SUSTAINABLE IRRIGATION 2006

First International Conference on Sustainable Irrigation Management, Technologies and Policies

Quarry plans in the management of water resources: case study of the River Serio

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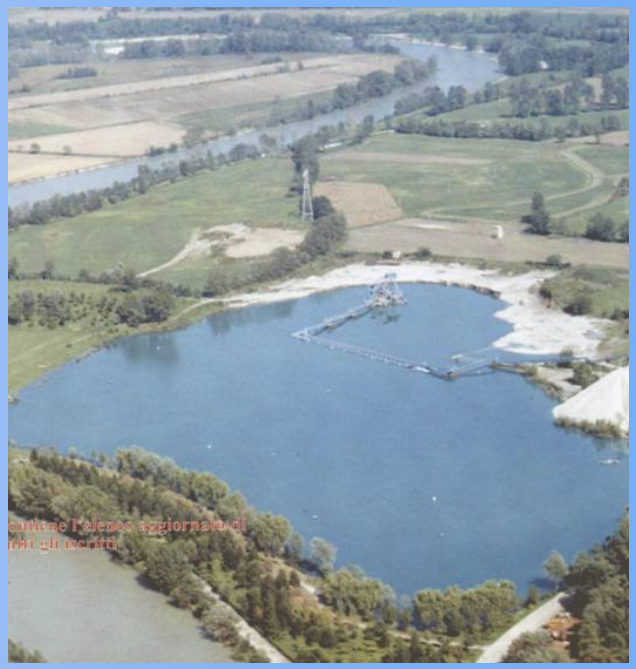


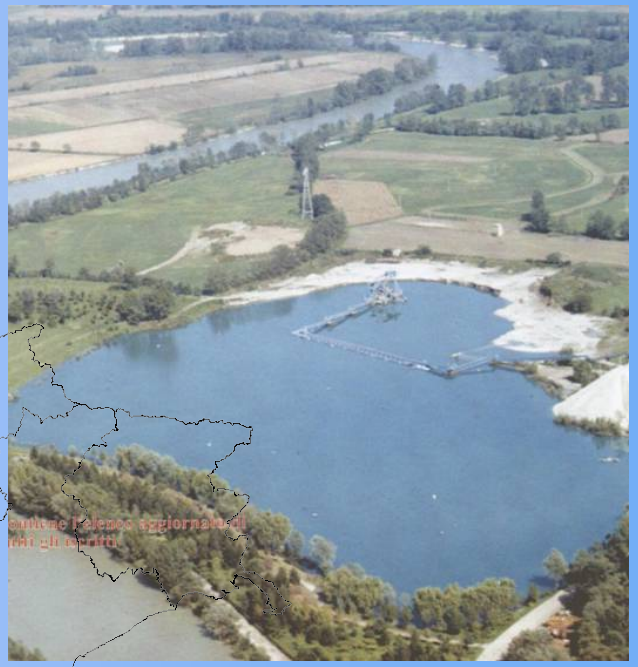
5 – 7 September 2006
Bologna, Italy

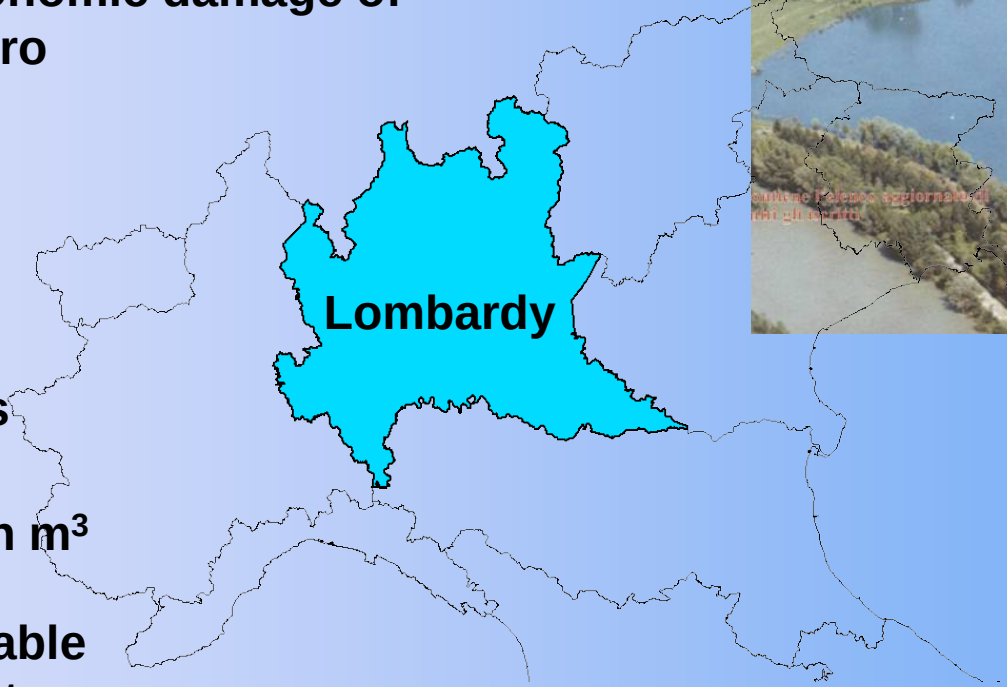
Organised by:
Wessex Institute of Technology, UK

AIM OF THE WORK

In the last years increase emergencies for water scarcity

Estimated economic damage of 230 million euro





Recent census:

700 quarry lakes

100 km² surface

350 – 700 million m³

Volume comparable to traditional water resources, subject to intensive exploitation

Quarry reservoirs may, then, become a strategic means for the mitigation of water scarcity

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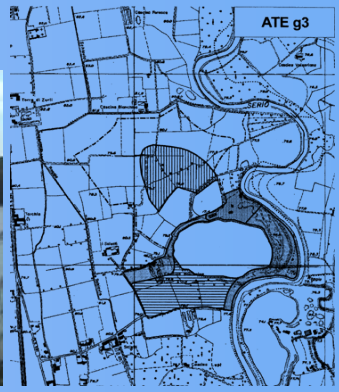
THE STUDY AREA



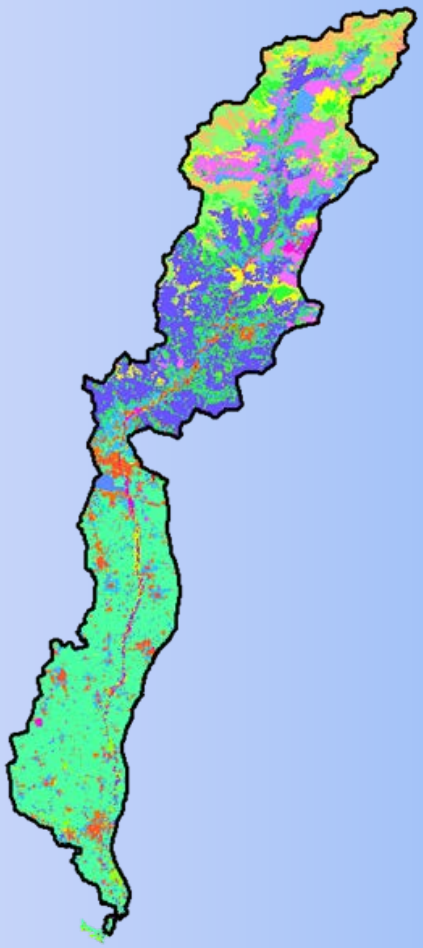
Characteristics of the quarries

	Actual state		Planned expansion	
Quarry code	Surface [m^2]	Depth [m]	Surface [m^2]	Depth [m]
ATE g2	51400	16	0	-
ATE g3	163250	15	160000	15
ATE g4	100200	15	98600	15
total	314850	-	258600	-

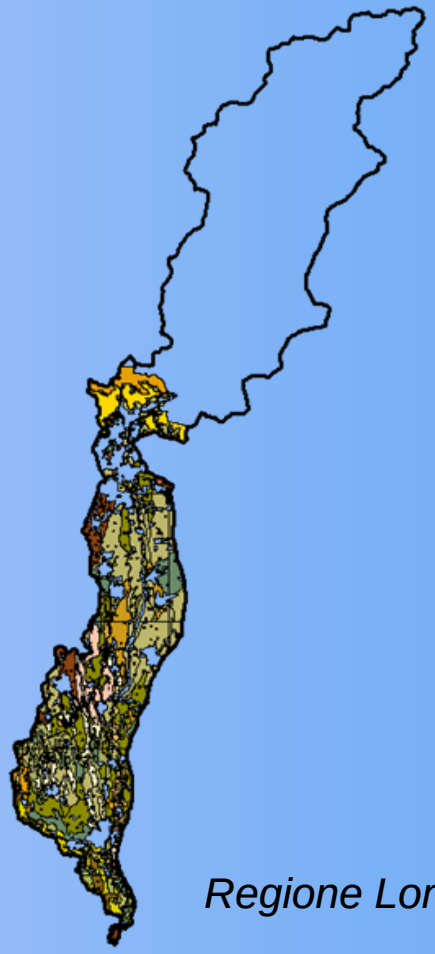
AVAILABLE DATA: cartography

DEM

LAND USE



LITHOLOGY



Regione Lombardia

AVAILABLE DATA: time series

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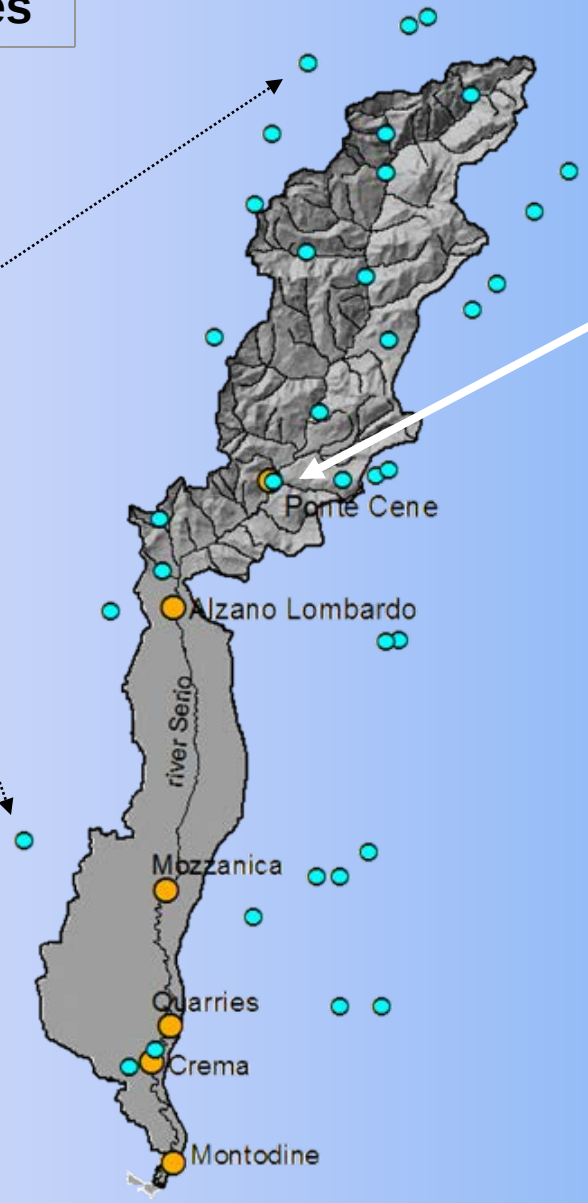
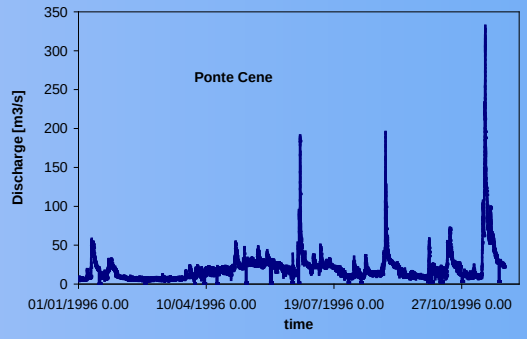
Rainfall data

ARPA Regione Lombardia



Long series discharge 1995 - 2005



Consorzio di Bonifica Media Pianura Bergamasca

DROUGHT HYDROLOGY

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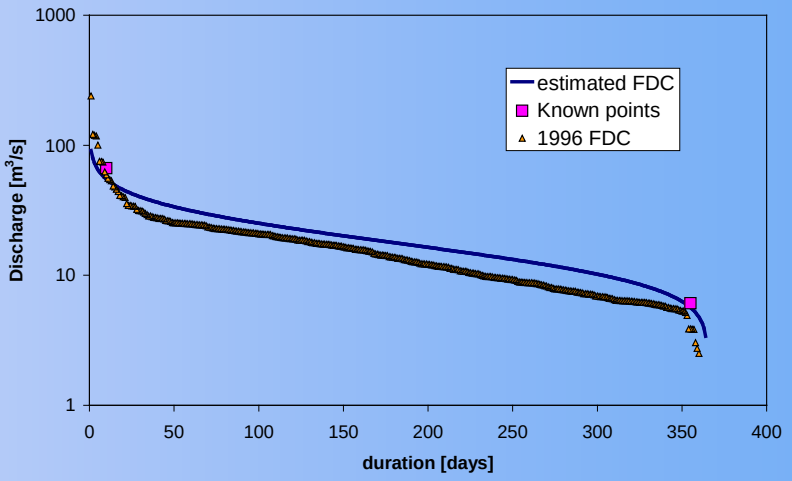


$$D(q) = 365\left[1 - F_q(q)\right]$$

$$f(y) = \frac{1}{\sigma_y\sqrt{2\pi}}\exp\left\{-\frac{1}{2}\left[\frac{y-\mu_y}{\sigma_y}\right]^2\right\}$$

$$\sigma_y^2 = \ln\left[\left(\frac{\sigma_q}{\mu_q}\right)^2 + 1\right] \qquad \mu_y = \ln(\mu_q) - 0.5\sigma_y^2$$

Bartolini, 2004

$$\mu_q = a_1 S^{b_1} H^{c_1} \qquad \sigma_q = a_2 S^{b_2} H^{c_2}$$

S = drainage area [km²]

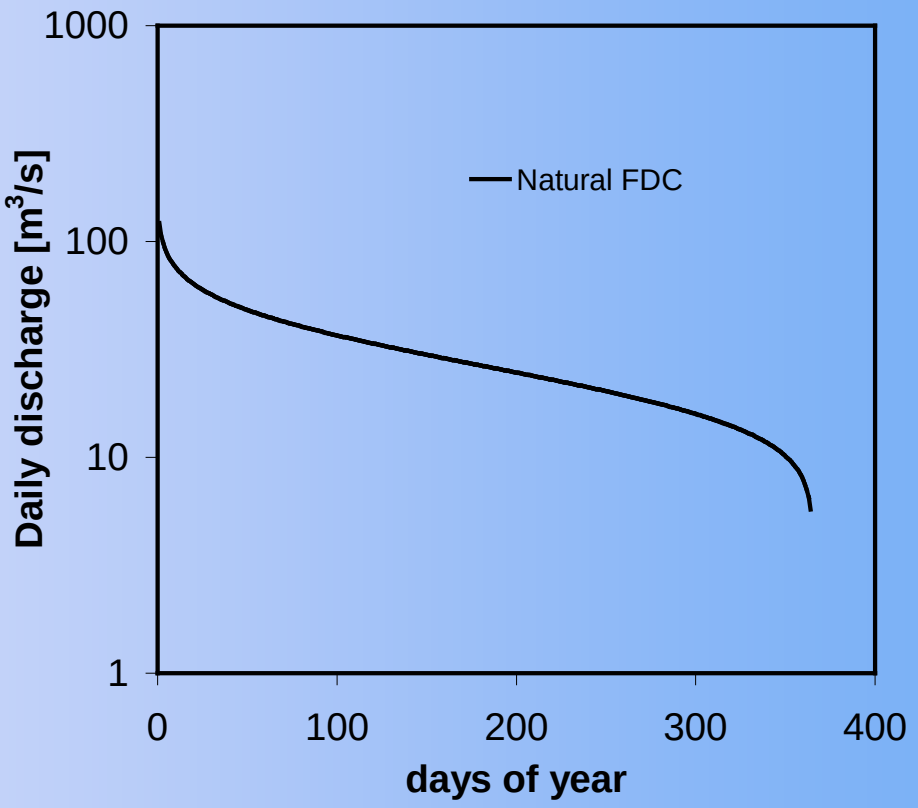
H = average annual rainfall [m]

a_1	a_2	a_3	b_1	b_2	b_3
0.0216	0.99	1.43	0.023	0.924	1.148

DROUGHT HYDROLOGY

S = 711 [km²]

H = 1.7 [m]



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DROUGHT HYDROLOGY

$S = 711\ [km^2]$

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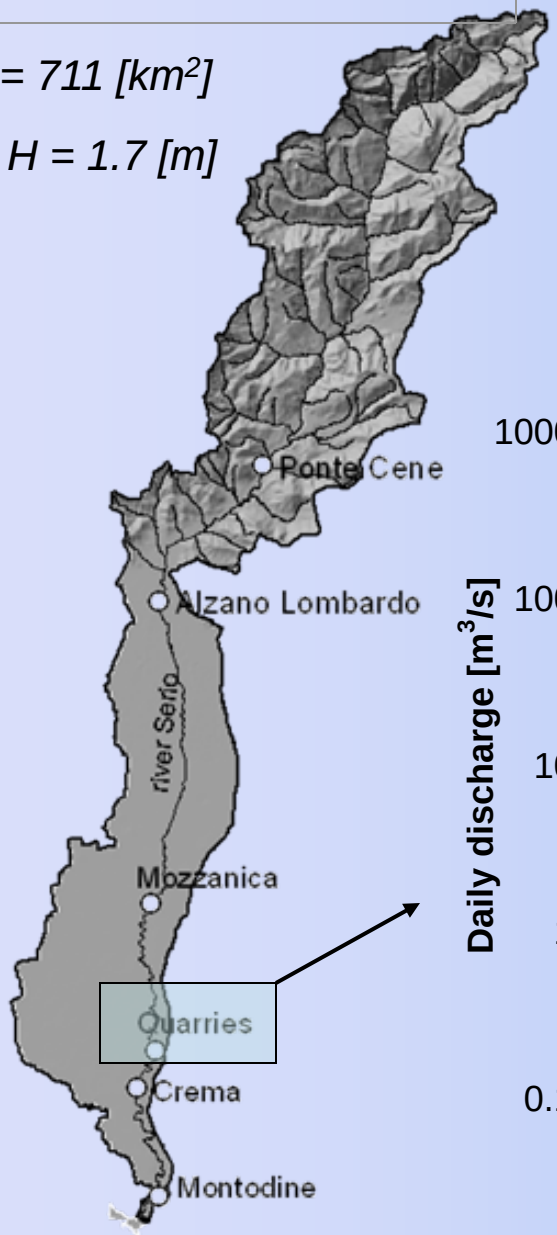
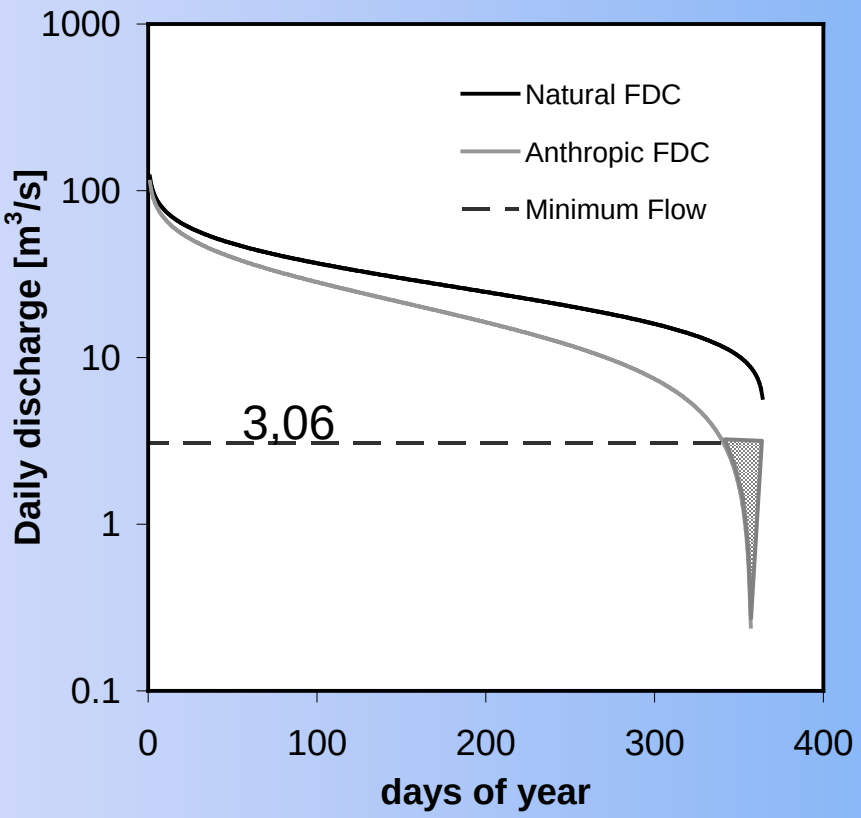


upstream = 10,33 m³/s

downstream = 2,26 m³/s

Nome	gen	feb	mar	apr	mag	giu	lug	ago	set	ott	nov	dic	media annua derivata	media annua da concessione
Roggia Comenduna	0	0	0	4.80	4.80	4.80	4.80	4.80	4.80	0	0	0	-	2.41
Roggia Morlana	0	0	0	4.57	4.57	4.57	4.57	4.57	4.57	0	0	0	-	2.29
Roggia Borgogna	0	0	0	4.37	4.37	4.37	4.37	4.37	4.37	0	0	0	-	2.19
Roggia Guidana	0	0	0	0.40	0.40	0.40	0.40	0.40	0.40	0	0	0	-	0.20
Roggia Ponte Perduto	0	0	0	0.18	0.18	0.18	0.18	0.18	0.18	0	0	0	-	0.09
Roggia Brusaporto	0	0	0	1.20	1.20	1.20	1.20	1.20	1.20	0	0	0	-	0.60
Rogge Unite	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0	0	0	-	0.13
Roggia Vecchia	0	0	0	0.30	0.30	0.30	0.30	0.30	0.30	0	0	0	-	0.15
Roggia Babbiona	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	-	2.27
Roggia Borromea	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	-	1.40
Roggia Malcontenta	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	-	0.44
Piccole Derivazioni	0	0	0	0.84	0.84	0.84	0.84	0.84	0.84	0	0	0	-	0.42



24 days under the minimum flow

Deficit volume = 3.700.000 m³

WATER MANAGEMENT

Targets to preserve during water scarcity period

Environmental quality → ***3,06 m³/s***

\+

Agricultural needs → ***2,26 m³/s***

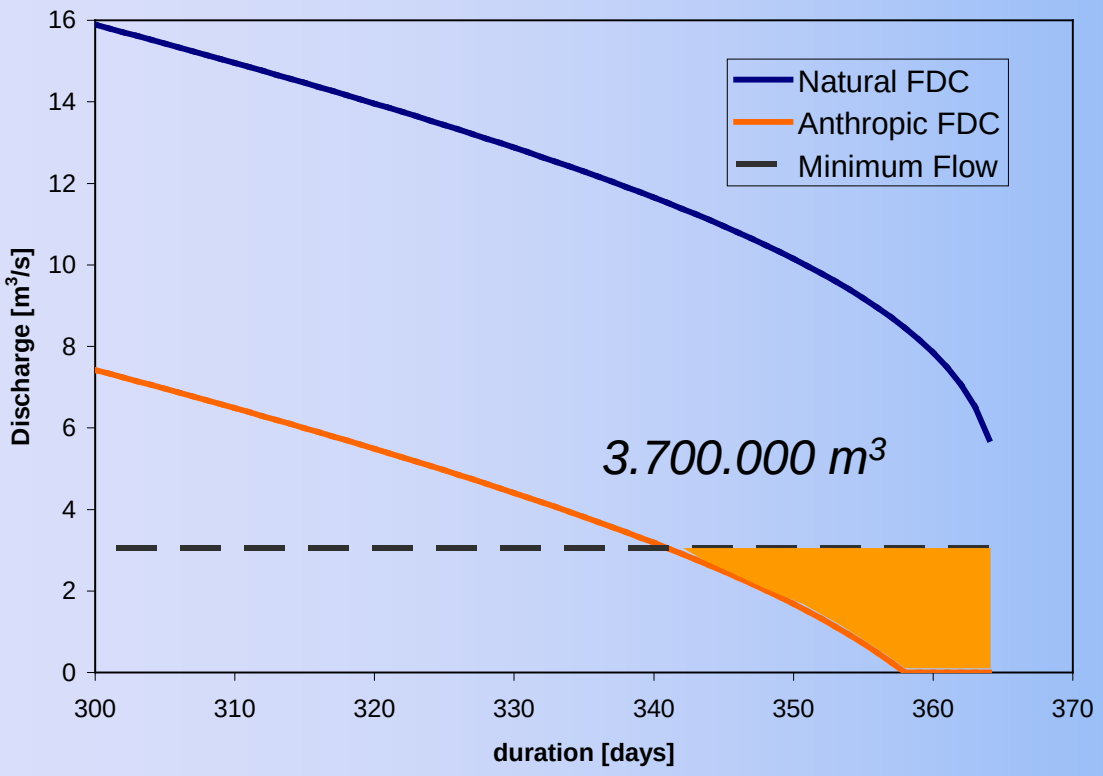
=

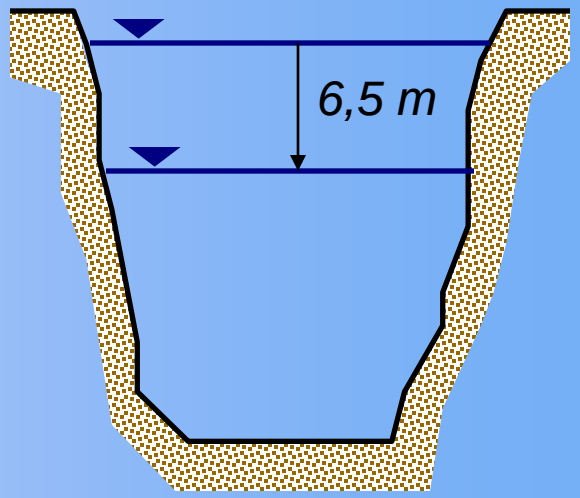
Environmental quality + **Agricultural needs** → ***5,32 m³/s***

ROLE OF THE QUARRIES

HP: quarries as a whole in future expansion scenario ***573.450 m²***

Environmental quality

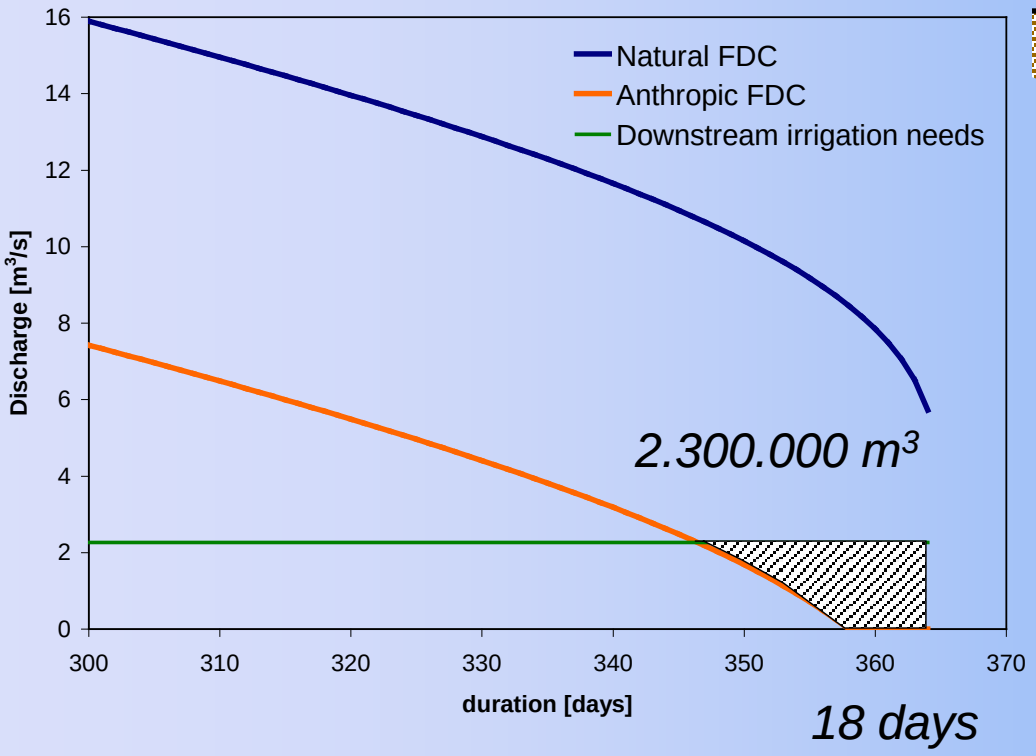


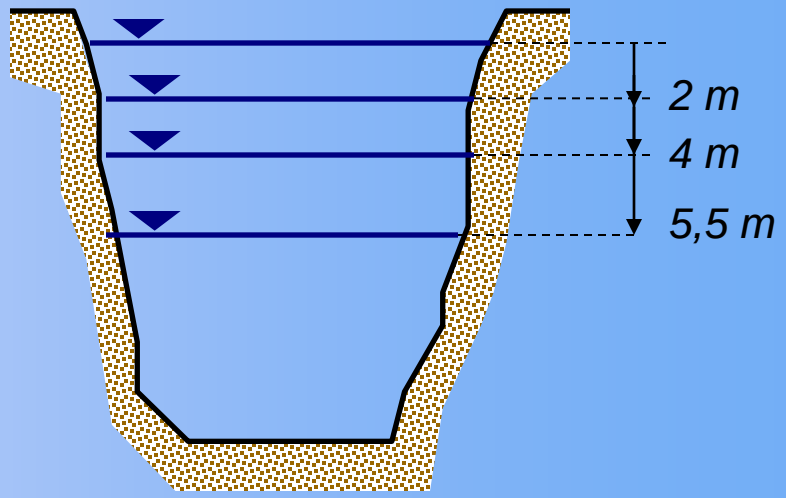


ROLE OF THE QUARRIES

HP: quarries as a whole in future expansion scenario ***573.450 m²***

Agricultural needs





6 – 12 - 16 days

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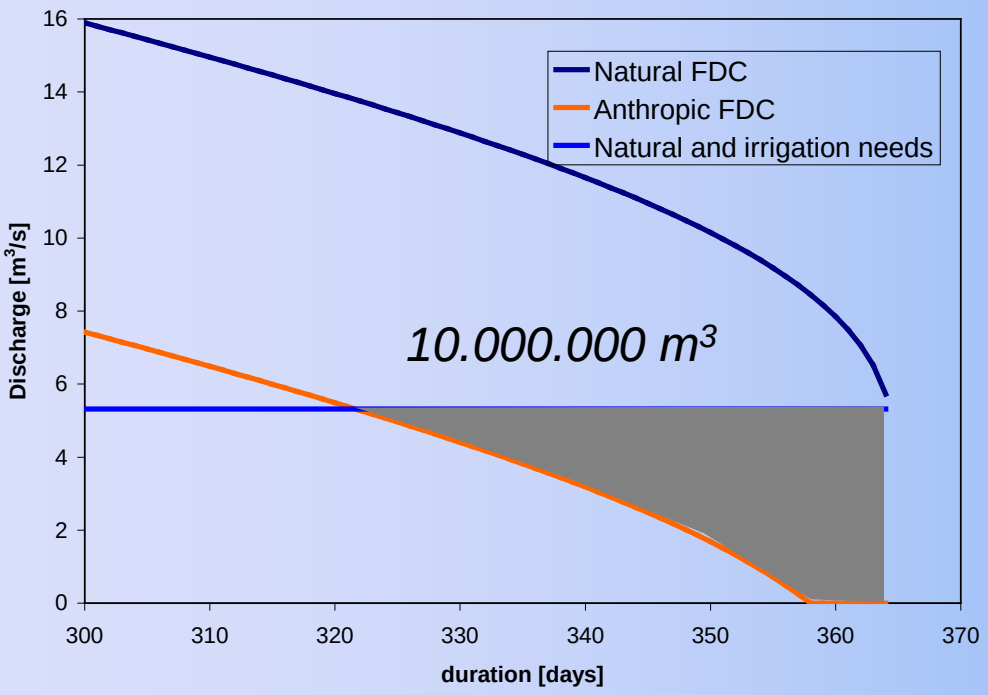
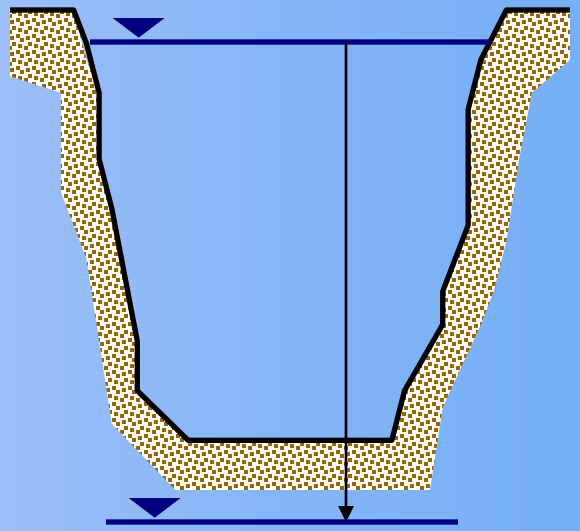
ROLE OF THE QUARRIES

HP: quarries as a whole in future expansion scenario ***573.450 m²***

Environmental quality + **Agricultural needs**

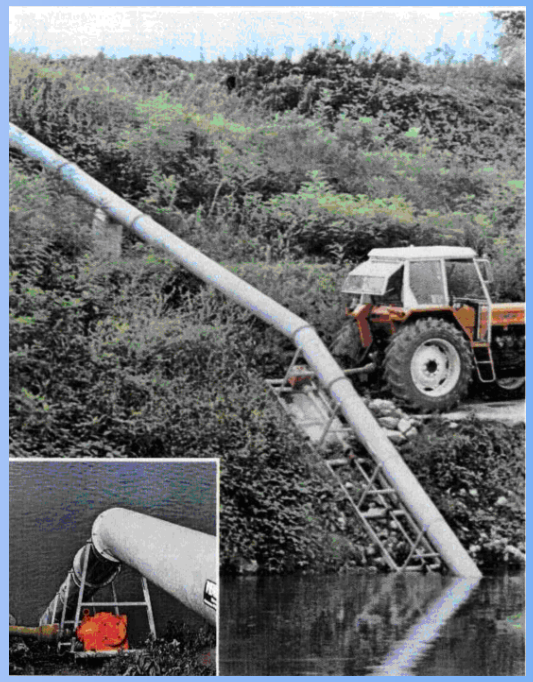


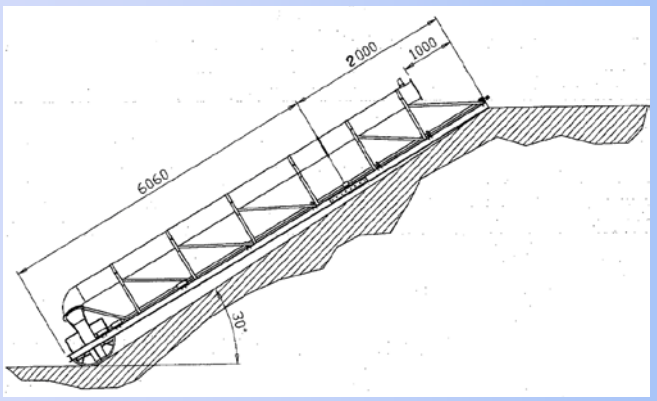


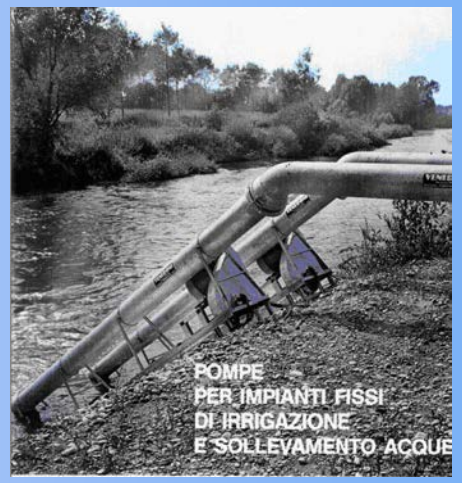
OPERATING STRUCTURES

Cost analysis

5 pumps, supply and installation	150.000 €
fuel, 30 days, H 24	54.000 €
Labour, 2 workers, 30 days	36.000 €
TOTAL	240.000 €





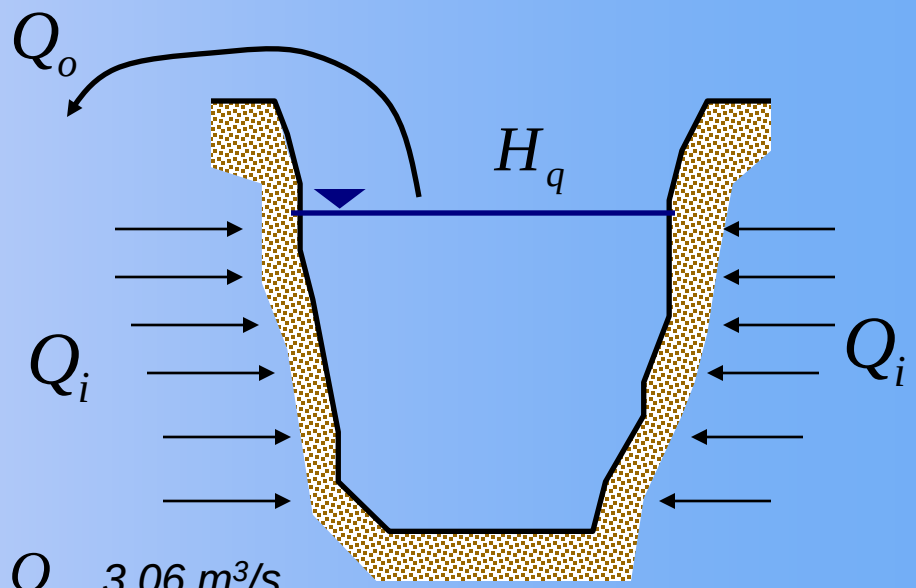


DRAINING TIME

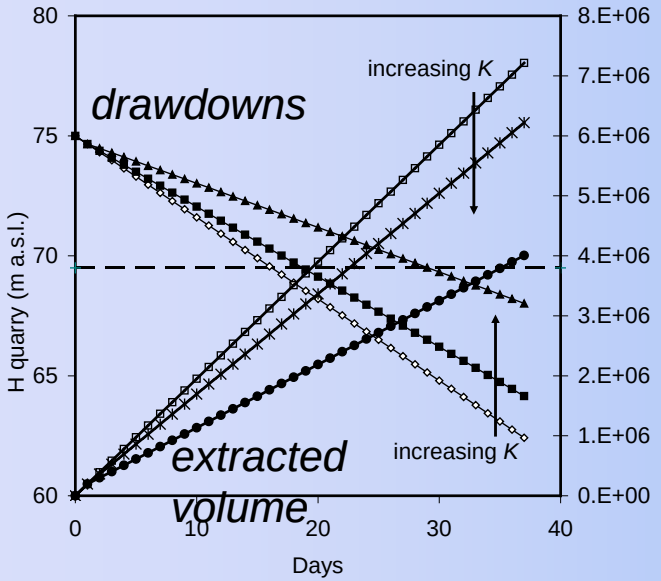
Conductivity, k = 3•10^{-5} m/s

$$\frac{\Delta W}{\Delta t} = Q_i - Q_o \qquad Q_i = \left(h_2^2 - H_q^2\right)\frac{K\,P}{2\,L}$$

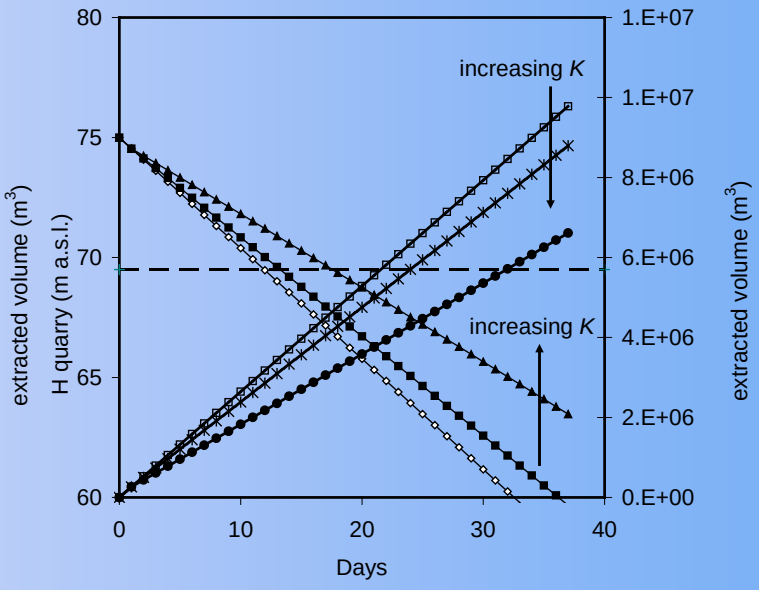
$$L = 573\,(h - H)\sqrt{Kh}$$



Q_o *2,26 m³/s*



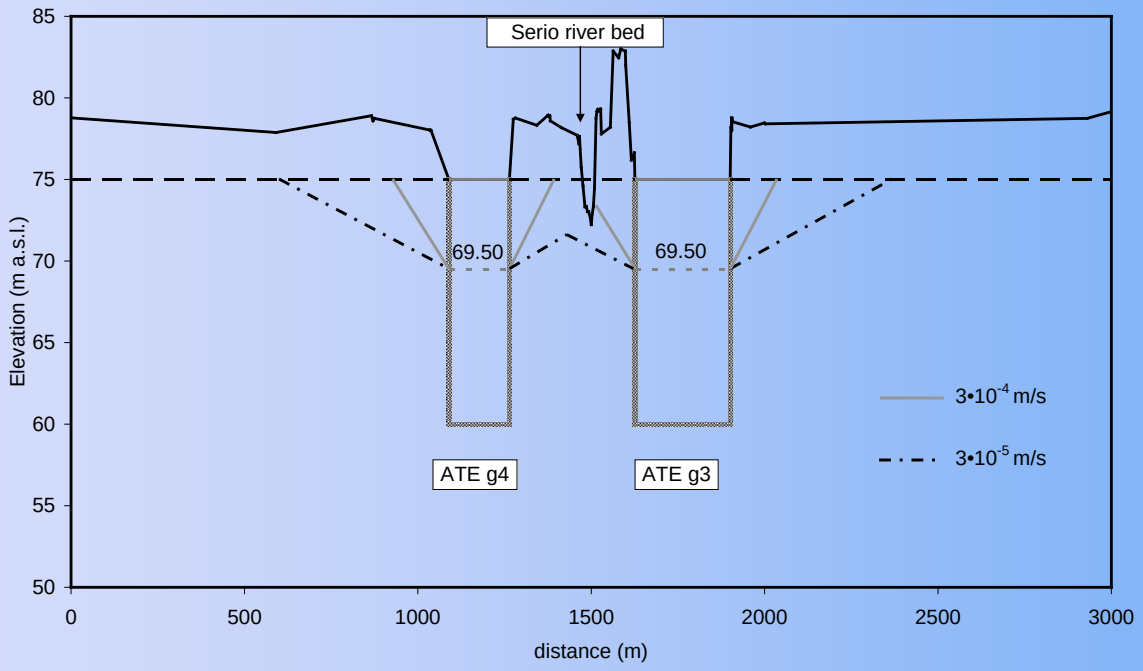
Q_o *3,06 m³/s*



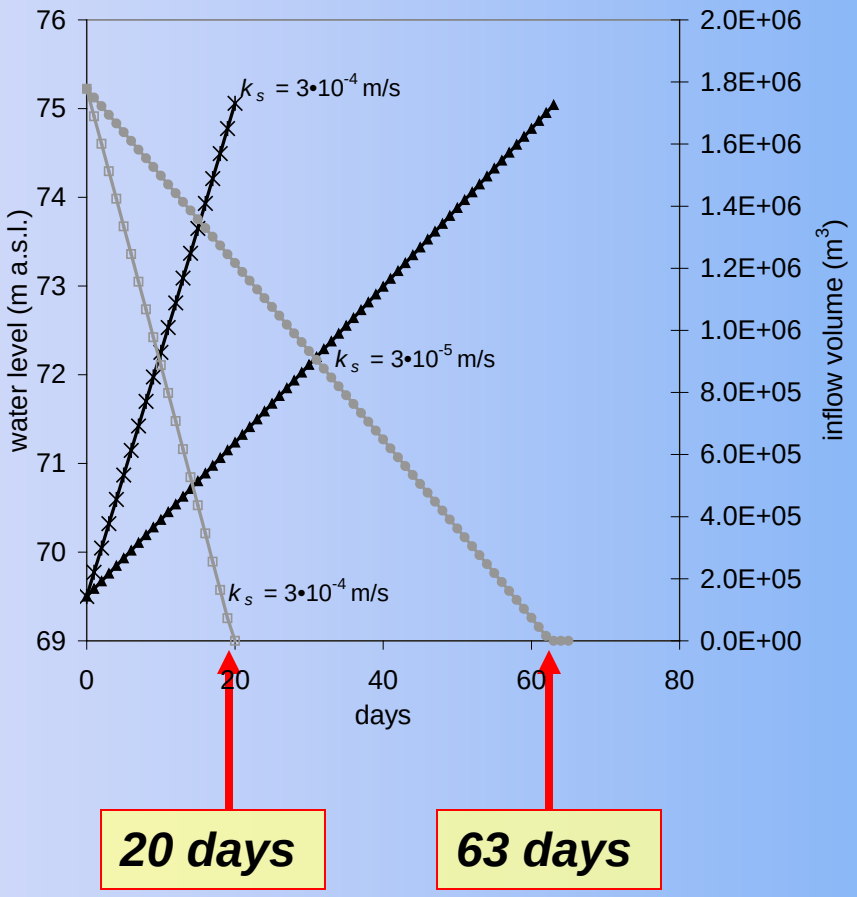
Conductivity, k = 3•10^{-5} - 3•10^{-4} - 3•10^{-9} m/s

PIEZOMETRIC HEAD

$$h_2 = \left(H^2 + \frac{2QL}{KP} \right)^{0.5}$$



REFILLING TIME



CONCLUSIONS

In the present study we investigated the possibility of rehabilitating and using volumes made available by the creation of quarries of inert materials in watercourse flood plains for maintenance of supplies in times of water scarcity

The results show the great importance quarries may have in environment conservation and agricultural activities

With a drawdown of 5.5 m it is possible to maintain in the river Serio the discharge necessary for the downstream water withdrawals for a 16 days period

Alternatively, by means of the same drawdown, it is possible to maintain the minimum flow in the river for natural life for a 12 days period

Need of in situ test for parameter estimation

Analysis with a bidimensional time varying model