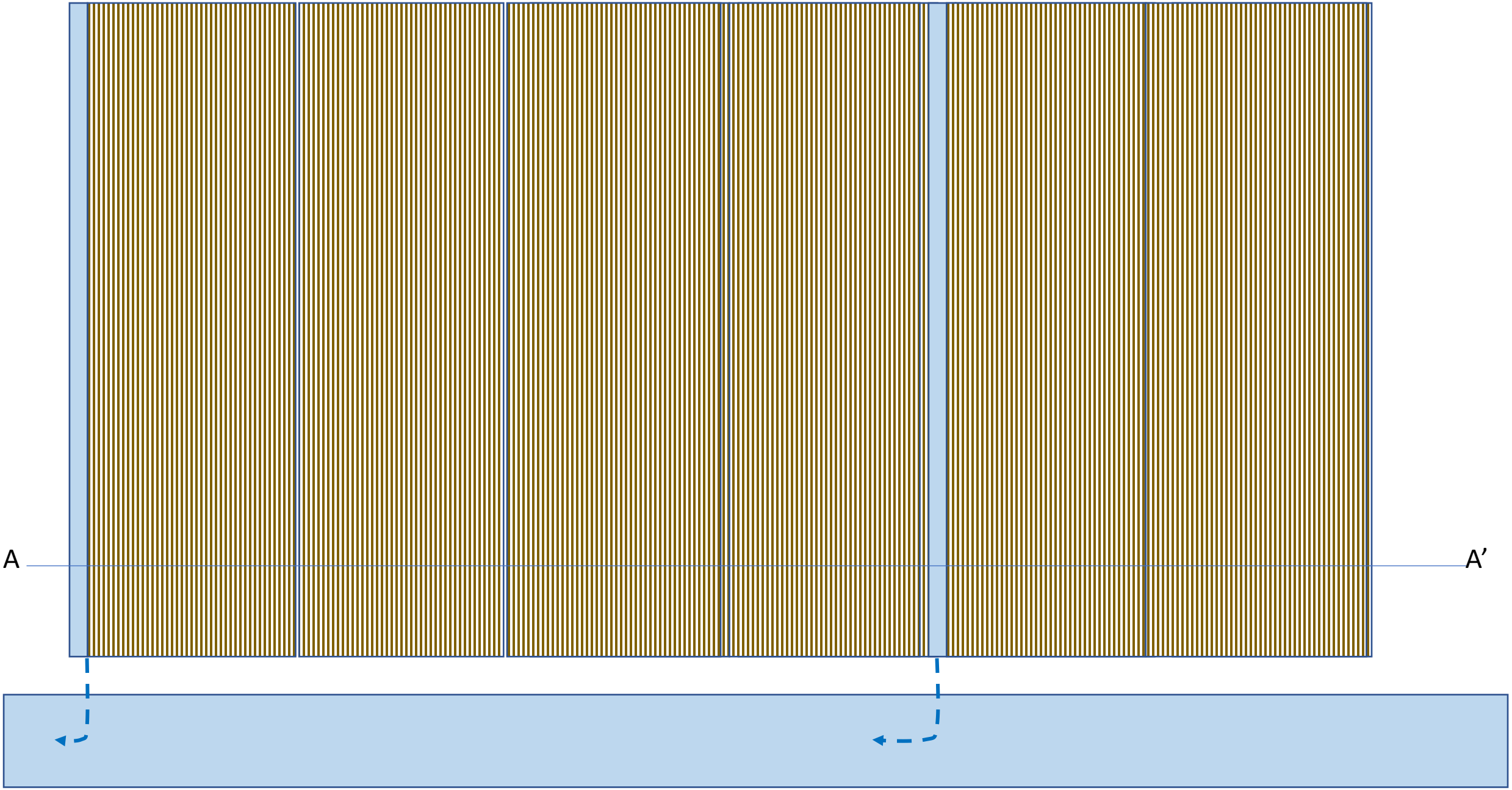
0 1.000 2.000 Meters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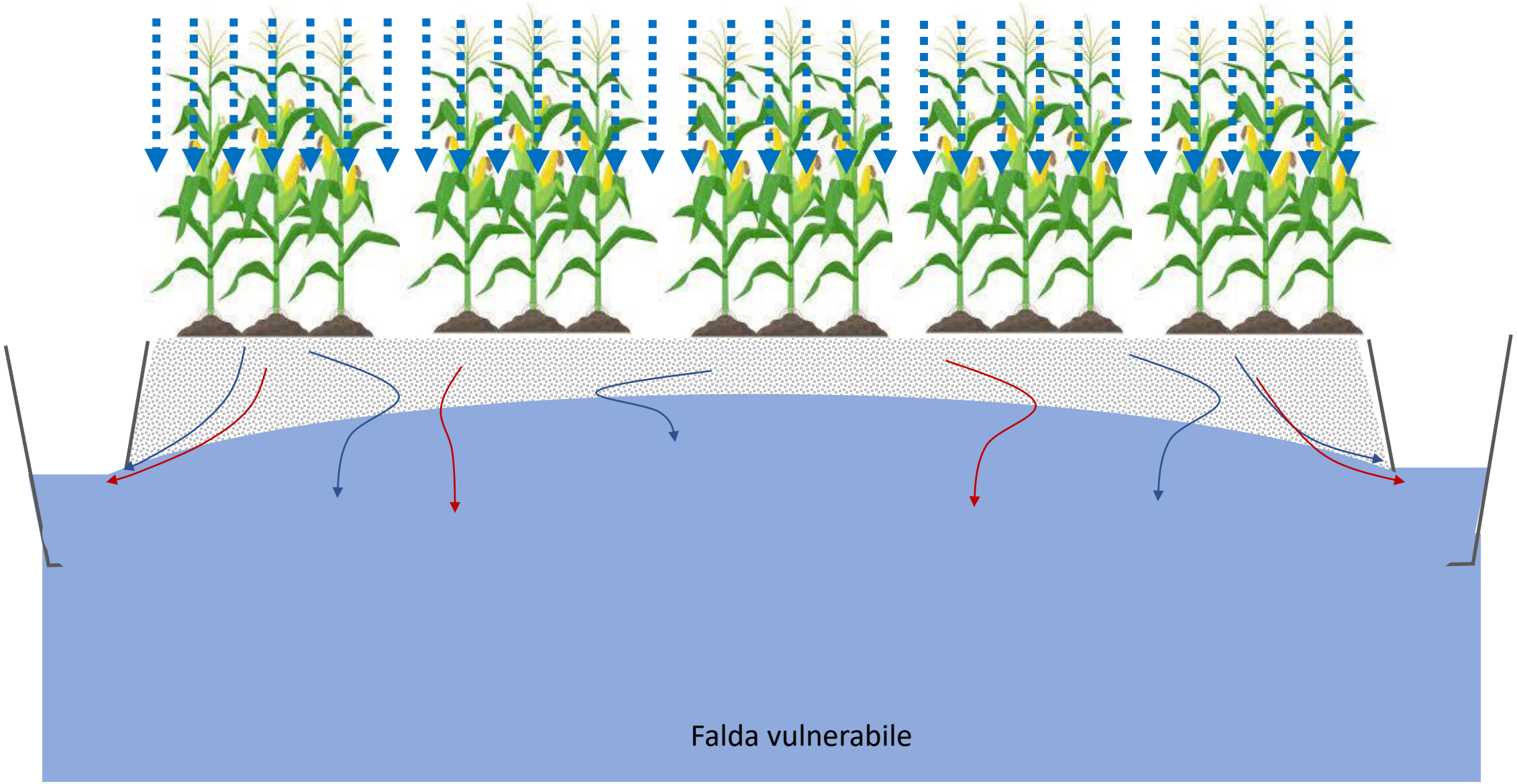
Prevalente restituzione alla falda



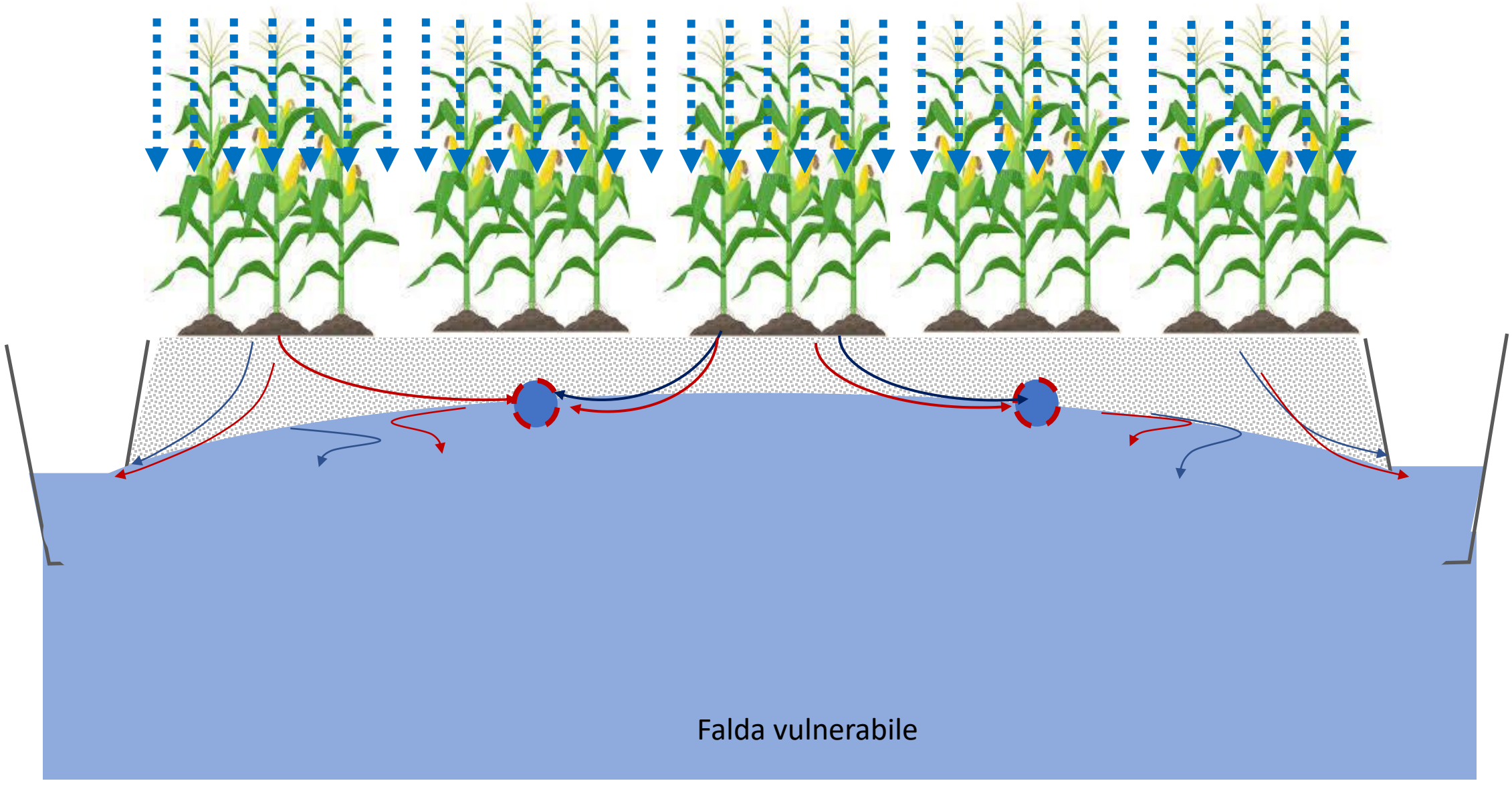
Intercettazione dei flussi verso la falda e dei deflussi superficiali e trattamento di denitrificazione eterotrofa delle acque drenate mediante BIOREATTORI

Spandimento di liquami in due fasi:

1. Metà maggio prima della semina mais;

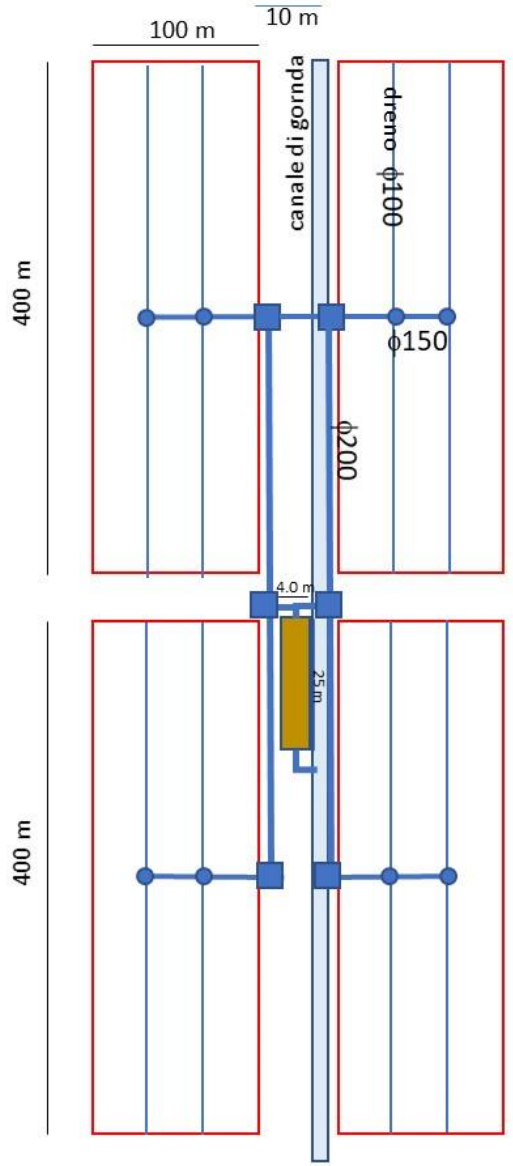
2. Metà settembre dopo la trinciatura mais

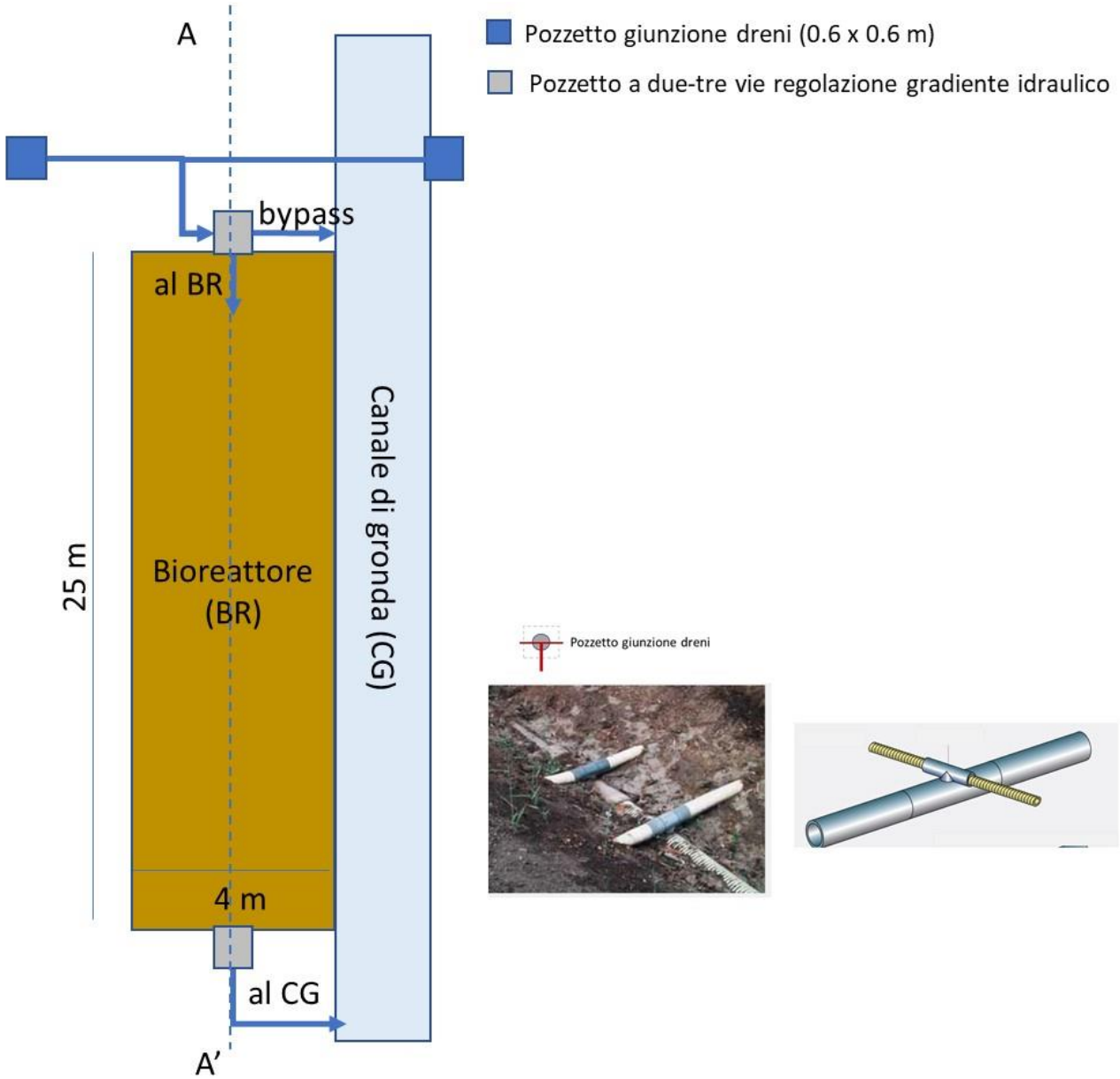
Prevalente restituzione alla falda



BIOREATTORE a servizio di un'area di 16 ha

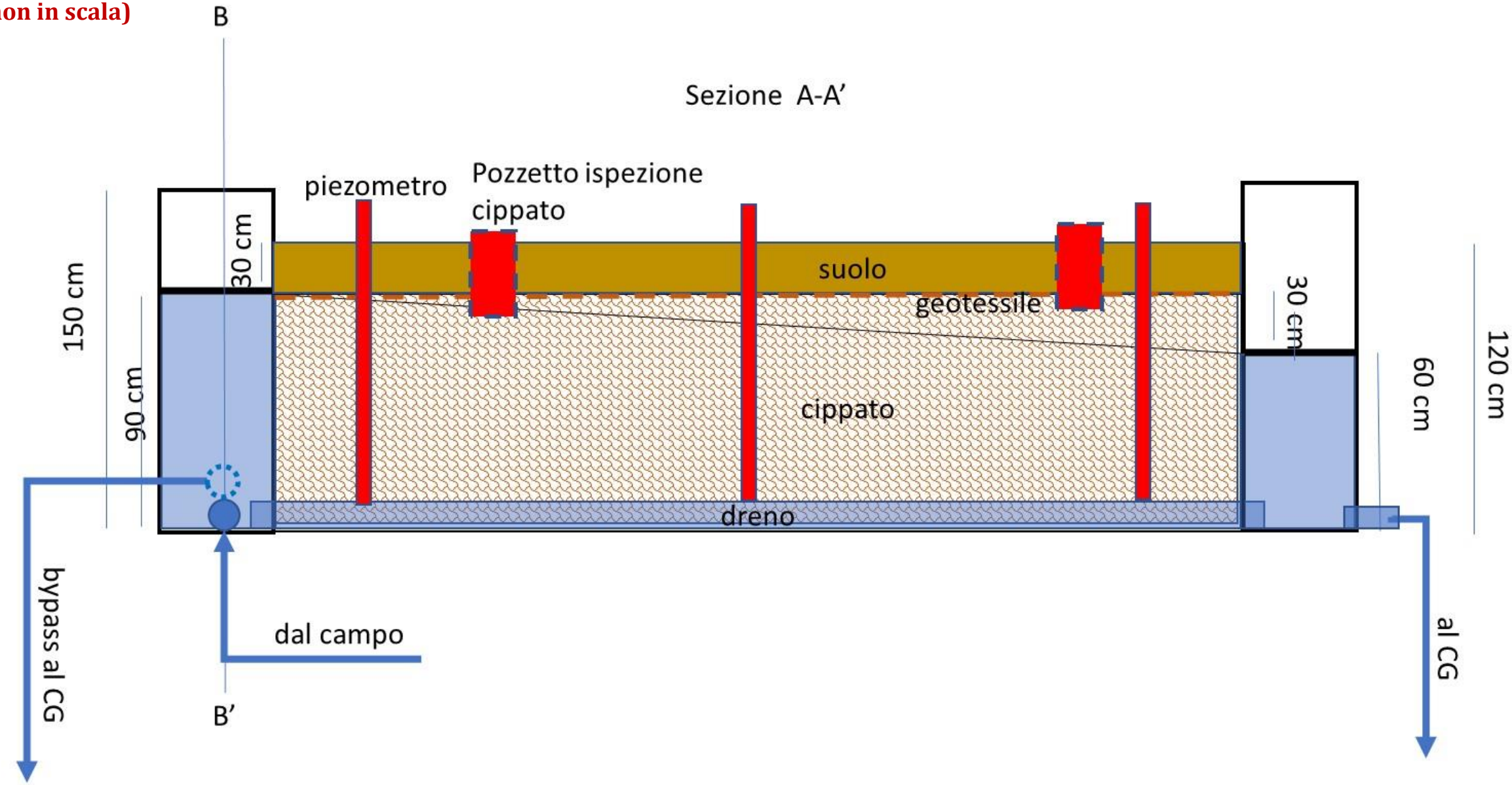
(non in scala)



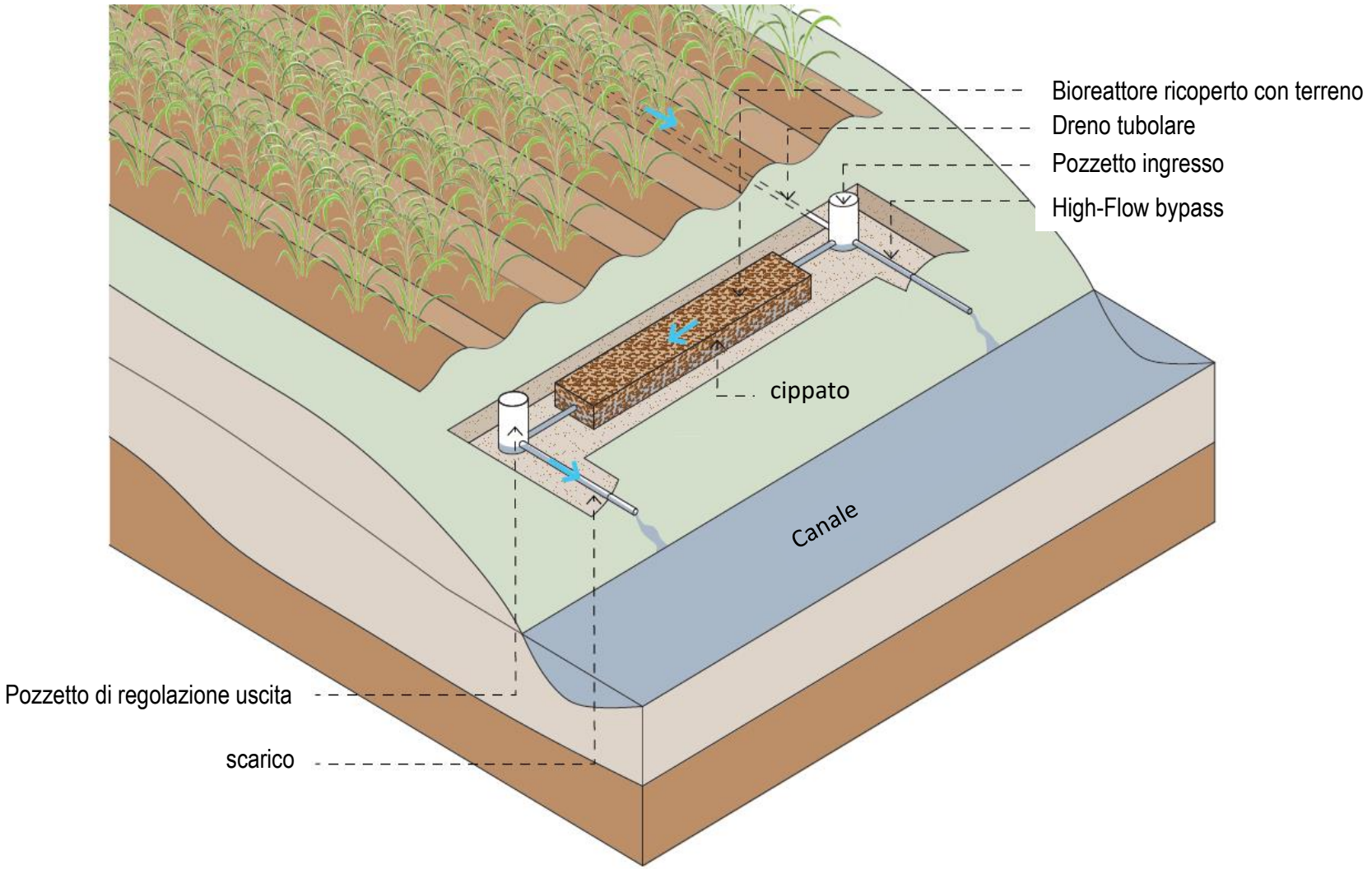


SCHEMA DI BIOREATTORE

(non in scala)

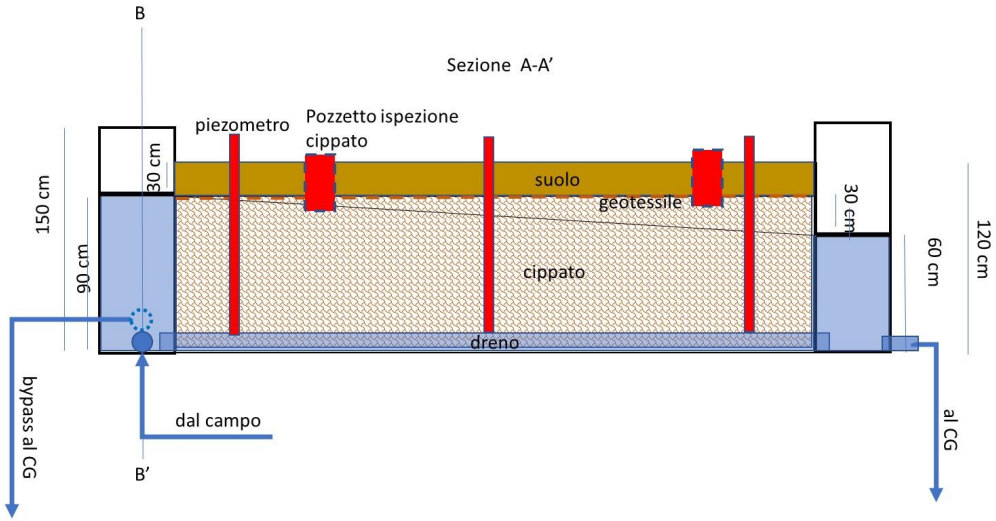


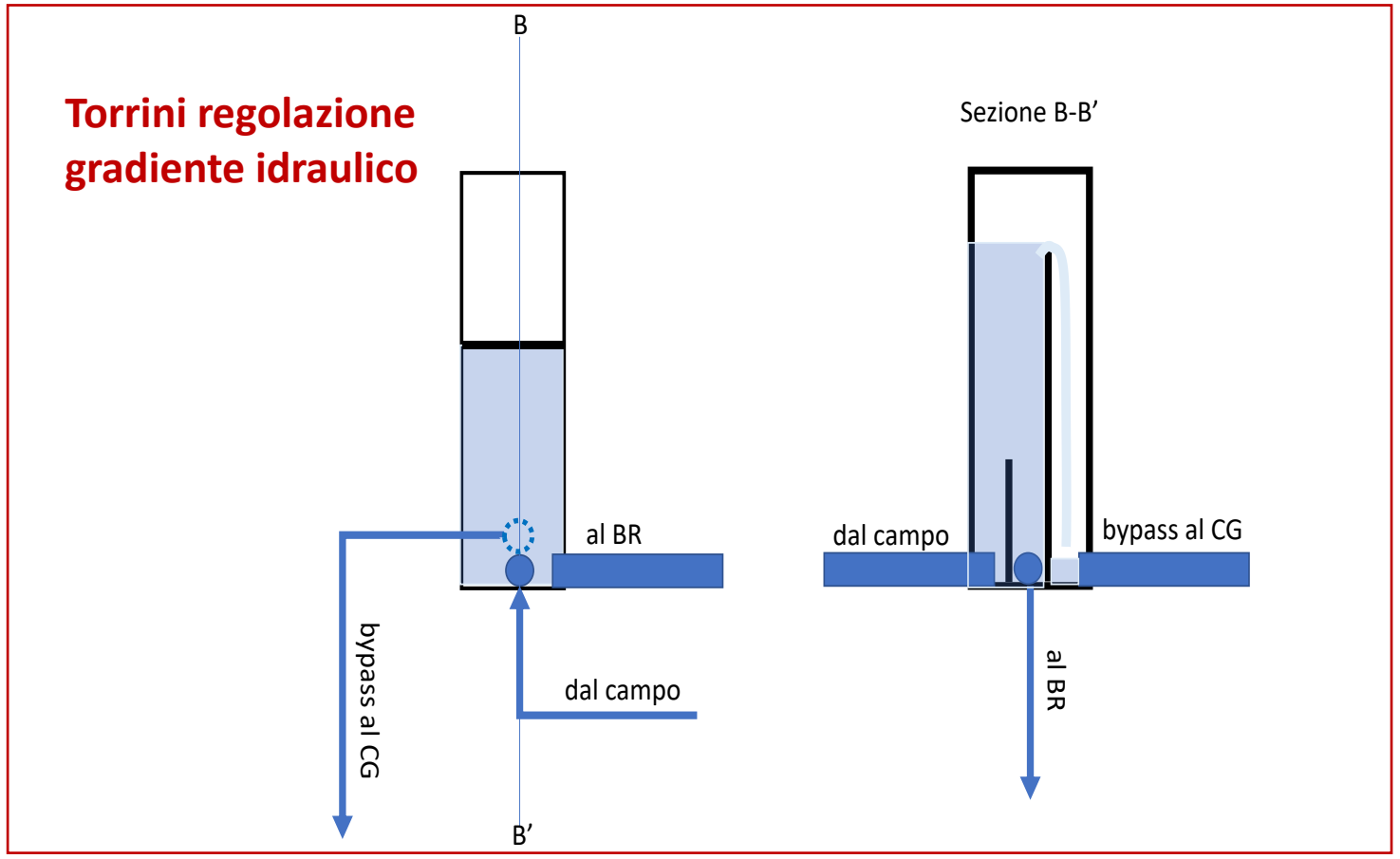
BIOREATTORE off-line



SCHEMA DI BIOREATTORE

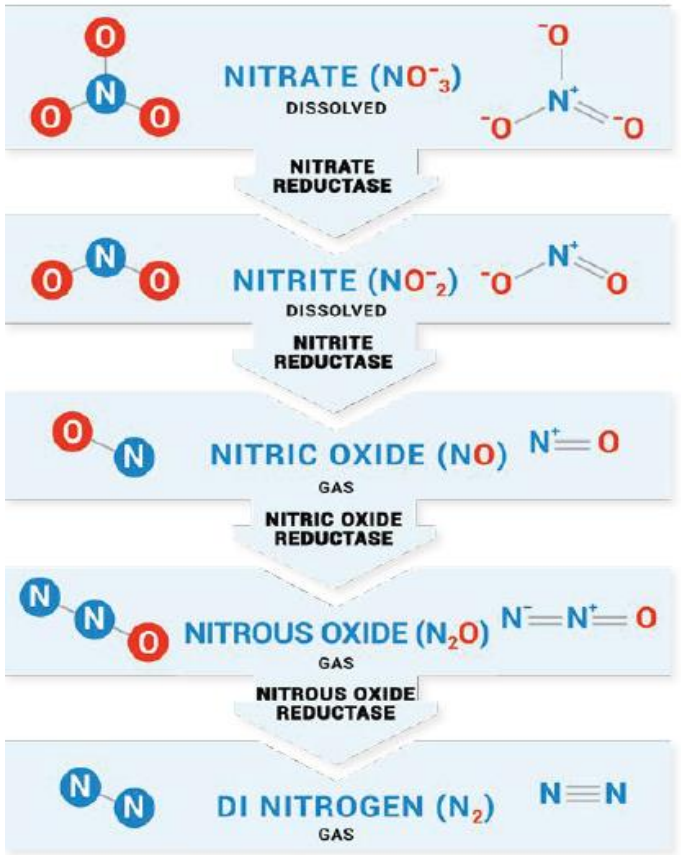
(non in scala)





Catena di reazioni denitrificazione

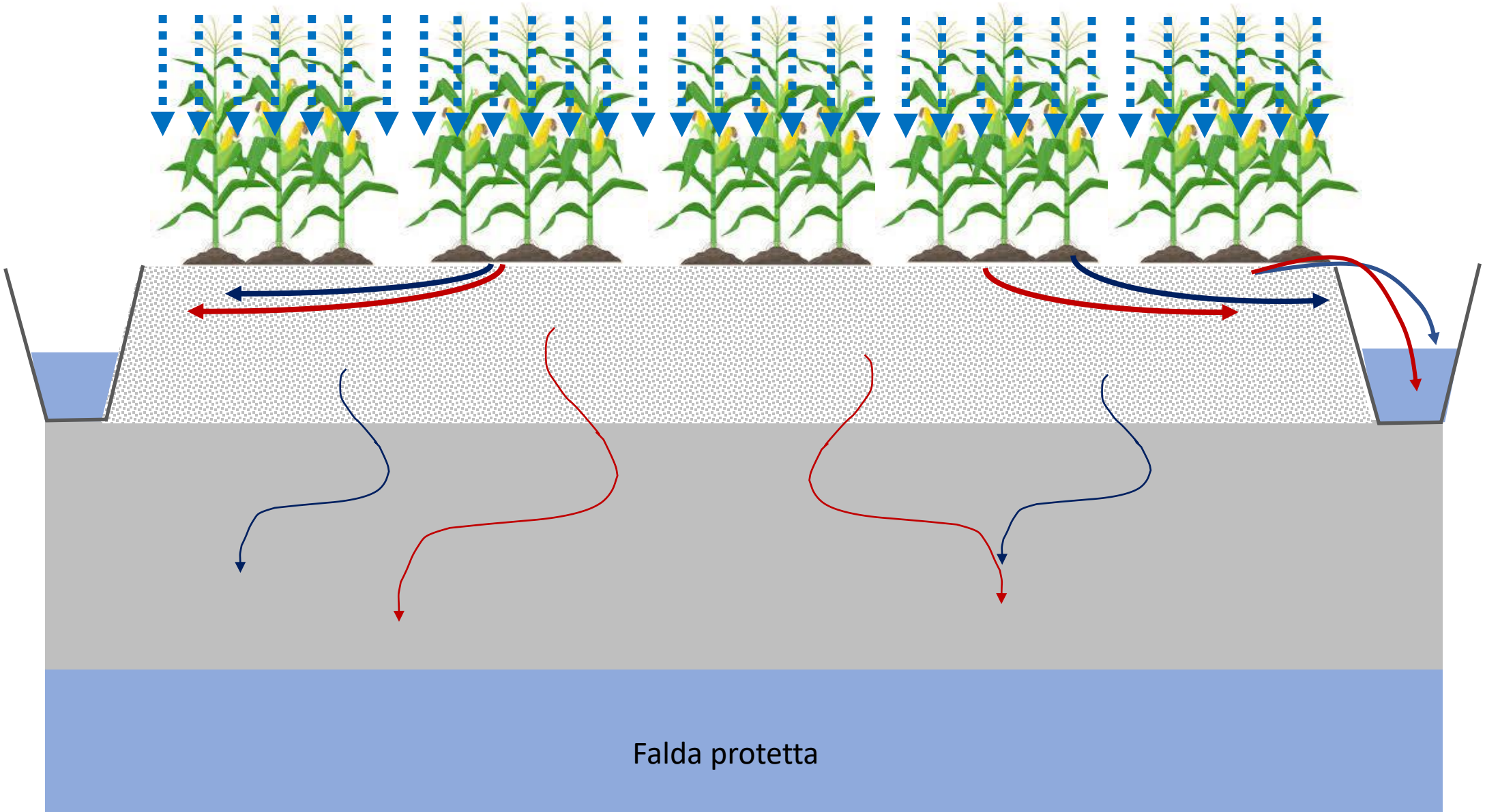
Tempo di ritenzione idraulica 4÷6 ore



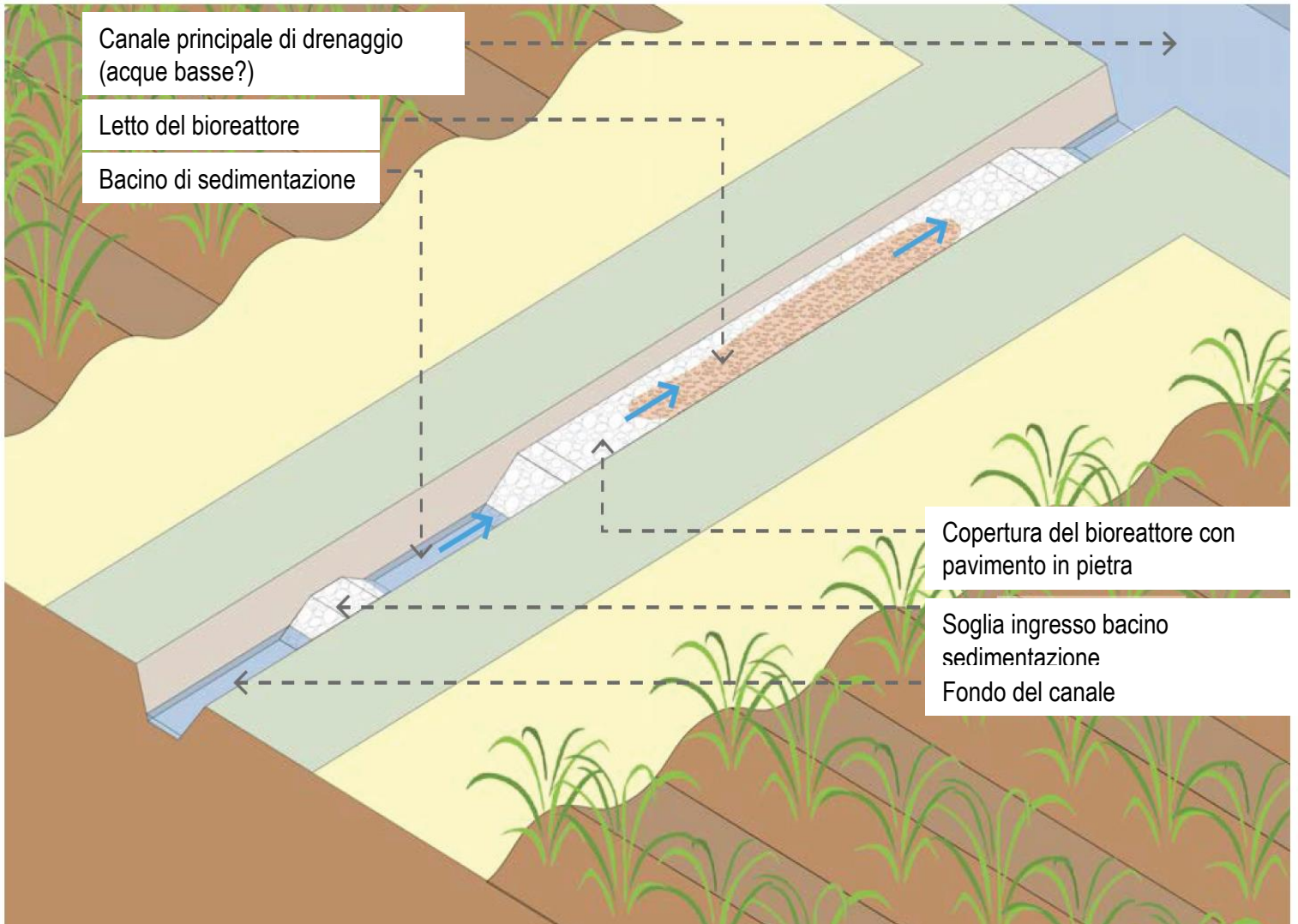
Tempo di ritenzione troppo breve (protossido di azoto)

Tempo di ritenzione troppo lungo metano, acido solfidrico

Prevalente restituzione al reticolo superficiale



BIOREATTORE in-line

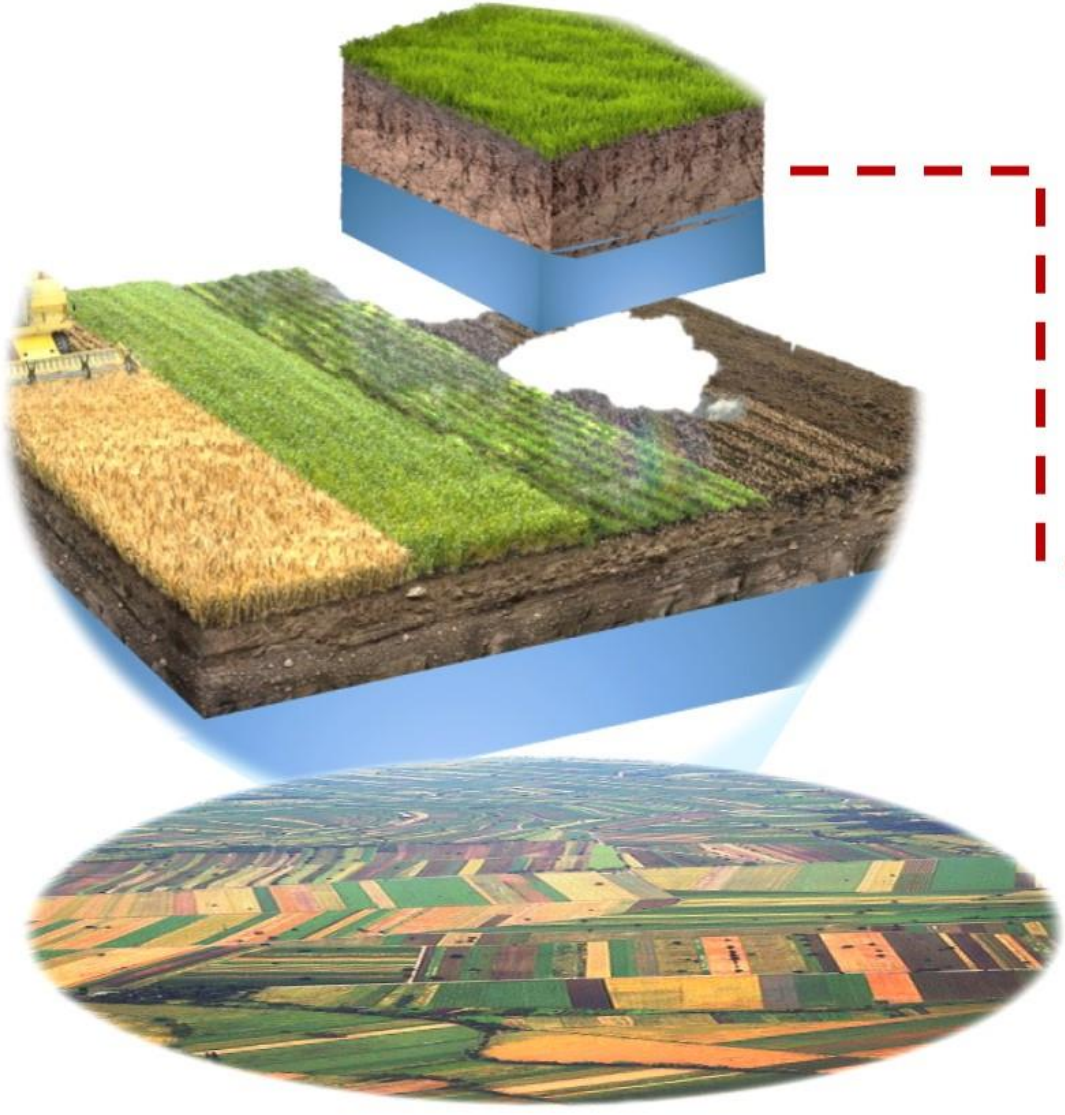


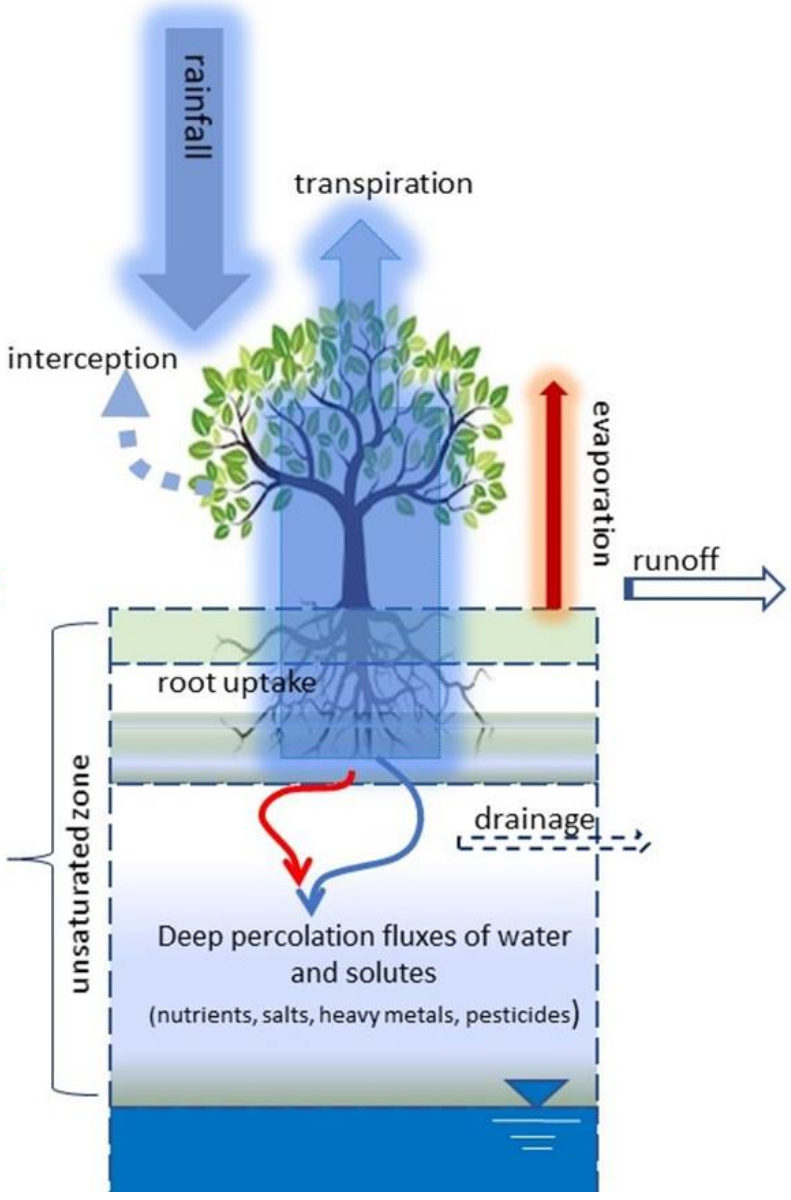
Simulazioni su base fisica del processi di flusso dell'acqua e di trasporto dei soluti mediante **modelli AGRO-IDROLOGICI**

- ✓ Individuazione dei meccanismi di arrivo del nitrato in falda e/o nel reticolo superficiale
- ✓ Progettazione del drenaggio

MODELLI AGRO-IDROLOGICI

FLOWS – HAGES
Flows of Water and Solutes in
Heterogeneous Agro-Environmental Systems

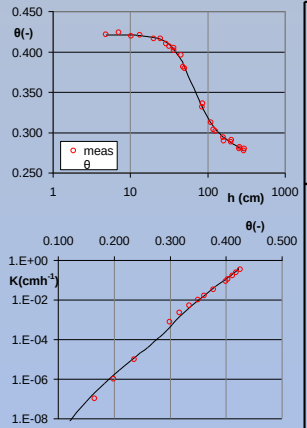


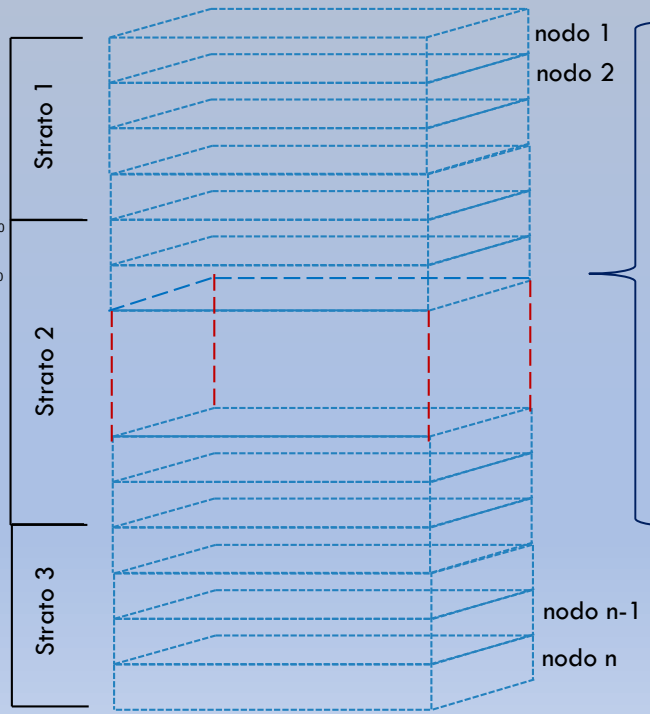


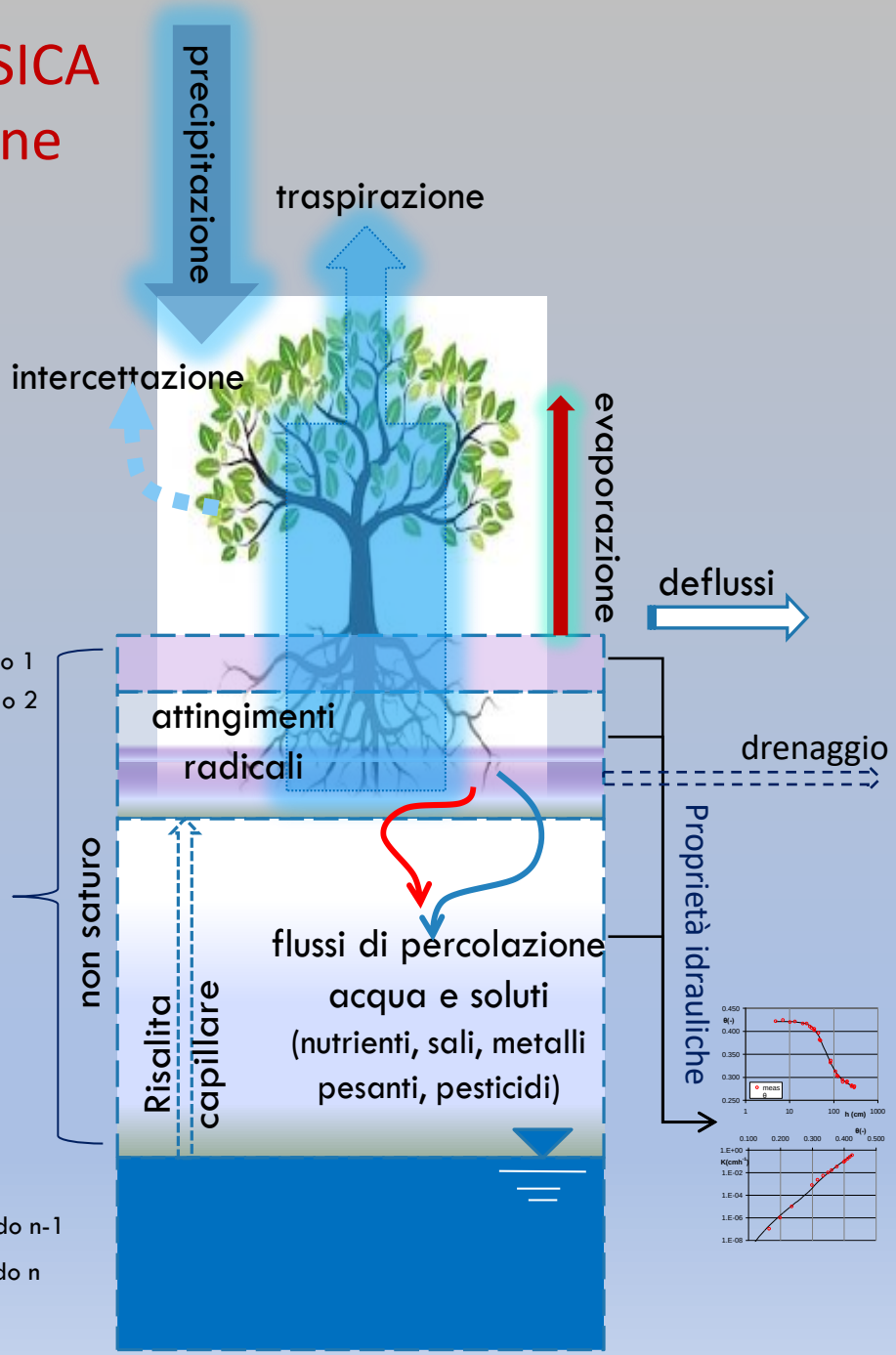
MODELLI DINAMICI SU BASE FISICA
Richards, Convezione-Dispersione

$$\frac{\partial\theta}{\partial t} = C(h)\frac{\partial h}{\partial t} = \frac{\partial\left[K(h)\left(\frac{\partial h}{\partial z}+1\right)\right]}{\partial z} - S(h)$$

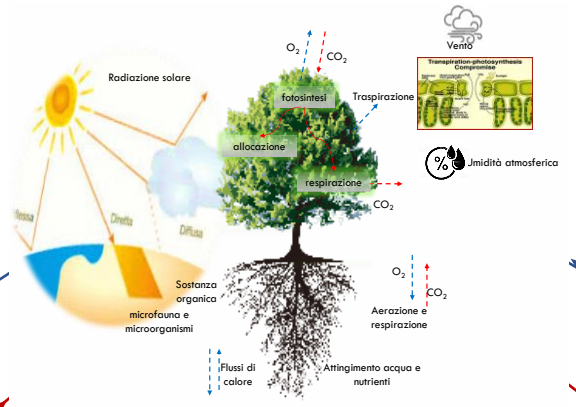
$$\frac{\partial}{\partial t}\left(\rho_b C_a + \theta C_l\right) = \frac{\partial}{\partial z}\left(D_e\frac{\partial C_l}{\partial z}\right) - \frac{\partial}{\partial z}\left(J_w C_l\right) - r_s$$

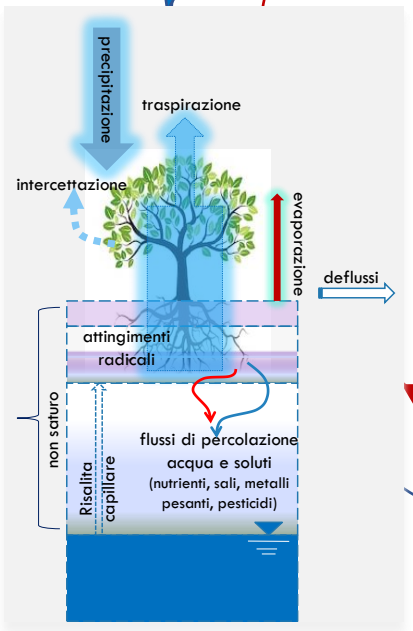




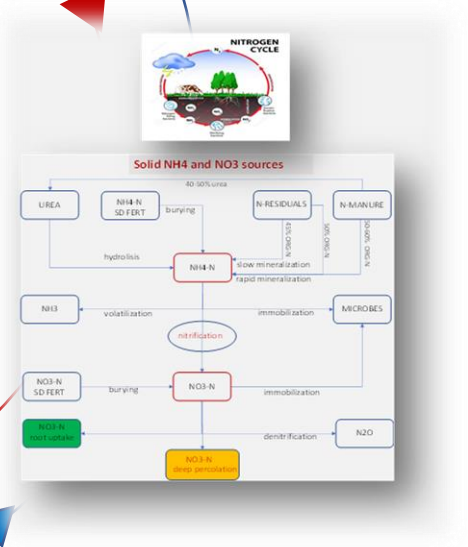


Modellazione integrata





Stesso Δt di simulazione



FLOWS-HAGES output (per il calcolo di numerosi servizi ecosistemici)

MODEL COMPONENTS	MODEL OUTPUTS
WATER	– Soil water content in the upper horizon, root zone and entire soil profile; – Evapotranspiration and Root Uptake; – Water Interception by vegetation, – Field scale Runoff production – Deep percolation water fluxes and groundwater recharge – ….
SOLUTES AND POLLUTANTS	– Advection-Dispersion-based transport processes of solutes at the soil surface, in the root zone and in the whole soil profile, physical and chemical non-equilibrium transport; – Nitrogen and phosphorous transport processes and transformations through mineralization, ammonification, nitrification, and denitrification, uptake; – Pesticides transport in dissolved phase, linear and nonlinear sorption and exchange processes, first-order decay, degradation, volatilization; – Heavy metals and bio-colloids (bacteria, viruses) transport, bio-colloids attachment/ detachment; – Deep percolation of nitrates, pesticides and other pollutants to the groundwater – Nitrogen, phosphorus and pesticides transfer from soil solution to runoff water – ….
CROP	– Daily time-step dynamic root uptake; – Relation between transpiration and environmental factors such as water and nutrient availability; – Plant nitrogen budget; – Dry matter production, yield, residue production, and decomposition; – Water and nitrogen root uptake; compensated and uncompensated root water uptake, active and passive nutrient root uptake

2000/60/EC - *Water Framework Directive*

91/676/EEC -*Nitrate Directive*

128/2009/EC-*Pesticide Directive*

FLOWS

Help

Simulation settings

Simulation(s): single
Irrigation: no (only rainfall)
Vegetation: yes
Solute transport: yes - ADE
decay: no
adsorption: no

node settings

Number of nodes: 100
inhin: constant
Number of layers: 1
hin: -100
Model: Unimodal van Genuchten
Profile settings
Node settings

top & bottom boundary conditions

itopvar: variable
itbc: flux
hsurf: 9999
qsurf: 0.1
hsurfmax: 0.0
ibotvar: constant
ibbc: gradient
hbot: 0
qbot: -0.01
grad: 1
iCtopvar: constant

FLOWS: FLOw of Water&Solute transport in soil
A. Coppola, L. Randazzo, A. Basile, C. Fenu, A. Concas

time settings

dtin: 0.000010
dtmax: 1
dtmin: 0.000010
tmax: 30
Time settings

Solute parameters

Solute pulse parameters

tCinput: 0.000
tCinput_end: 0.500
Cinput: 0.040

Isotherm parameters

slope	exponent	uptake factor
1.000	1	0.000

Nitrogen transport

zfert: 0 Topt: 35 KhUR: 0.1 KvUR: 0.1

Isotherm parameters

	slope NH4	exponent NH4	uptake factor NH4
	1.000	1	1.000

	slope NO3	exponent NO3	uptake factor NO3
	0.000	1	1.000

save project
load project

Start

Vegetation parameters

extinction factor for LAI: 0.45

water and osmotic stress reduction functions for root uptake

Feddes water reduction function

Feddes water stress potentials

hI	hII	hIIIH	hIIIL	hIV
-1	-10	-400	-600	-8000

van Genuchten water stress parameters

hw50	pw1
-1000	3

van Genuchten salinity reduction factor

hs50	ps1
-1500	3

Maas&Hoffman salinity reduction factor

aMH	bMH
-760	0.000794

root distribution function: uniform root distribution

logistic root distribution

rda	rdb	rdc
1.027	15.016	0.074

Vrugt distribution

pz	zstar
10	1.5

Units

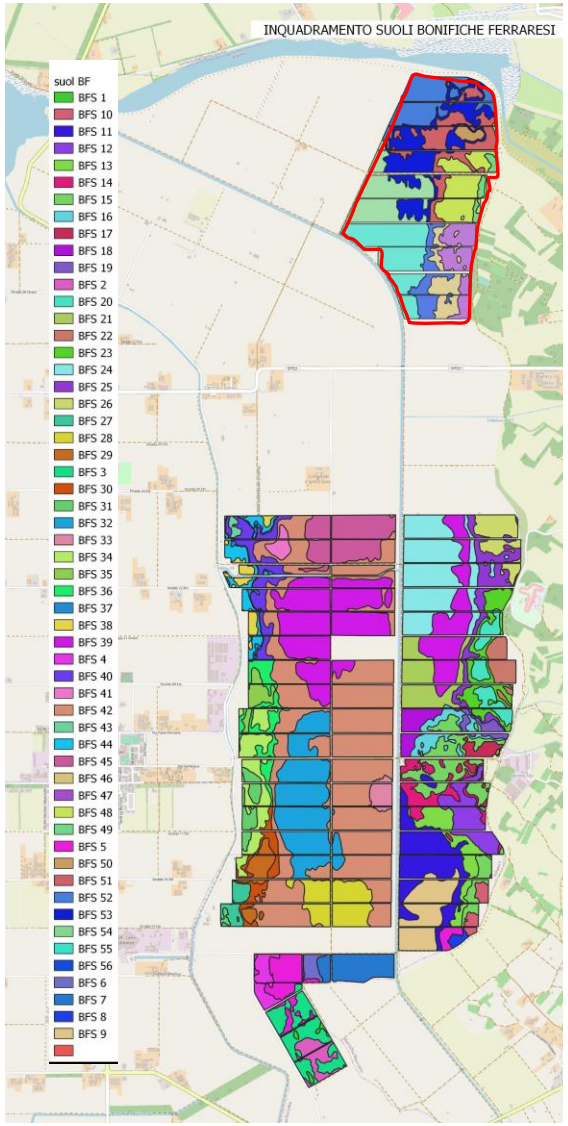
length L: cm
mass M: g
time T: seconds

Drain

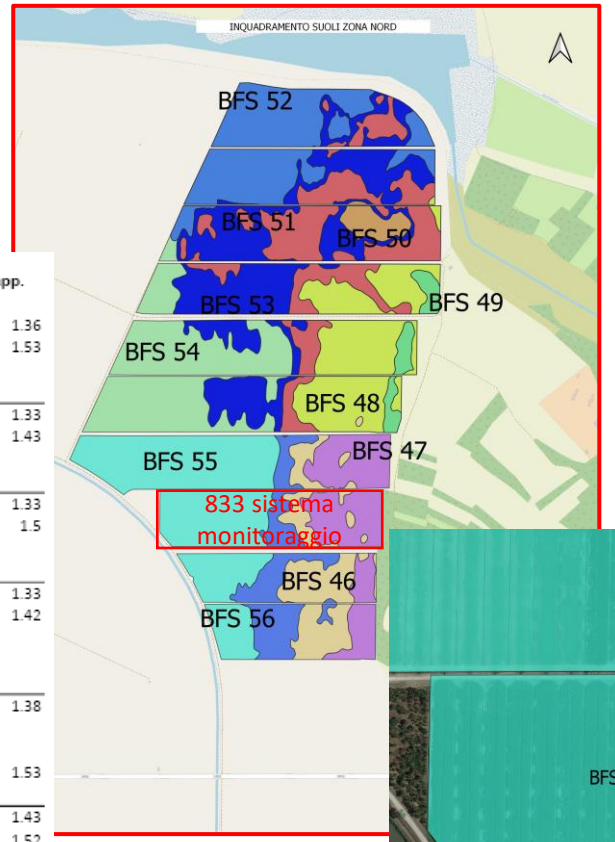
drain: no

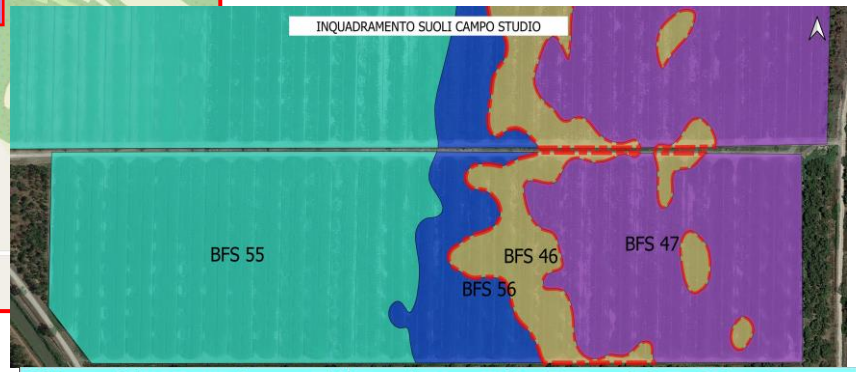
Ldr	zimp	zdr	Rdr
200	200	80	10

Mappa dei suoli BF



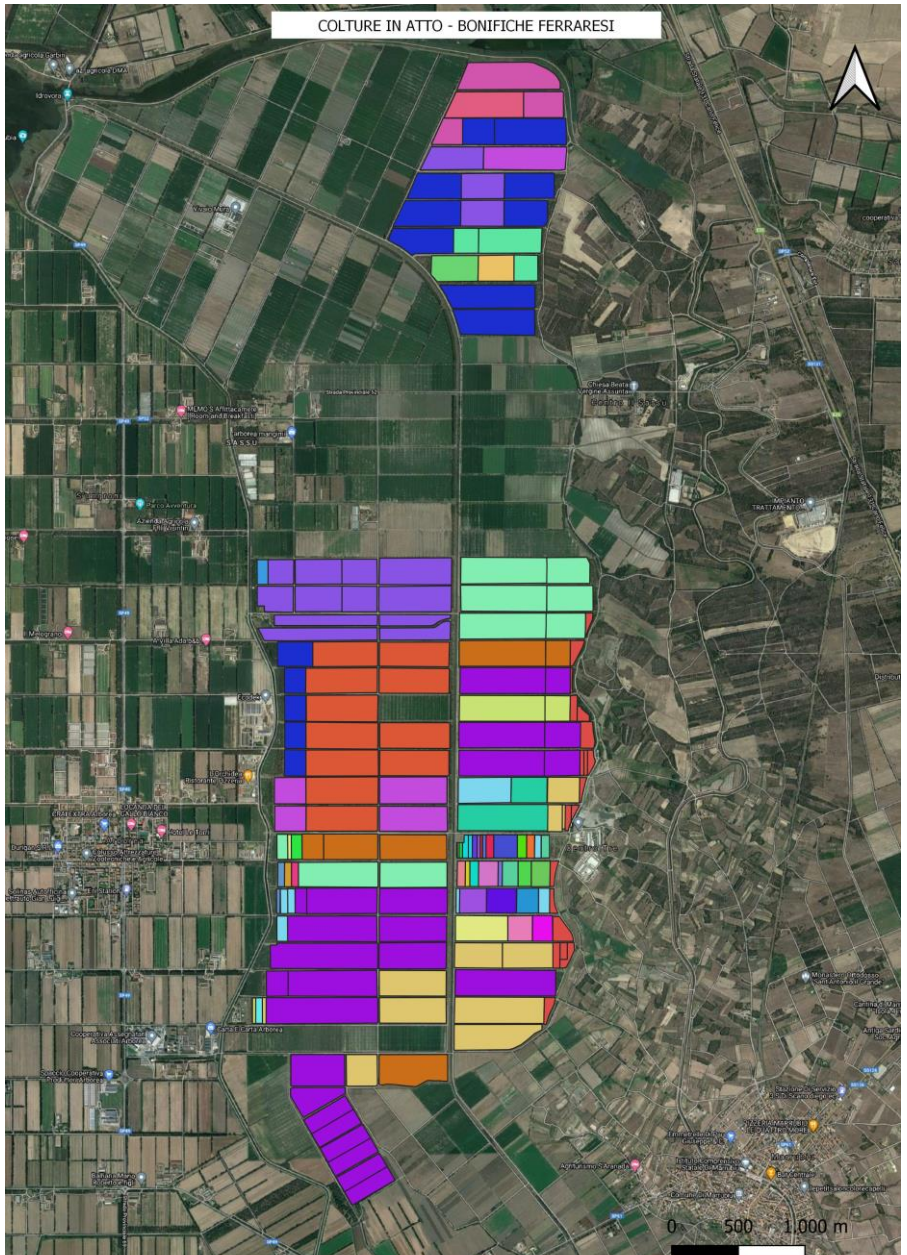
SOIL	Orizzonte	prof. (cm)	sabbia	limo	argilla	Tess U.S.D.A.	C. Org	S. Org	Dens.app. g/cm3
BFS1	Ap	0-40	80	8	12	FS	0.84	1.45	1.36
BFS1	C	40-83	85.4	3.4	11.2	SF	0.12	0.21	1.53
BFS1	BCg	83-115	85	3	12	SF			
BFS1	Cg	115-150	39	47	14	F			
BFS2	Ap	0-43	5.8	28.8	65.4	A	0.9	1.55	1.33
BFS2	Bk	43-95	7	26.2	66.8	A	0.39	0.67	1.43
BFS2	Cg1	95-120	6	46	48	AL			
BFS2	Cg2	120-180	23	47	30	FA			
BFS3	Ap	0-40	12.4	37.6	50	A	1.06	1.83	1.33
BFS3	Bk	40-93	14.2	40.7	45.1	AL	0.23	0.4	1.5
BFS3	Bgk	93-160	37	28	35	FA			
BFS3	Cg	160-180	25	30	45	A			
BFS4	Ap	0-50	6.7	24	69.3	A	0.88	1.52	1.33
BFS4	Bw	50-105	7	33.9	59.1	A	0.48	0.83	1.42
BFS4	2C	105-115	84	7	9	SF			
BFS4	Cg1	115-150	45	33	22	F			
BFS4	Cg2	150-190	9	18	73	A			
BFS5	Ap1	0-40	10.6	37.2	52.2	A	0.74	1.28	1.38
BFS5	Ap2	40-85	9	18	73	A			
BFS5	2C	85-95	84	7	9	SF			
BFS5	Ck	95-140	47.7	32.9	19.4	F	0.17	0.29	1.53
BFS5	Cg	140-170	17	29	54	A			
BFS6	Ap	0-55	63.5	18.9	17.6	FS	0.49	0.84	1.43
BFS6	Bg	55-120	43.6	35.2	21.2	F	0.2	0.34	1.52
BFS6	2C	120-130	84	7	9	SF			
BFS6	Cg	130-150	12	15	73	A			
BFS7	Ap	0-45	14.7	28.09	56.4	A	1.11	1.91	1.31
BFS7	Cg	45-75	12.1	25	62.9	A	0.57	0.98	1.39
BFS7	2C	75-85	84	7	9	SF			
BFS7	2Cg	85-130	4	23	73	A			
BFS8	Ap1	0-40	18.5	28	53.5	A	0.86	1.48	1.35
BFS8	Ap2	40-80	20	40	40	AL			
BFS8	Ckm	80-110	84	4	12	SF			
BFS8	Cg	110-150	87.1	5.3	7.6	SF	0.02	0.03	1.6
BFS8	Ck	150-180	78	12	10	FS			
BFS9	Ap	0-35	15.9	27.6	56.5	A	1.06	1.83	1.32
BFS9	Bg	35-55	13.3	29.4	57.3	A	0.67	1.16	1.38
BFS9	2C	55-60	85	7	8	SF			
BFS9	Cg	60-130	14	32	54	A			
BFS10	Ap1	0-43	28.1	24	47.9	A	0.89	1.53	1.35
BFS10	Ap2	43-75	65.1	11.9	23	FSA	0.4	0.69	1.45
BFS10	C	75-120	90	3	7	S			
BFS10	Cg	120-140	82	7	11	S			
BFS11	Ap	0-40	15.1	31.1	53.8	A	1.19	2.05	1.3
BFS11	Bg1	40-70	23	23	54	A			
BFS11	2C	70-80	84	7	9	SF			
BFS11	Bg2	80-90	10.3	25.4	64.3	A	0.74	1.28	1.36
BFS11	Cg	90-120	17	22	61	A			

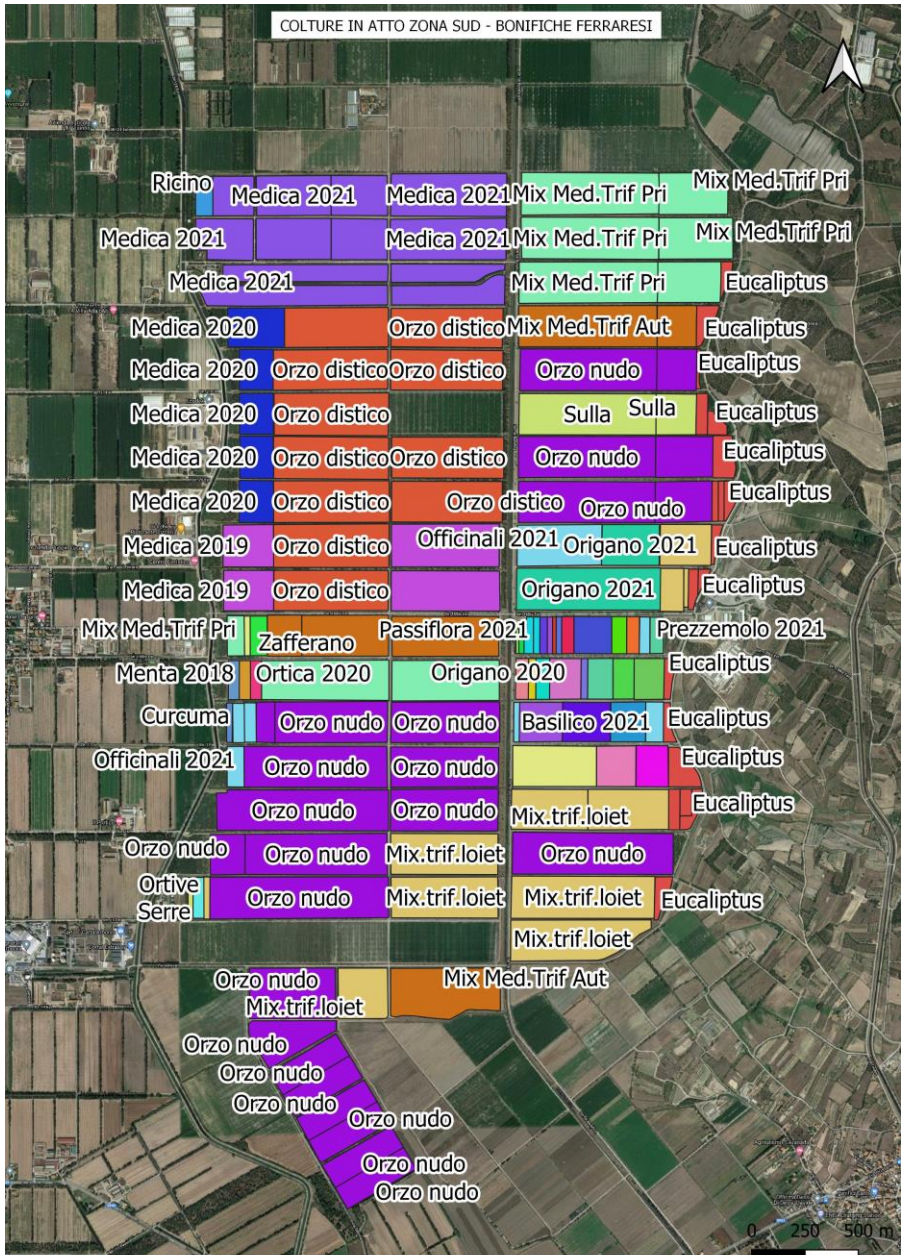




SOIL	Orizzonte	prof. (cm)	sabbia	limo	argilla	Tess USDA	C. Org	S. Org	Dens.app .g/cm3
BFS55	Ap	0-55	20,9	26,9	52,2	A	1,53	2,64	1,25
	2C	55-60	84	7	9	SF			
	Bg	60-100	7,5	21,5	71	A	0,67	1,16	1,36
	Cg	100-150	6	21	73	A			
BFS56	Ap	0-50	14,7	27,2	58,1	A	8,1	1,4	2,41
	2C	50-55	84	7	9	SF			
	Bg	55-115	2,8	24,1	73,1	A	7,9	1,23	2,12
	Cg	115-150	6	21	73	A			
BFS46	Ap	0-65	16,7	24,9	58,4	A	8,3	1,45	2,5
	2Bw	65-80	91	2	7	S	6,5		
	3Cg	80-160	67,7	3,7	28,6	FSA	7,2	0,08	0,14
BFS47	Ap	0-70	14,7	24,2	61,1	A	8,2	1,23	2,12
	2Cg	70-110	85,7	1,7	12,6	SF	8,3	0,05	0,09
	3Cg	110-150	56	4	40	AS			
	4Cg	150-160	20	19	61	A			

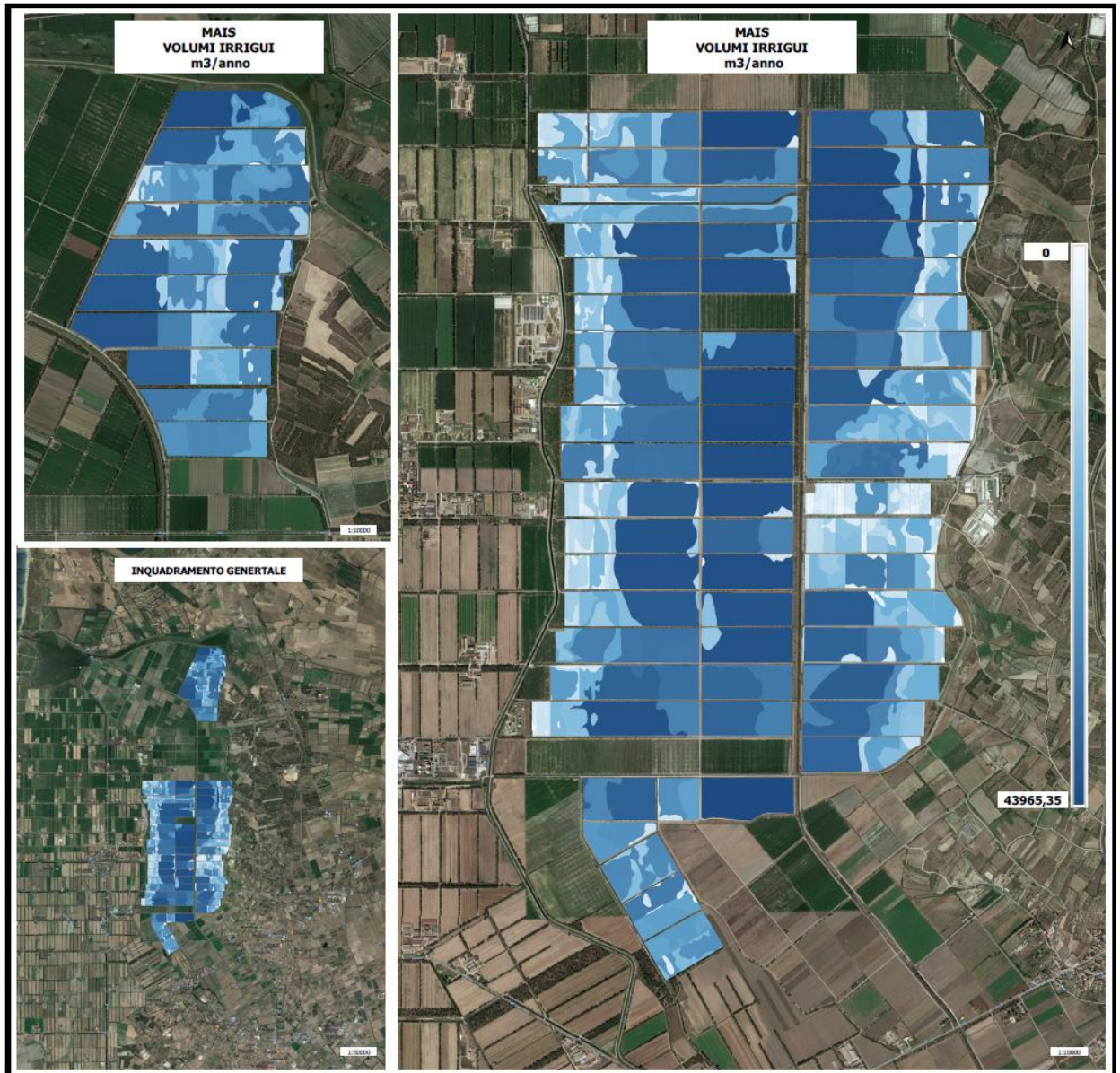
Mappa delle colture BF



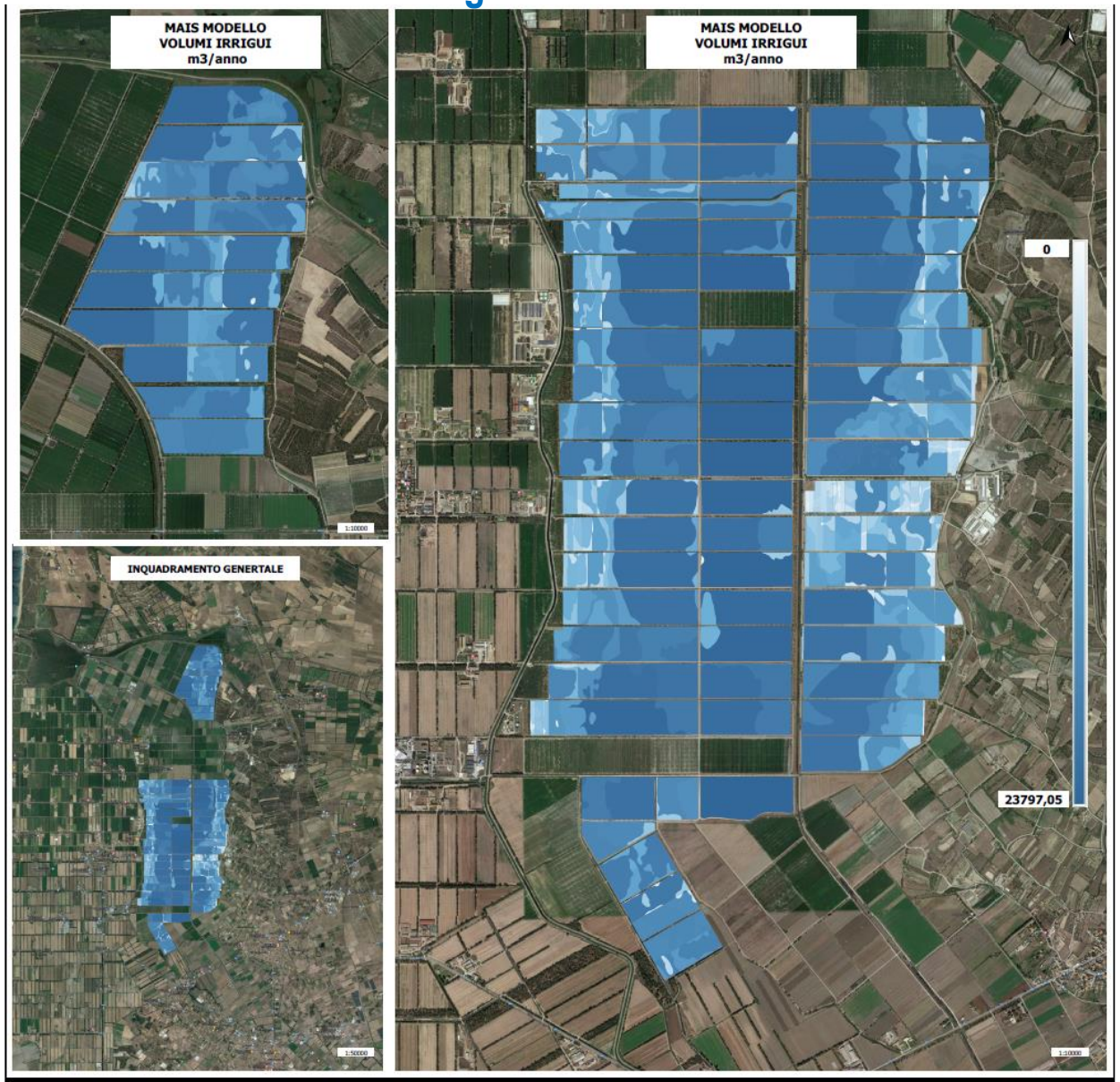


Flussi di percolazione verso la falda (MAIS)

volumi irrigui effettivi

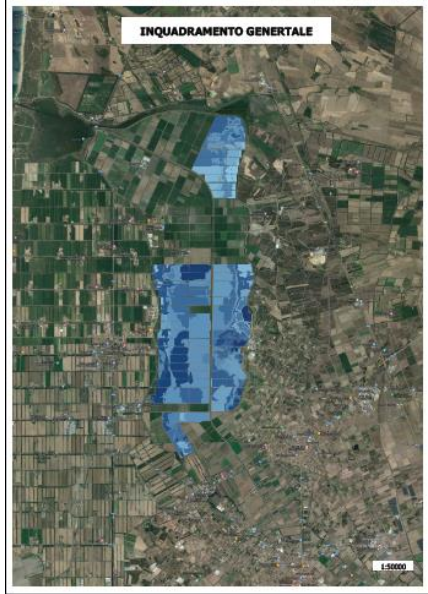


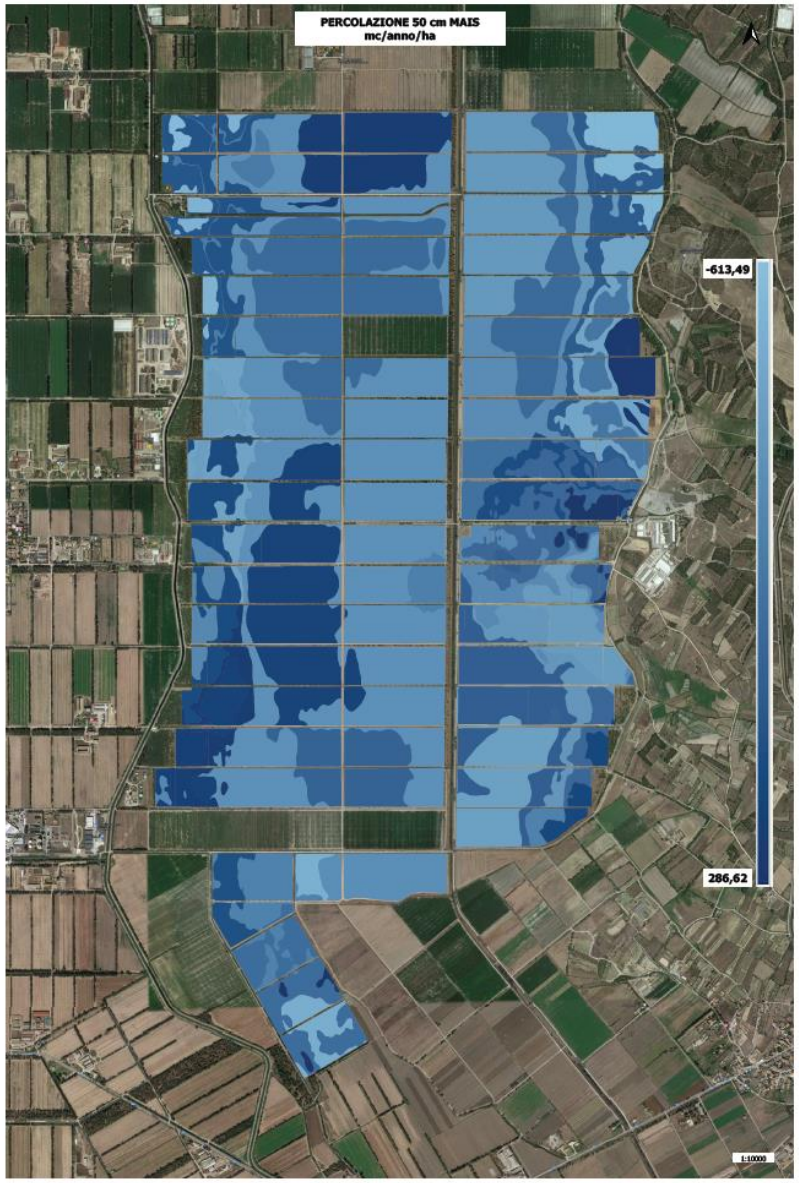
volumi irrigui calcolati da modello



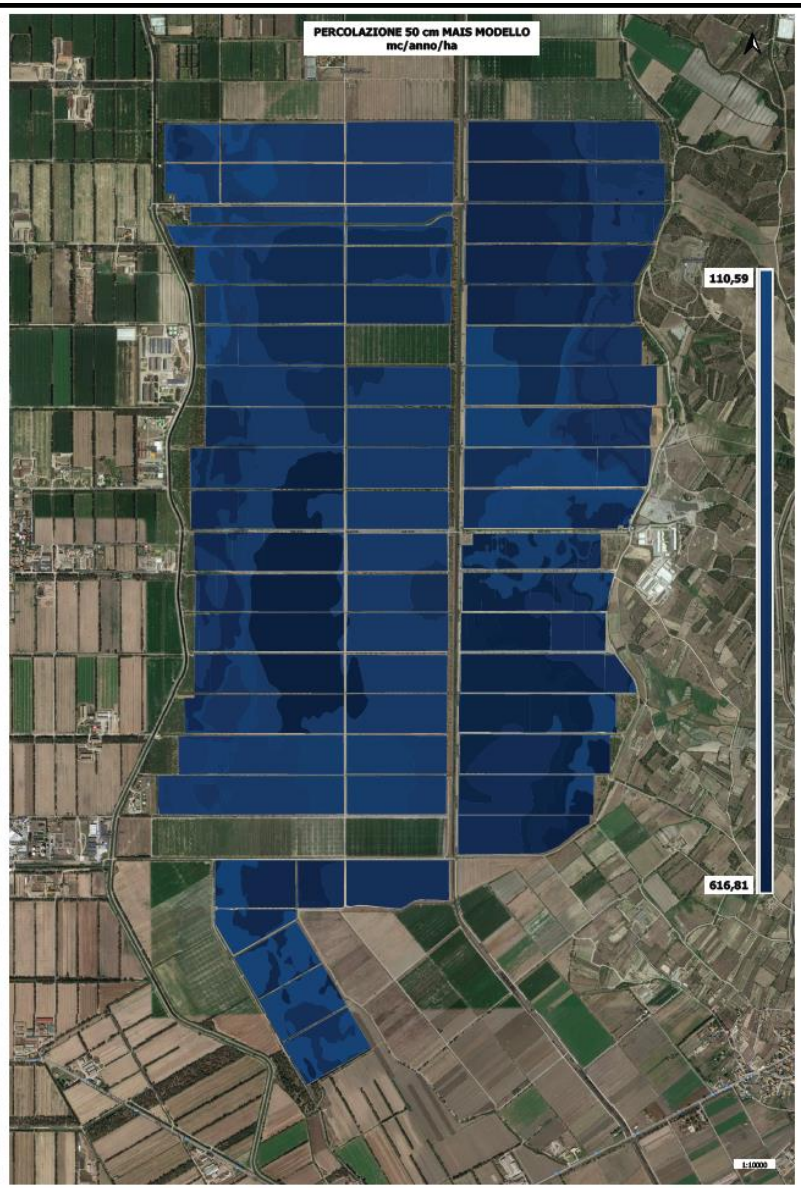
Flussi di percolazione verso la falda (MAIS)

Da volumi irrigui effettivi



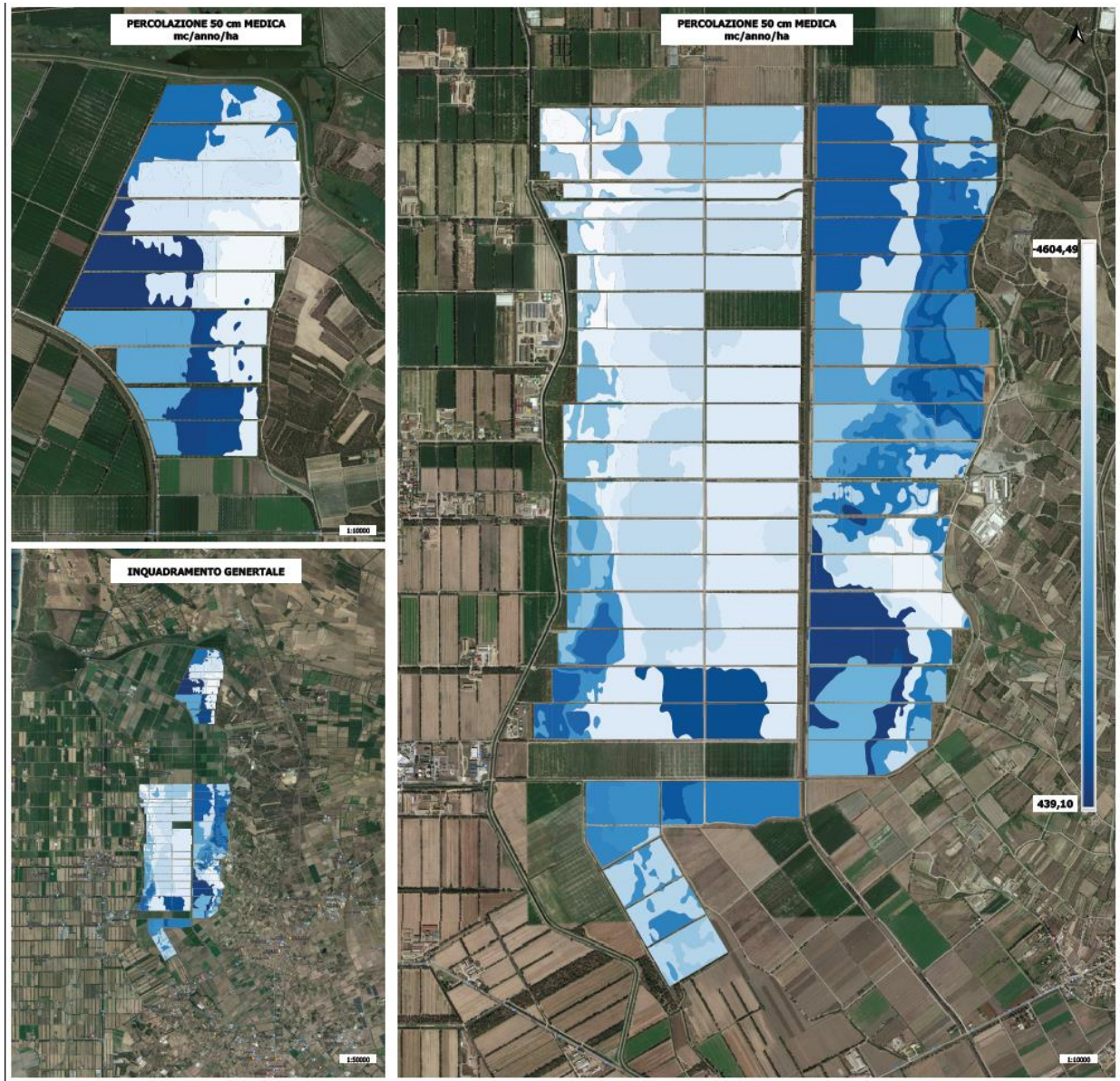


Da volumi irrigui calcolati da modello

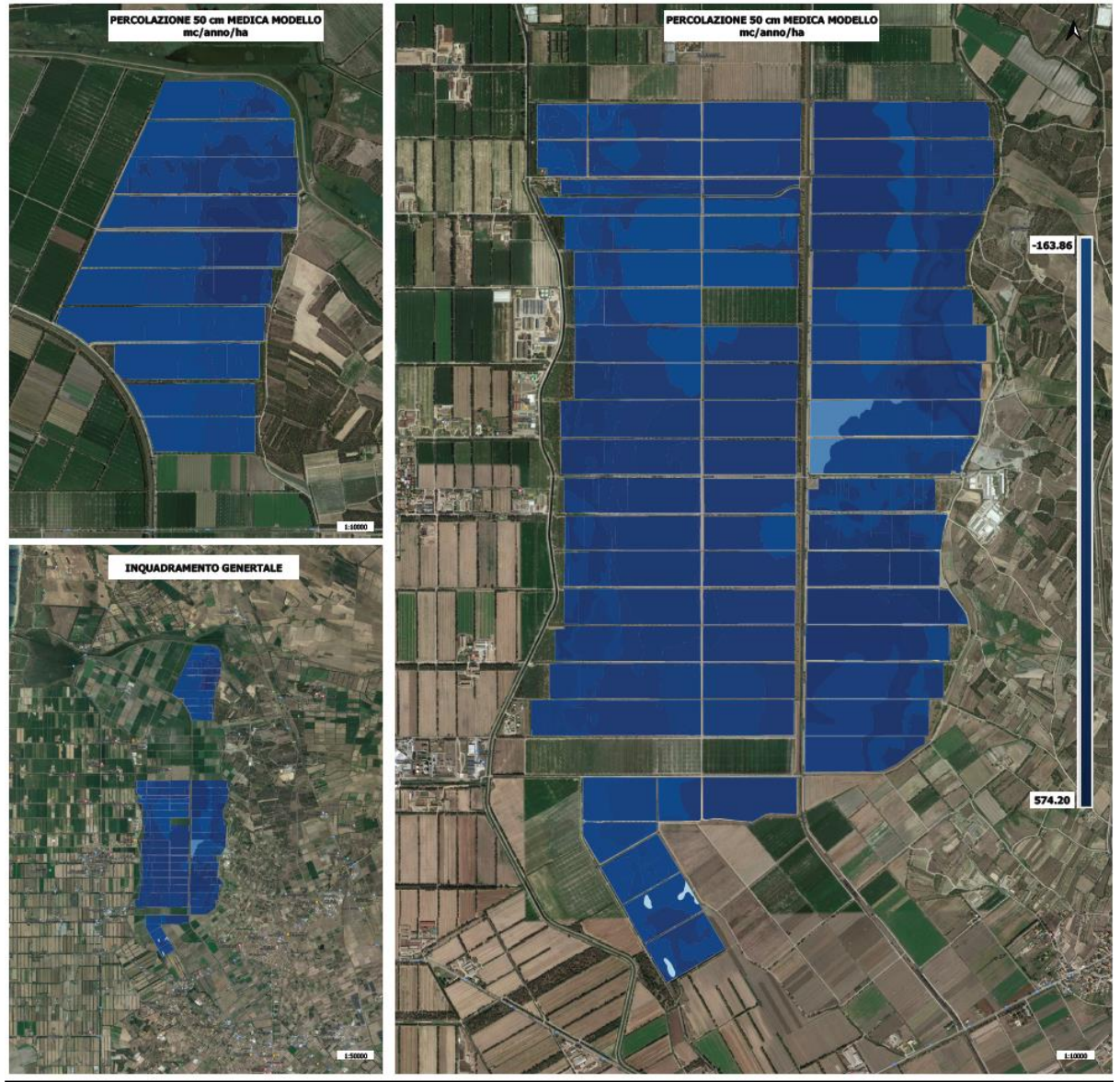


Flussi di percolazione verso la falda (MEDICA)

Da volumi irrigui effettivi

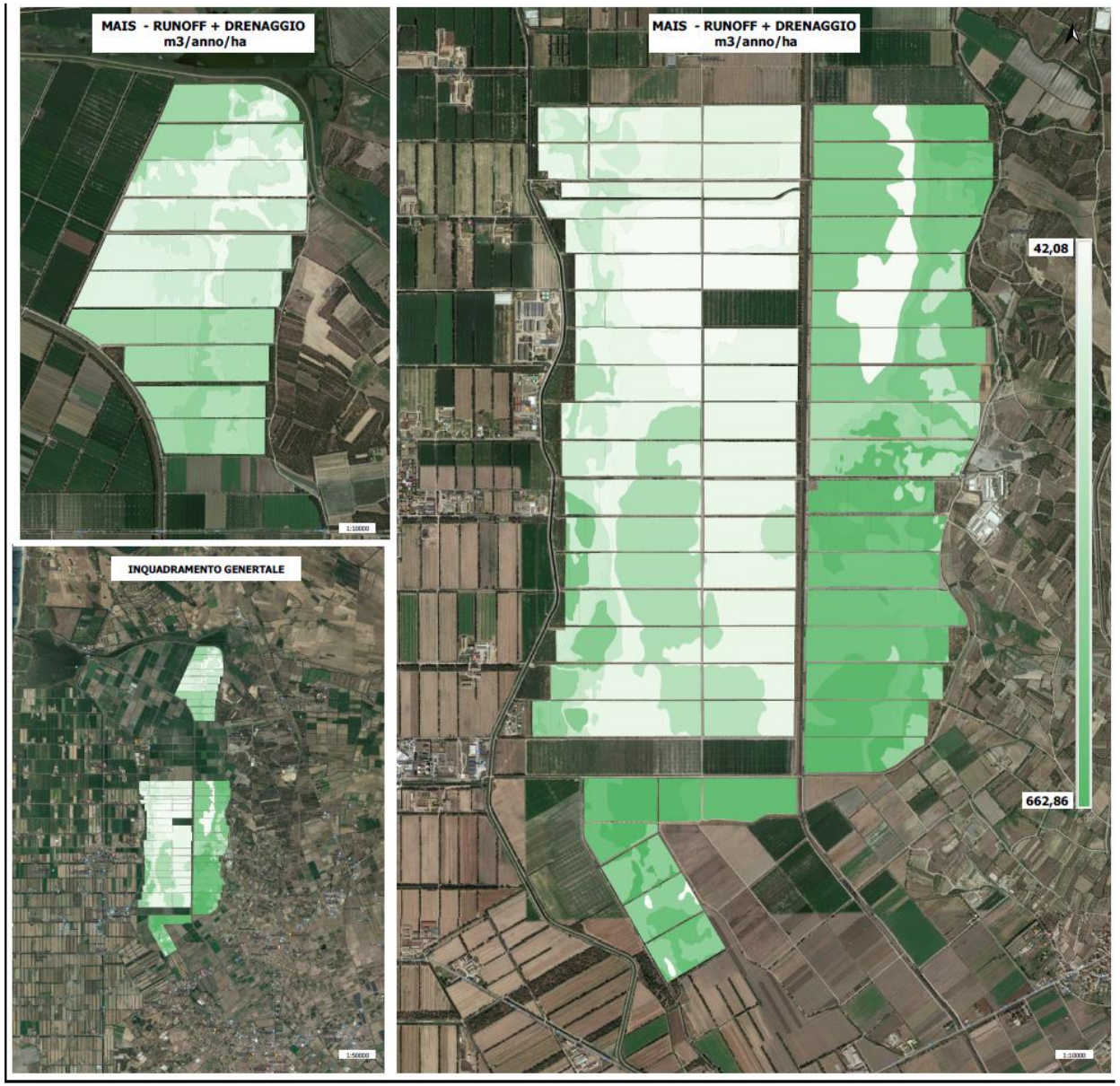


Da volumi irrigui calcolati da modello

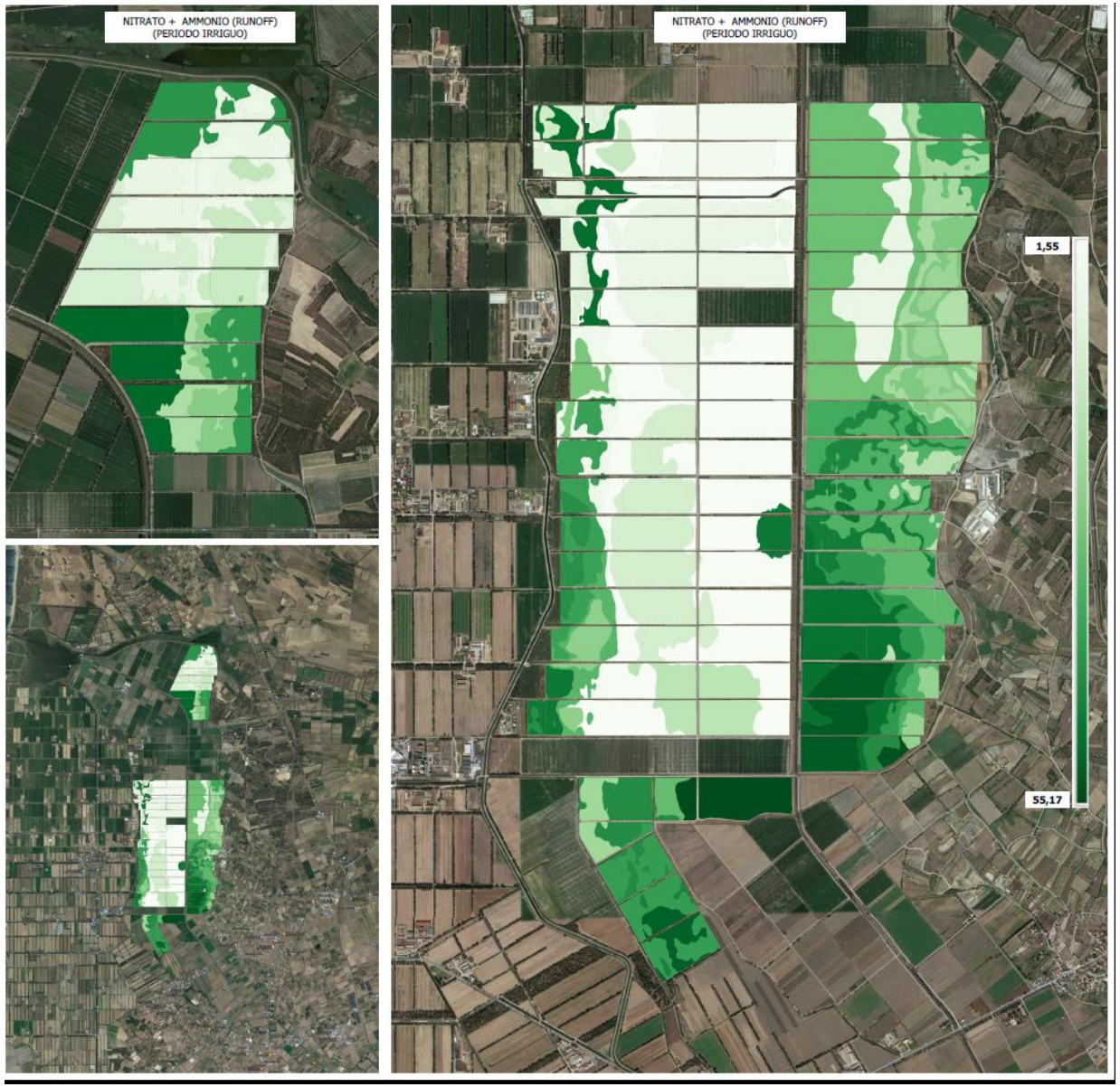


(MAIS)

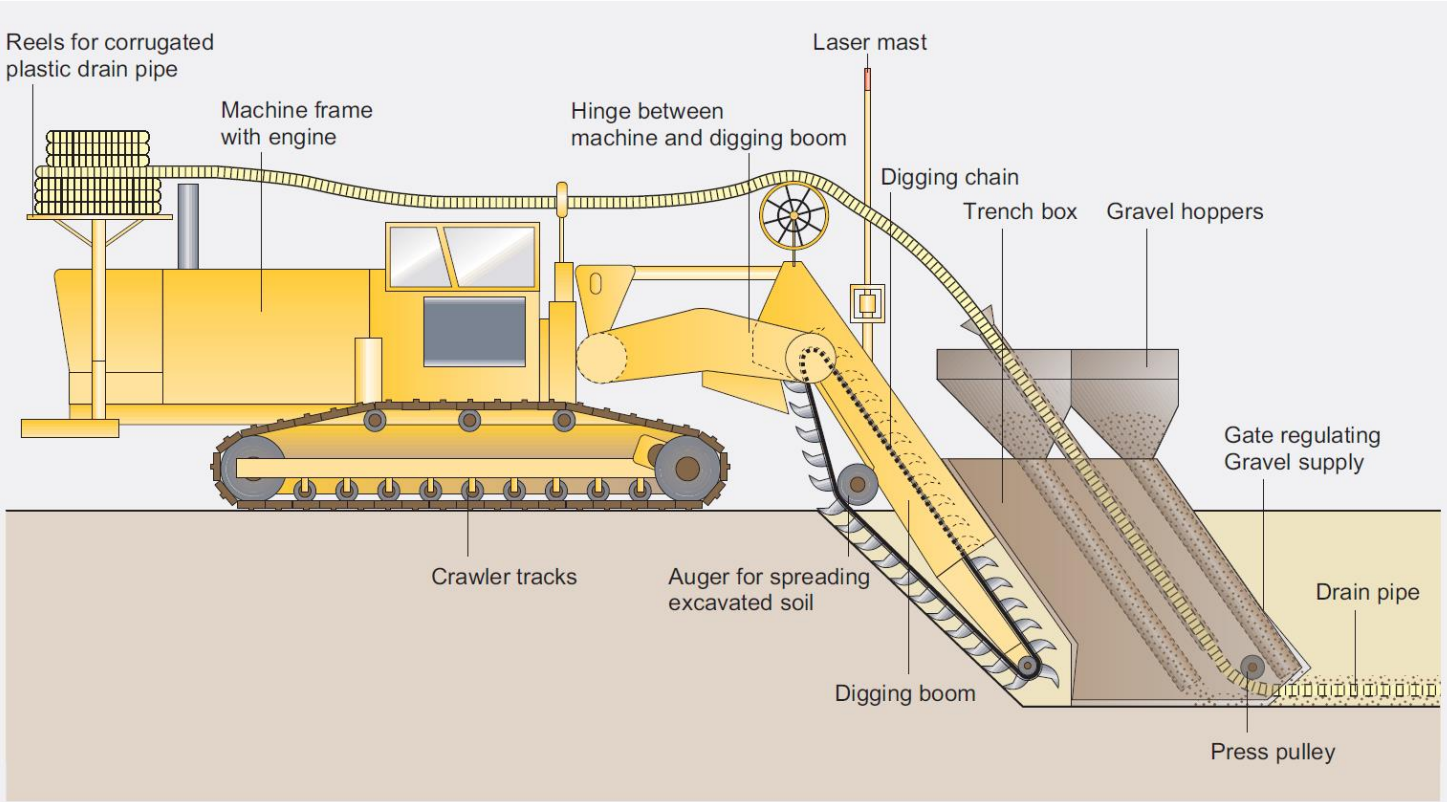
deflusso superficiale (m3/ha)

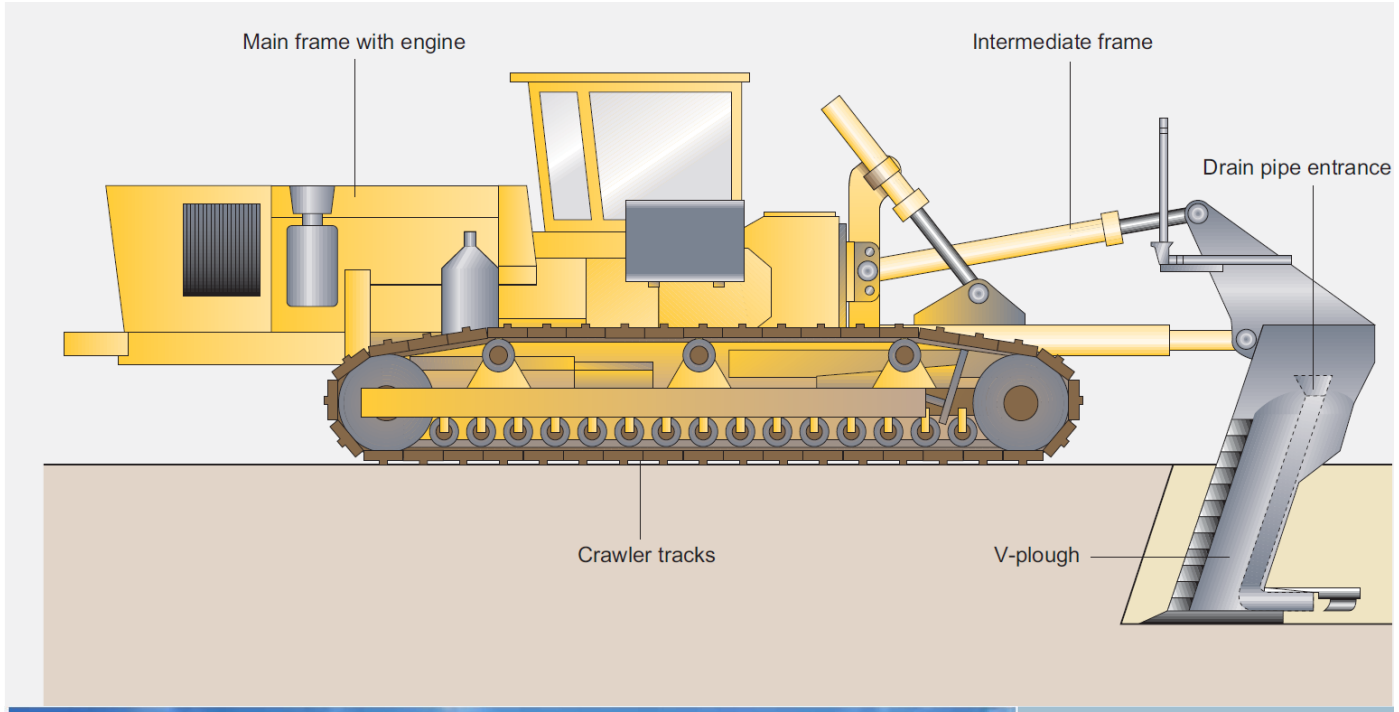


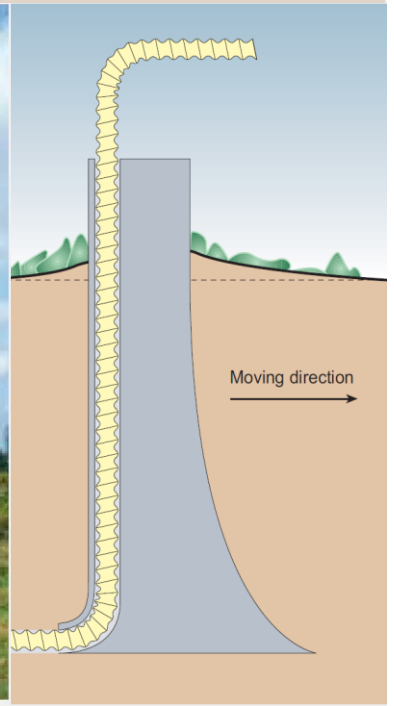
NO3 + NH4 in deflusso superficiale (kg/ha)



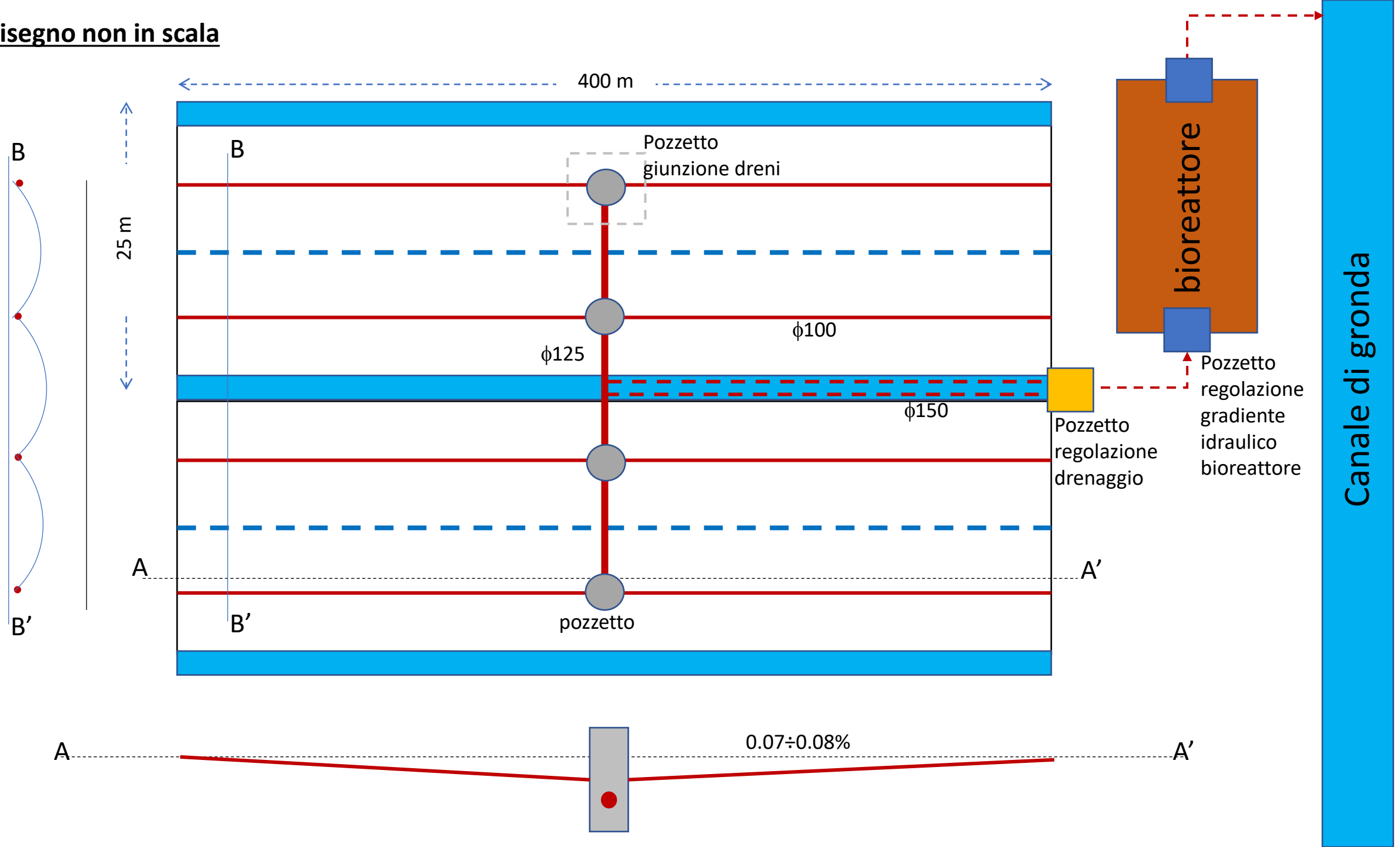
INSTALLAZIONE DEL SISTEMA DI DRENAGGIO

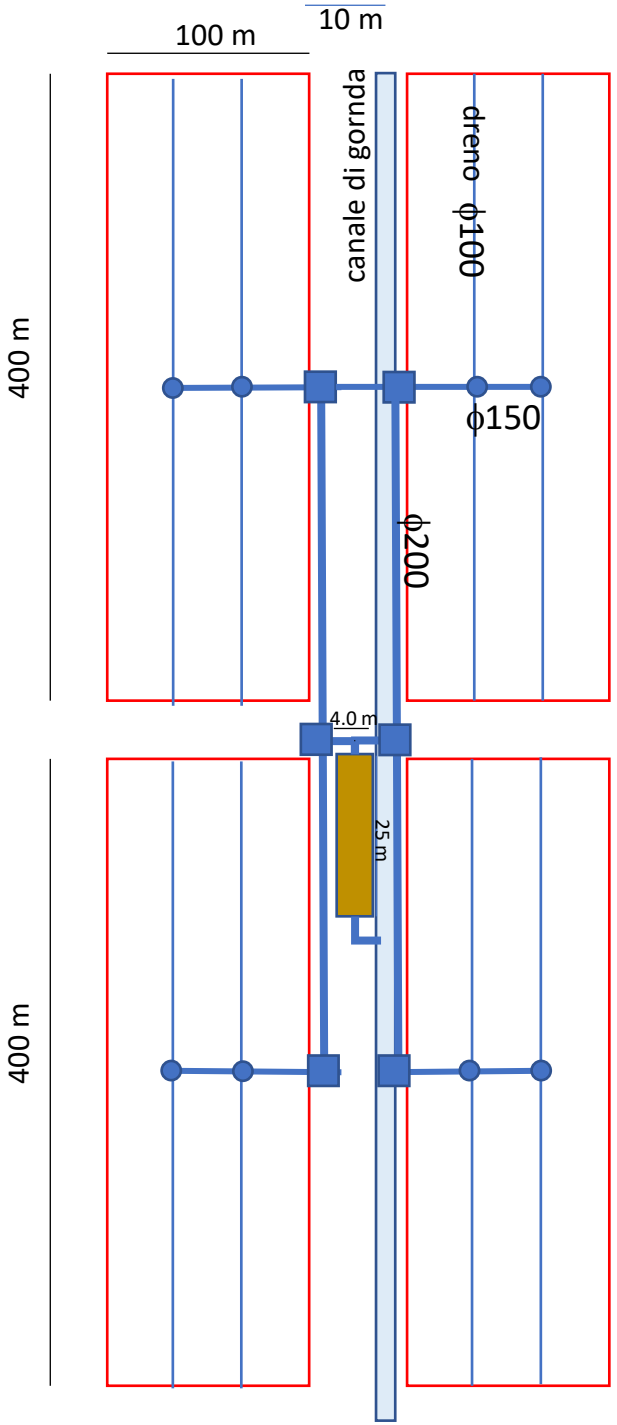

Reels for corrugated plastic drain pipe
Machine frame with engine
Hinge between machine and digging boom
Laser mast
Digging chain
Trench box
Gravel hoppers
Gate regulating Gravel supply
Drain pipe
Crawler tracks
Auger for spreading excavated soil
Digging boom
Press pulley

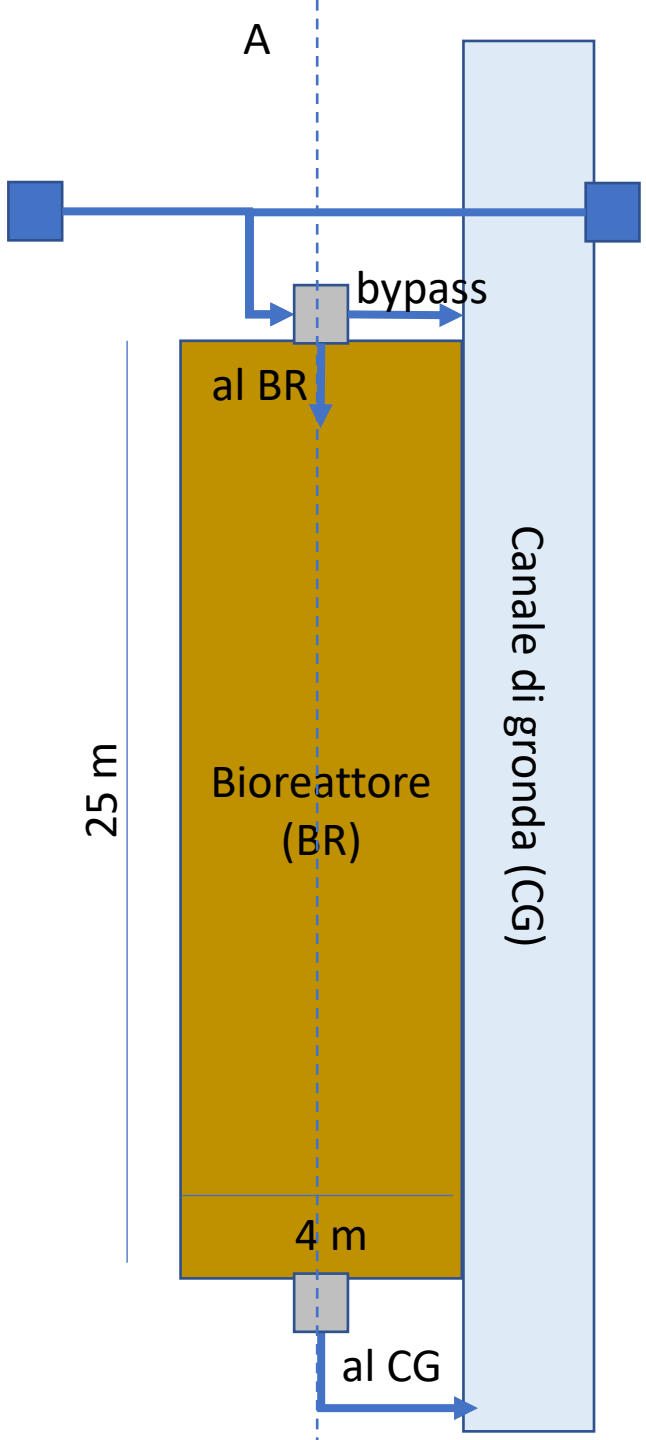

Main frame with engine
Intermediate frame
Drain pipe entrance
Crawler tracks
V-plough


Moving direction

Disegno non in scala

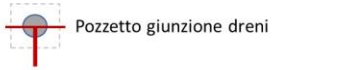


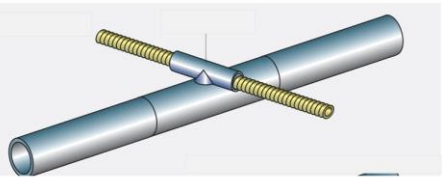


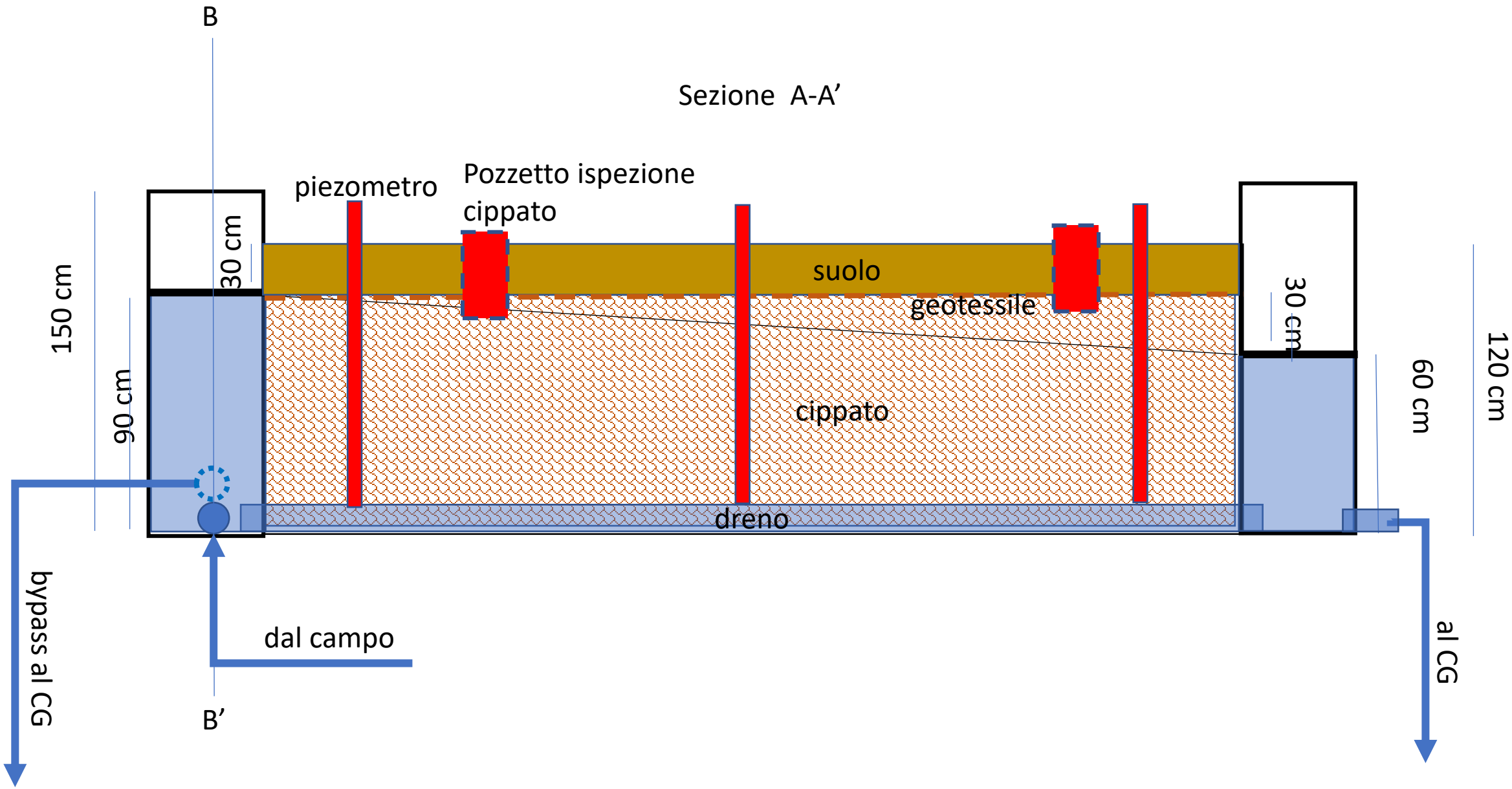


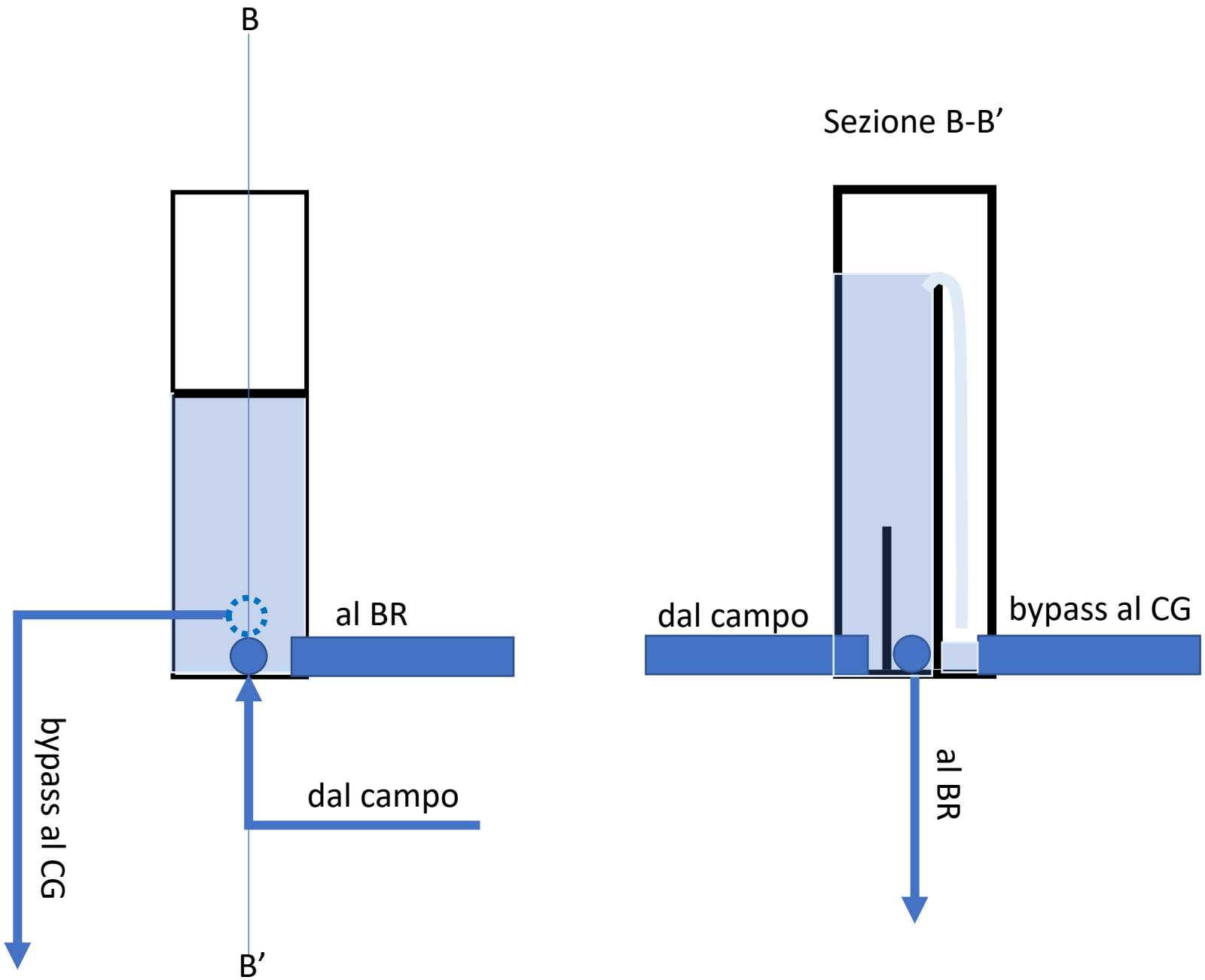
Pozzetto giunzione dreni (0.6 x 0.6 m)

Pozzetto a due-tre vie regolazione gradiente idraulico



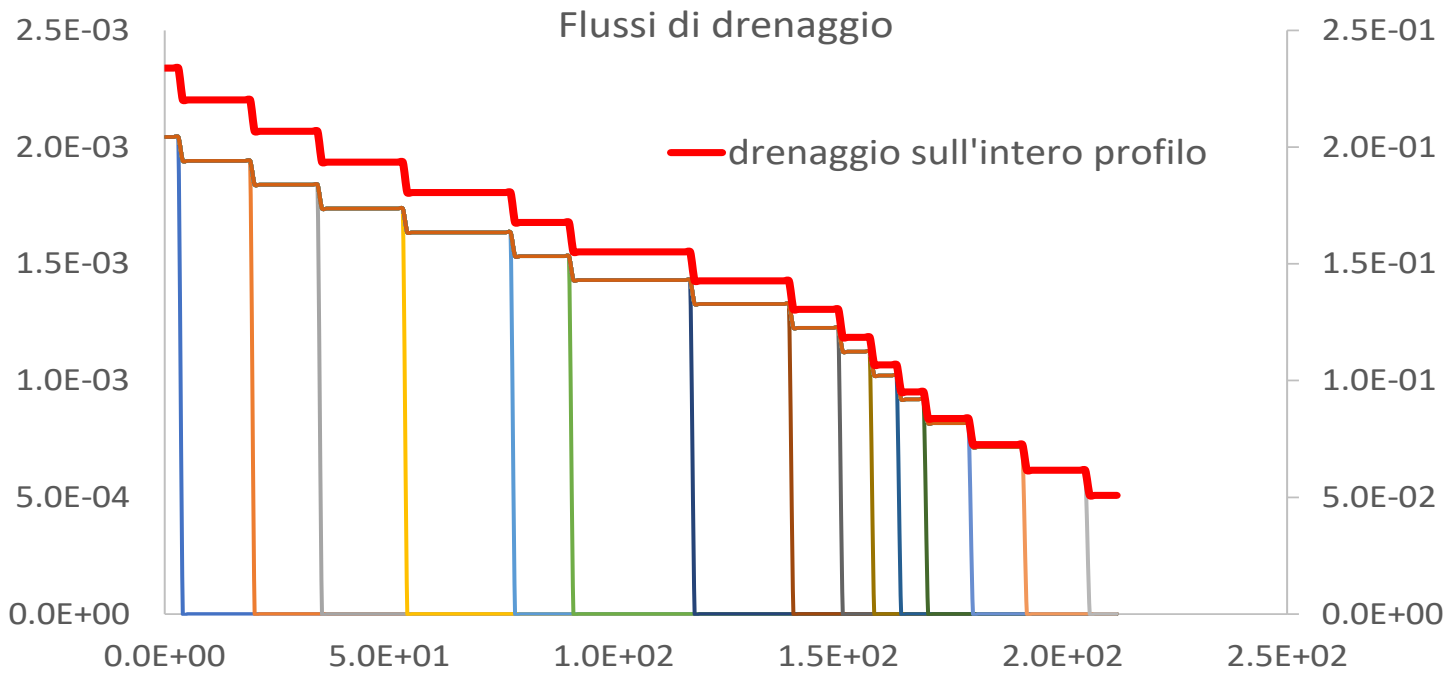


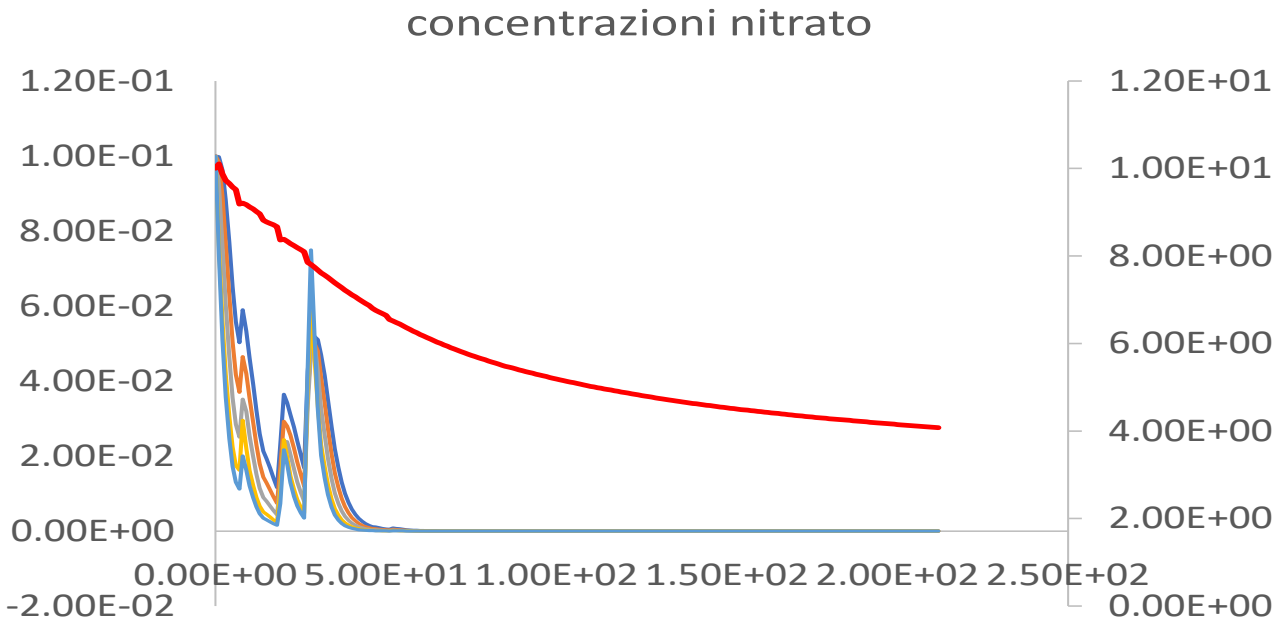

B
Sezione A-A’
piezometro
Pozzetto ispezione
cippato
suolo
geotessile
cippato
dreno
30 cm
150 cm
90 cm
30 cm
60 cm
120 cm
bypass al CG
dal campo
al CG
B’


B
al BR
bypass al CG
dal campo
B’
Sezione B-B’
dal campo
bypass al CG
al BR


GOLFO
DI
ORISTANO
DIVERSIVO
S. ANNA
CANALE IRRIGUO
TIRSO-ARBOREA
Rio di S. Anna
St.
S'Ena
Arrubia
ex Stagno
di Sassu
IDROVORA
DI SASSU
CANALE ACQUE ALTE
Arborea
Marrubiu
COLLETTORE
ACQUE BASSE
LIMITE
COMPRENSORIO
IDROVORA
DI LURI
Stagno
di
Marceddi
Terralba
St. di
S. Giovanni
Uras
DIGA DEL
MOGORO
DIVERSIVO MOGORO
Rio Sitzerri
S. Nicolò
d'Arcidano
Rio Mogoro


Stagno di Sassu
Marrubiu
TERRALI


Flussi di drenaggio
drenaggio sull'intero profilo
2.5E-03
2.0E-03
1.5E-03
1.0E-03
5.0E-04
0.0E+00
2.5E-01
2.0E-01
1.5E-01
1.0E-01
5.0E-02
0.0E+00
0.0E+00
5.0E+01
1.0E+02
1.5E+02
2.0E+02
2.5E+02


concentrazioni nitrato
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
-2.00E-02
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0.00E+00
5.00E+01
1.00E+02
1.50E+02
2.00E+02
2.50E+02

Pozzetto regolazione drenaggio

Pozzetto regolazione gradiente idraulico bioreattore