« Salsigne » : the restoration of a contaminated site taking sanitary, environmental and economic objectives into account

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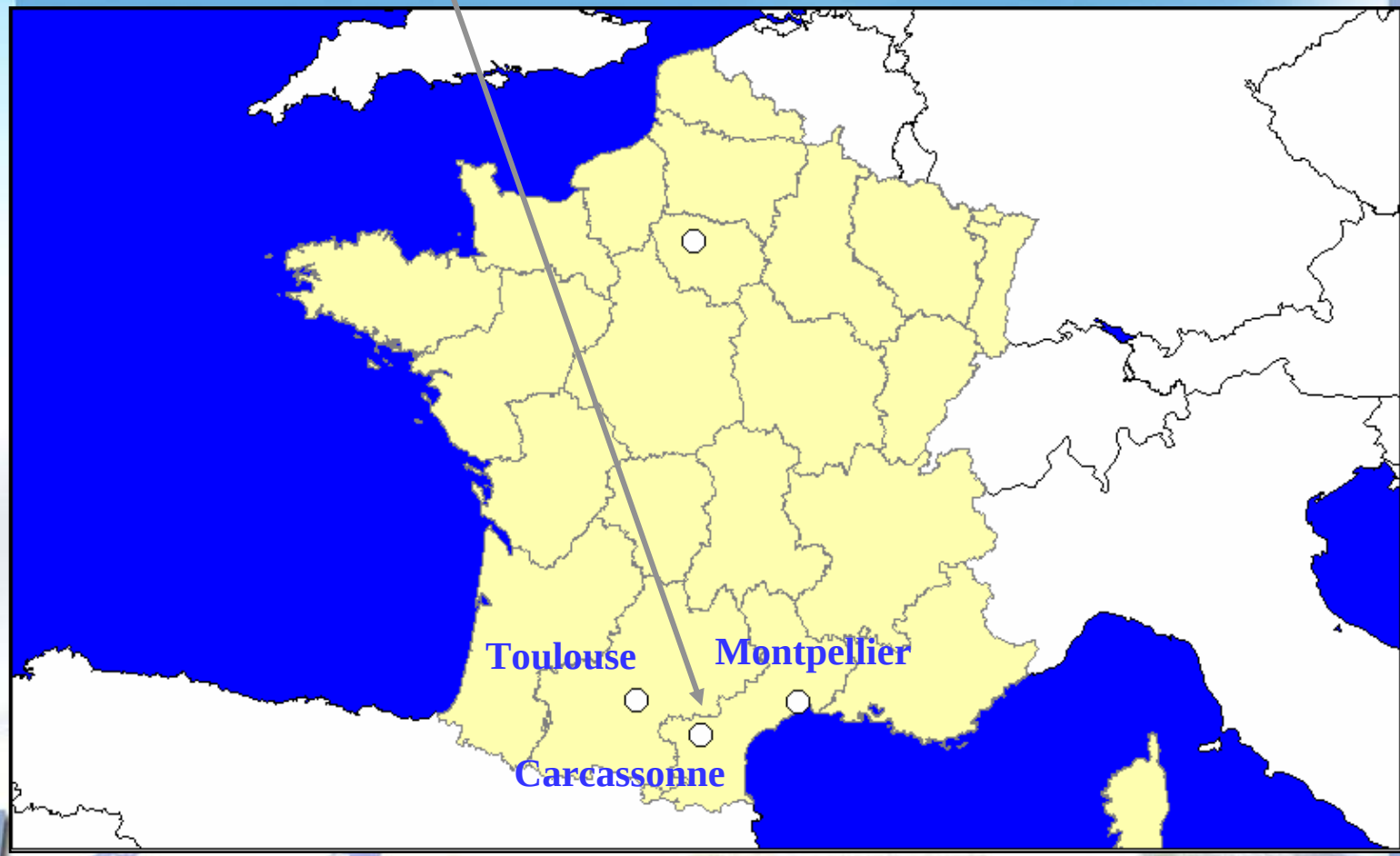
NATO CCMS Pilot Study 'Mega-Sites'

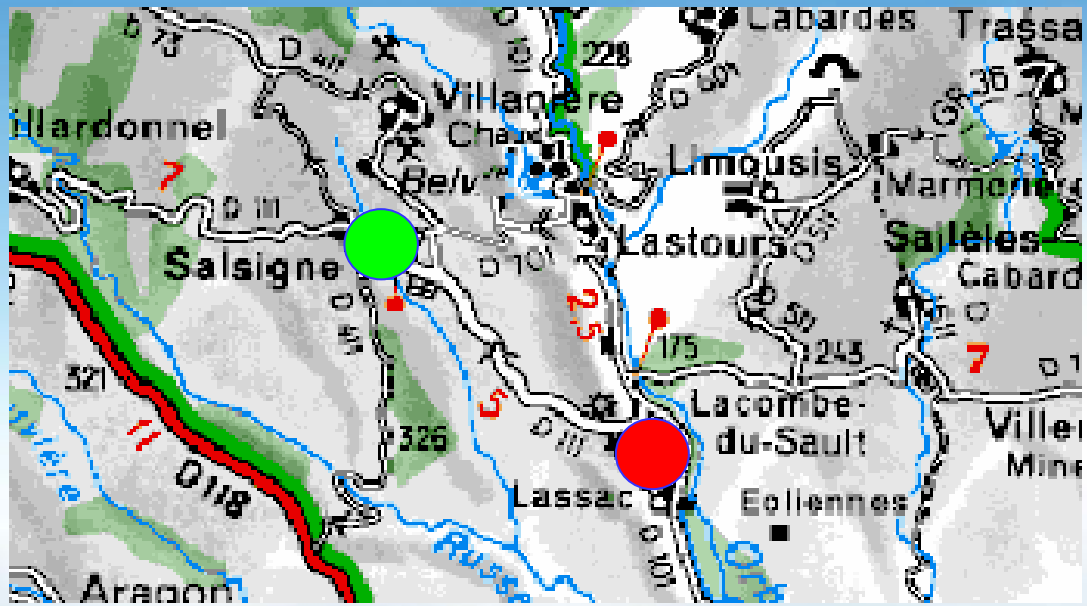
Scope of the presentation

- Introduction
  - Presentation of the site and the context
  - Historical background
  - Environmental context
  - Conceptual model
- Work done (1999 – 2004)
- Remediation project
  - Financial stakes ?
  - Why Phytostabilisation and how ?
- Conclusion

Salsigne – La Combe du Saut

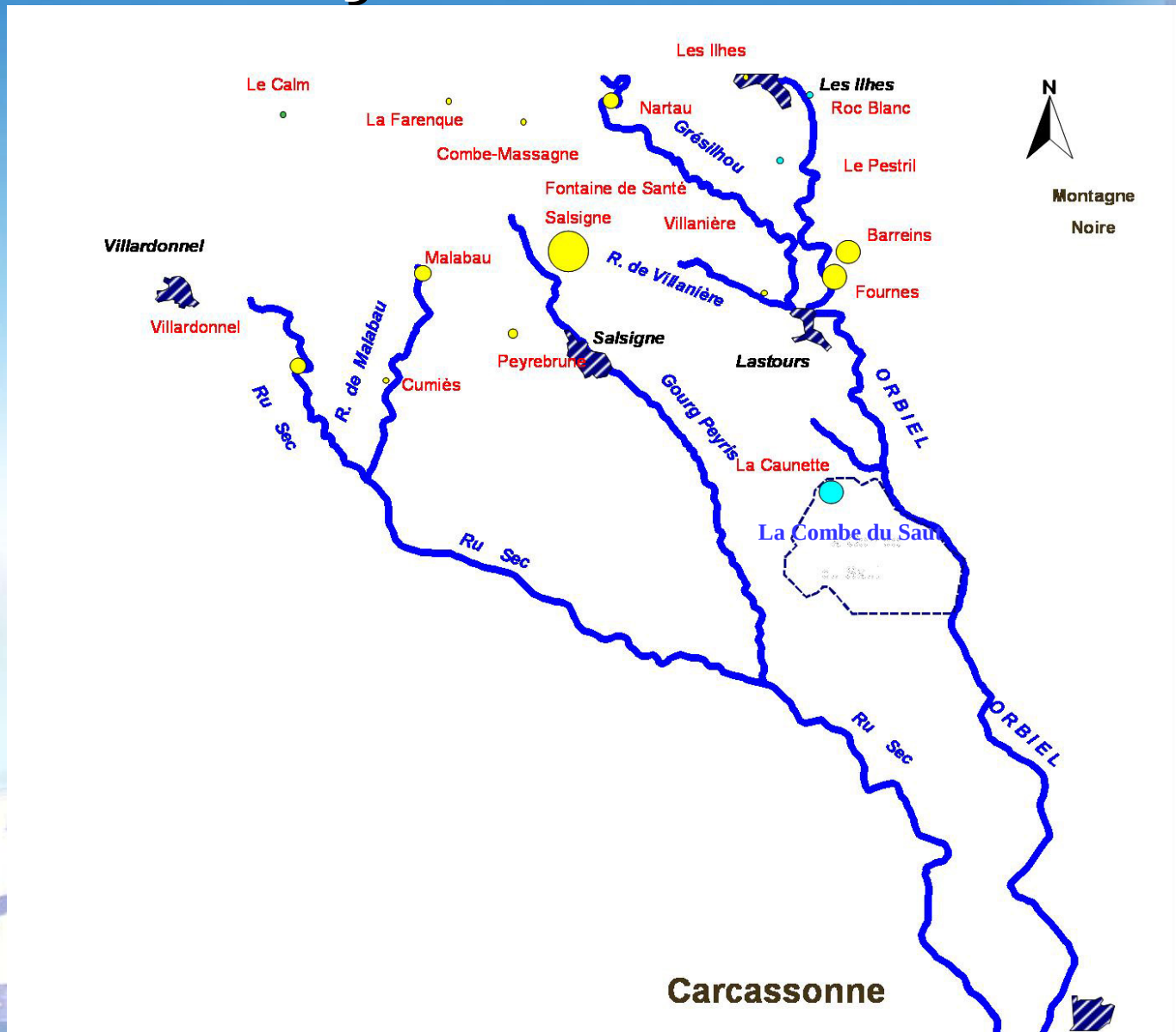


La montagne Noire



Carcassonne

Orbiel Valley : former mines



Geology

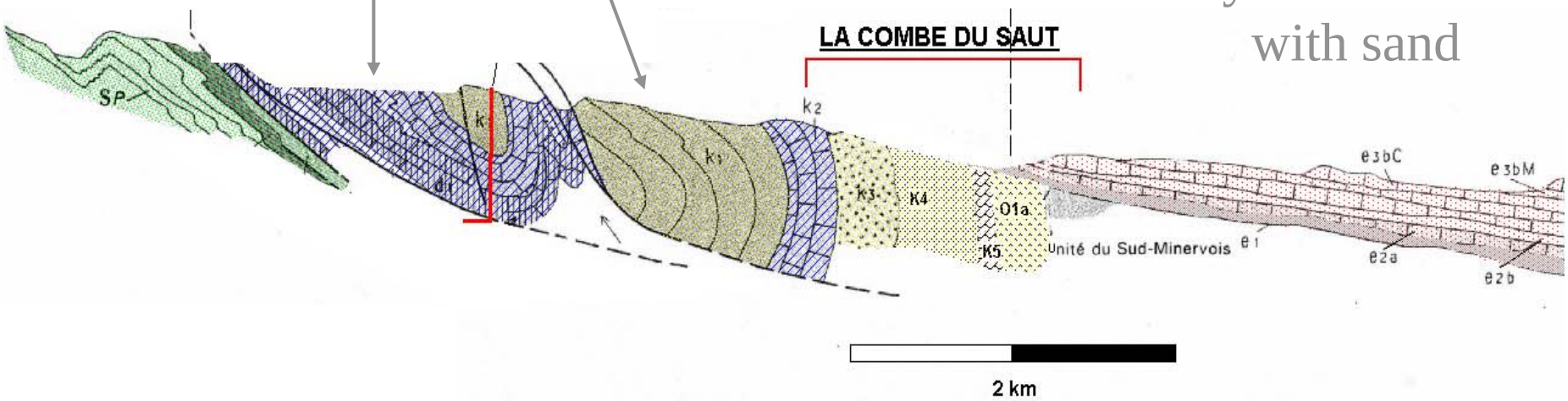
North

South

Limestone

Gres and shists

Clay and limestone with sand



Production during XXth Century

- Pyrometallurgy and cyanuration
- 15 million tonnes of ore
- 110 tonnes of gold

Period	Arsenic trioxyde (tons/year)
From 1924 to 1927	150 to 900
From 1928 to 1938	3000 to 6000
From 1939 to 1954	1000 to 10 000
From 1955 to 1960	6000 to 7000
From 1961 to 1992	10 000 (in 1990)
TOTAL	200 000

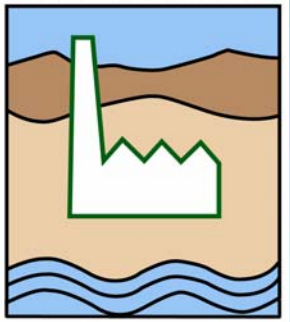
Mission of ADEME

1998 : 30 million of euros

- **June 1999 :** Monitoring
  Waste management
  Demolition
  Studies

- **March 2004 :** Remediation project
  Monitoring plan

DIFPOLMINE



Diffuse Pollution from Mining Activities

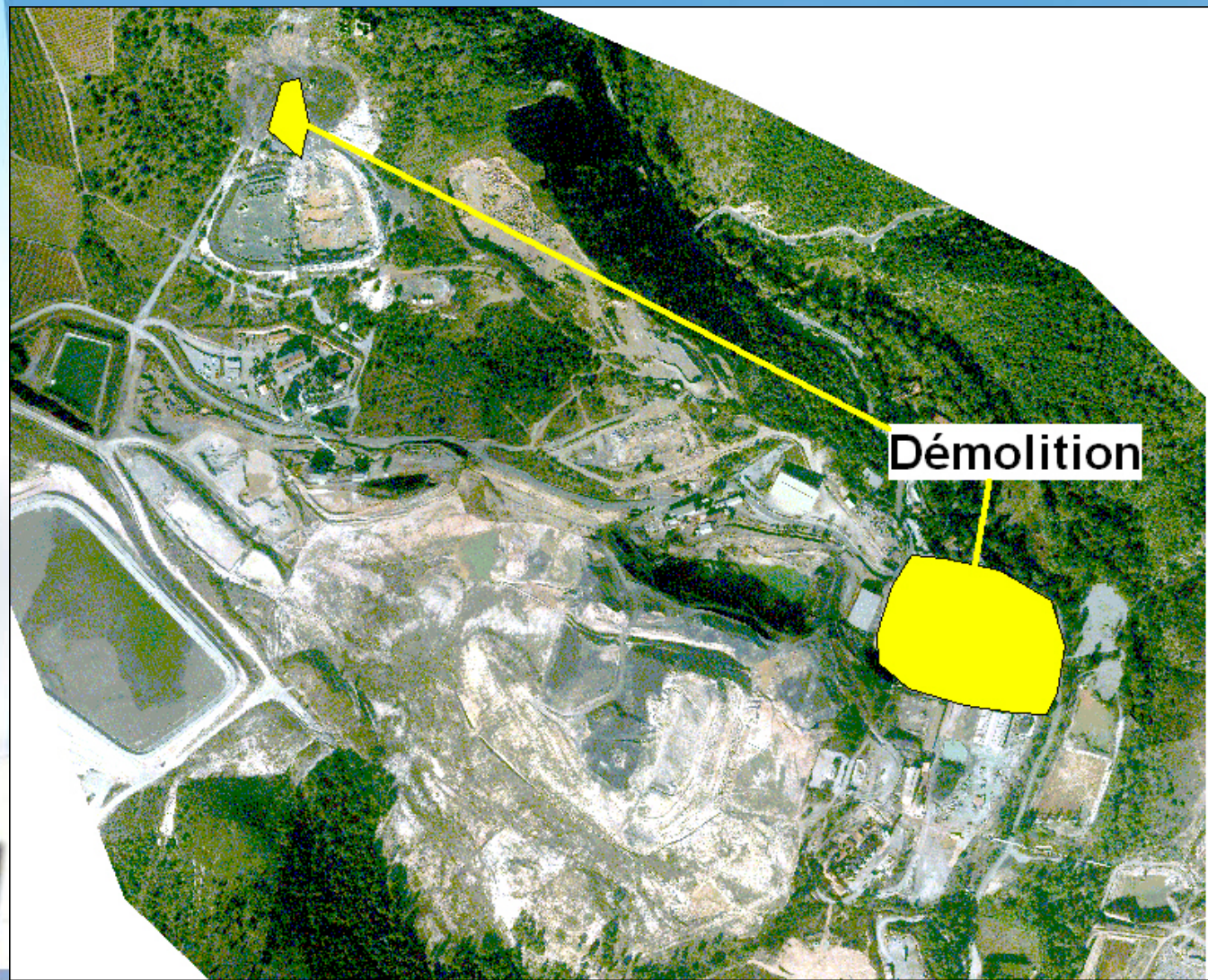
Difpolmine demonstration project

- Life Environment 2002
- Water management and phytostabilisation
- www.ademe.fr/difpolmine
  - IRH Environment
  - Limburg University
  - Budapest University
  - Water Agency RMC

1999

Waste management

Demolition

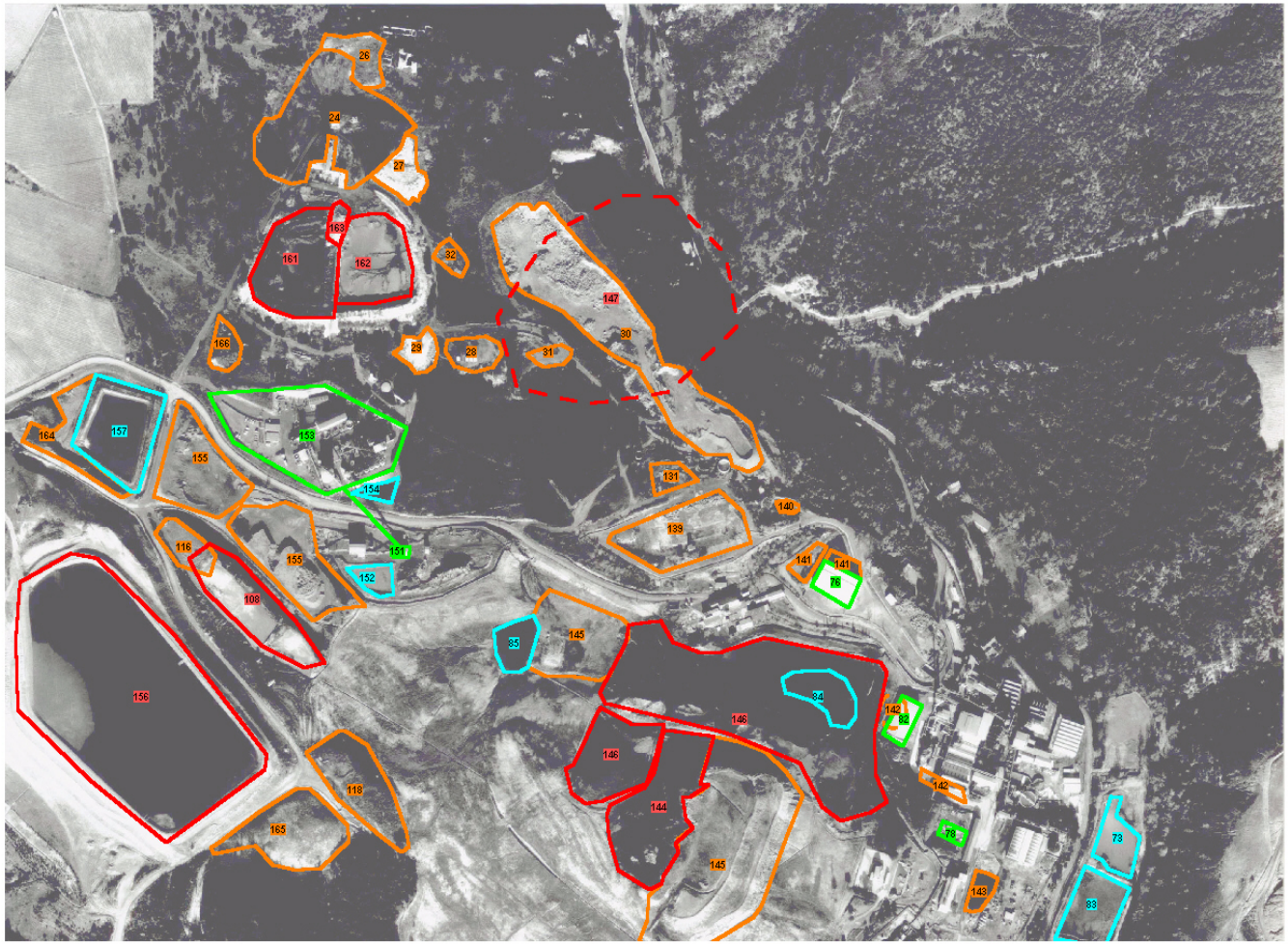


Demolition

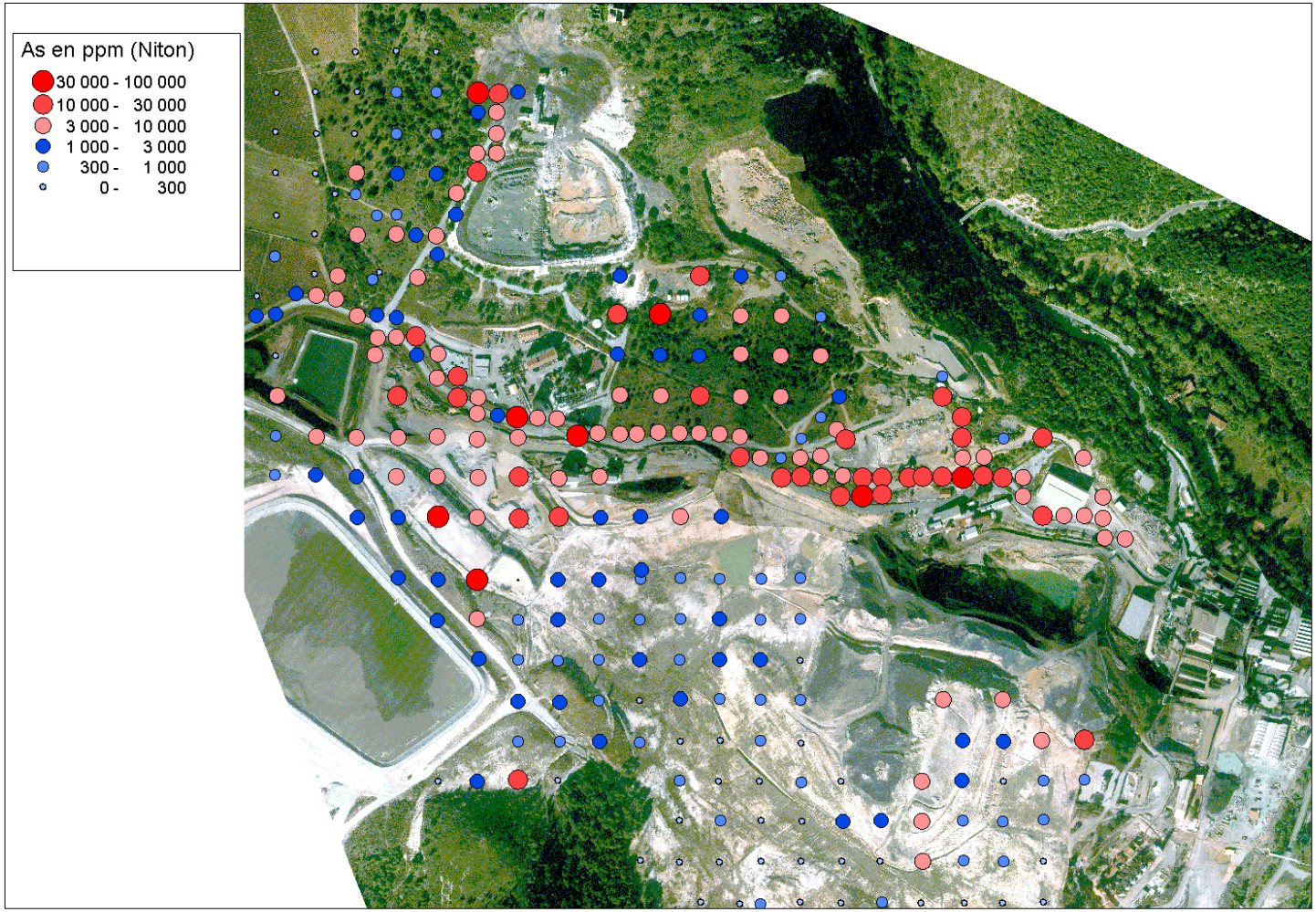
Watertight area

Watertight area

Source characterisation



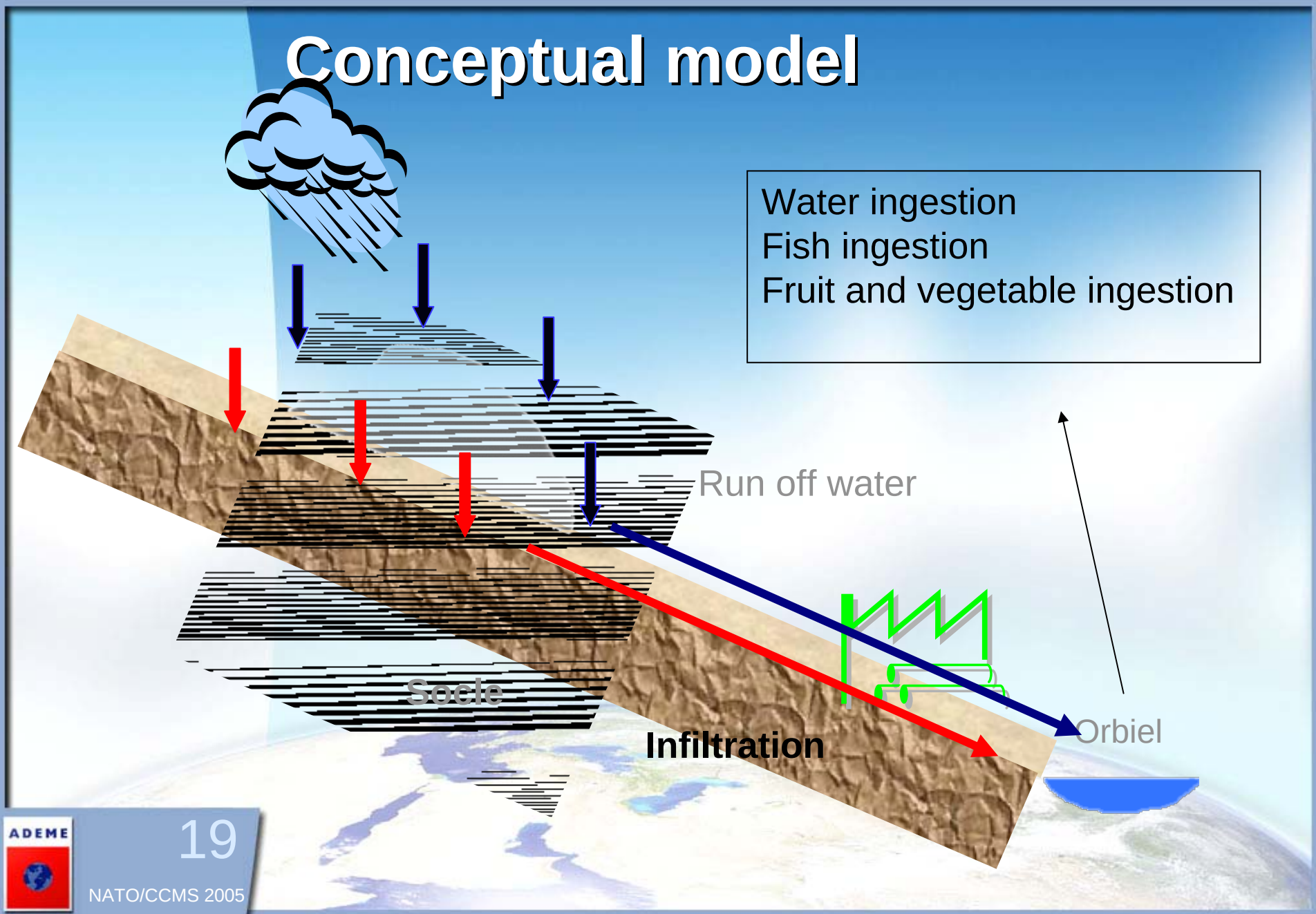
Arsenic soil concentration



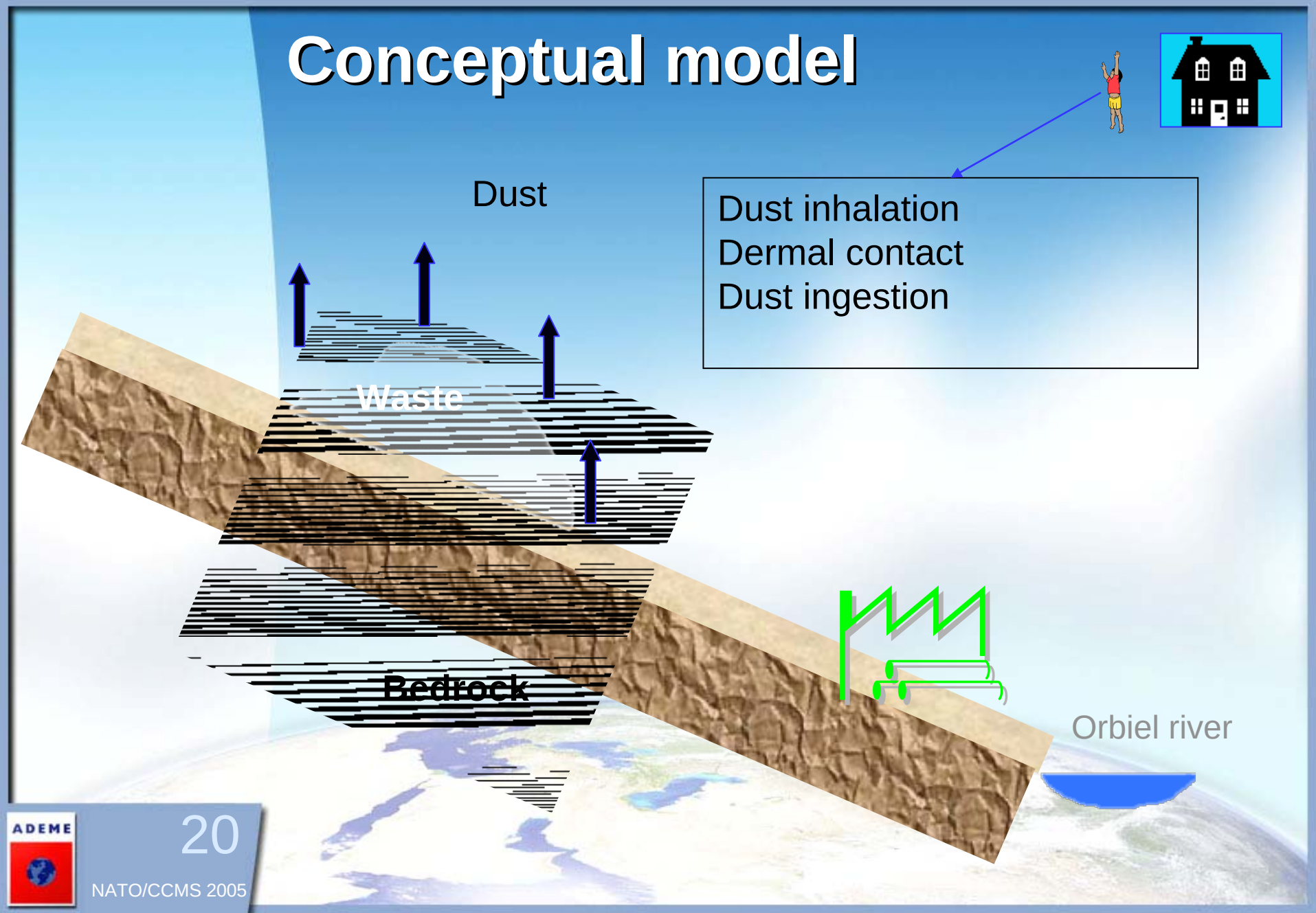
Sources

- 2,4 million m^3 of waste and polluted soil
- 53 hectares

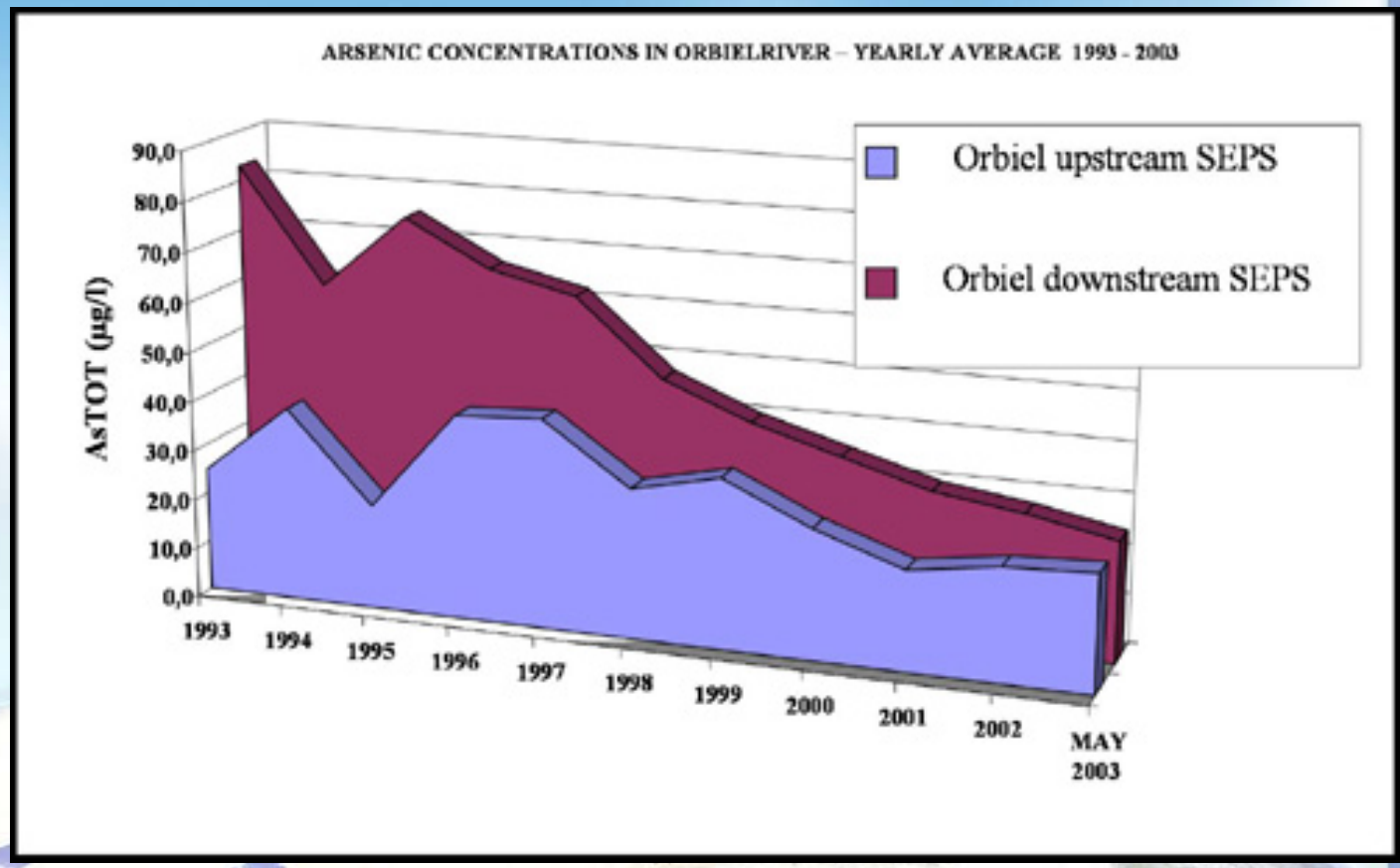
Conceptual model



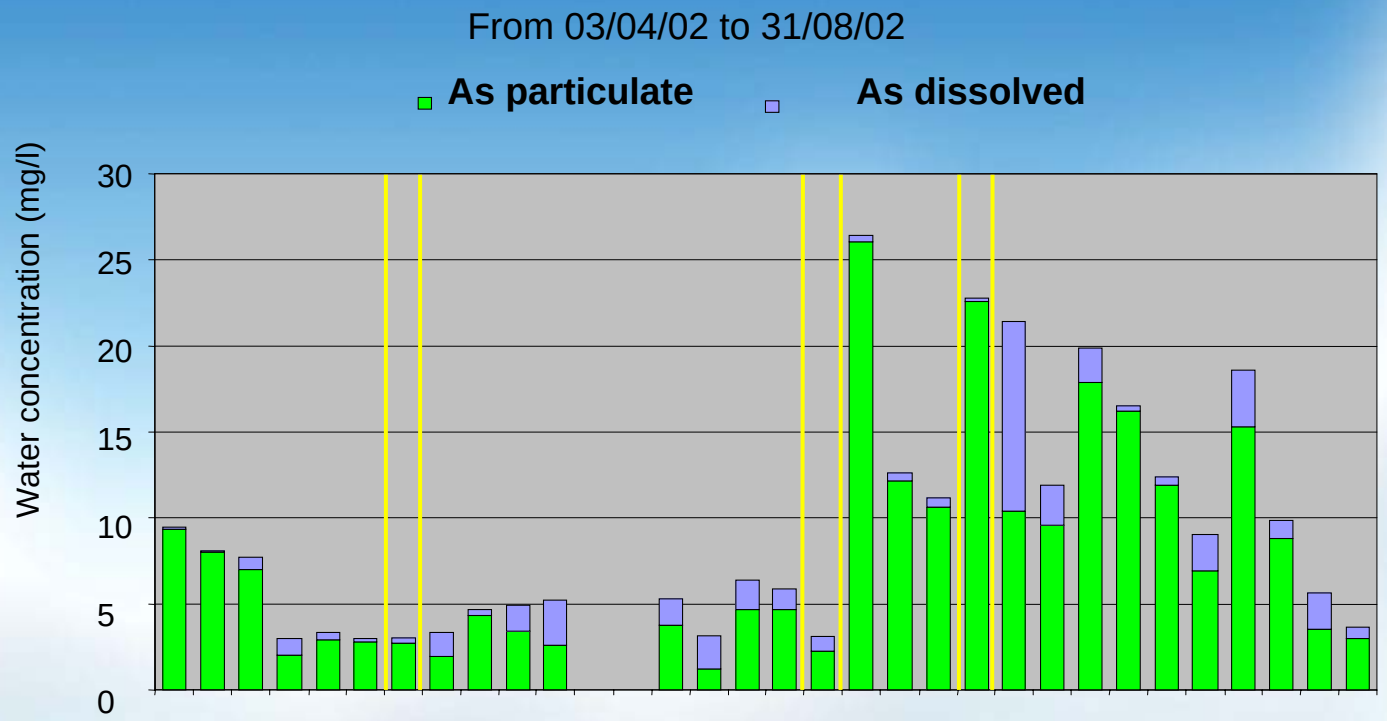
Conceptual model



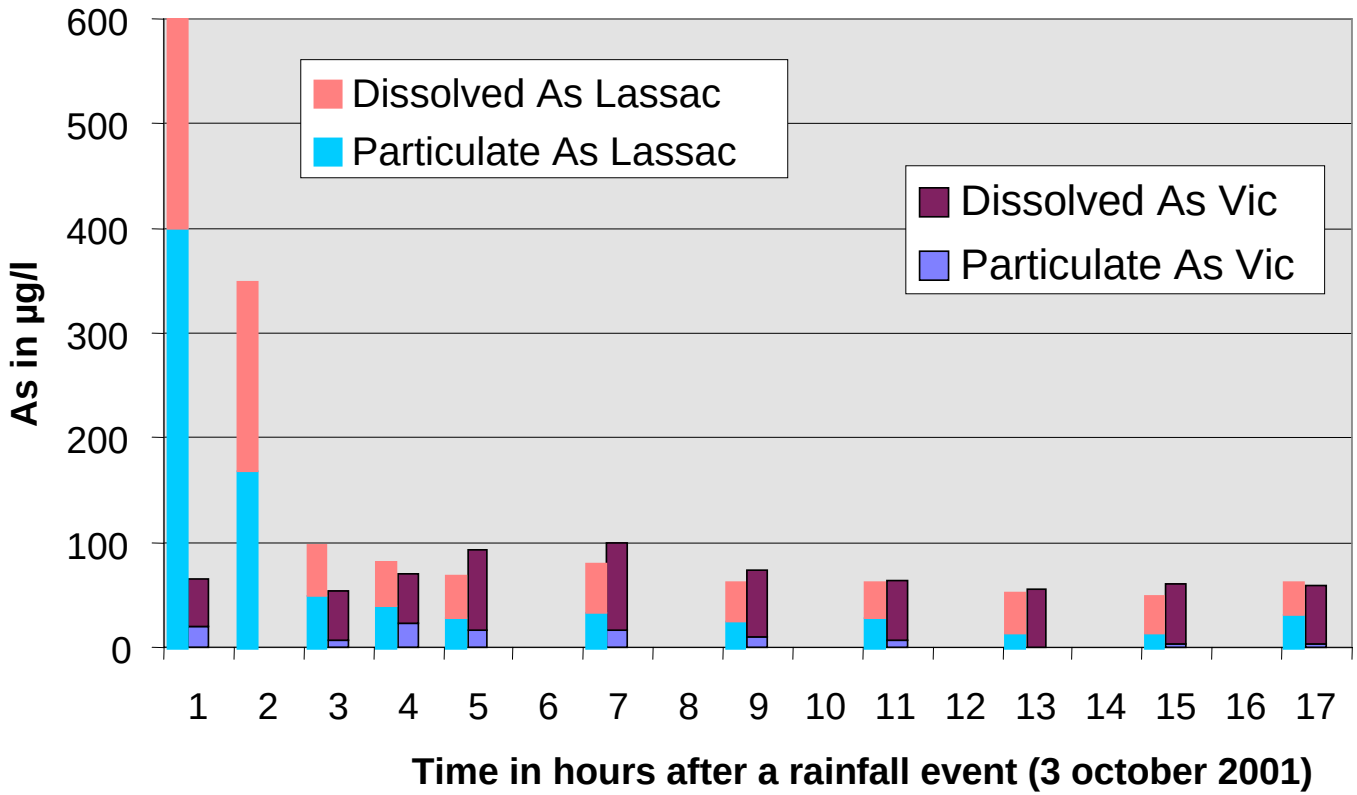
Yearly average As concentration in the river Orbiel



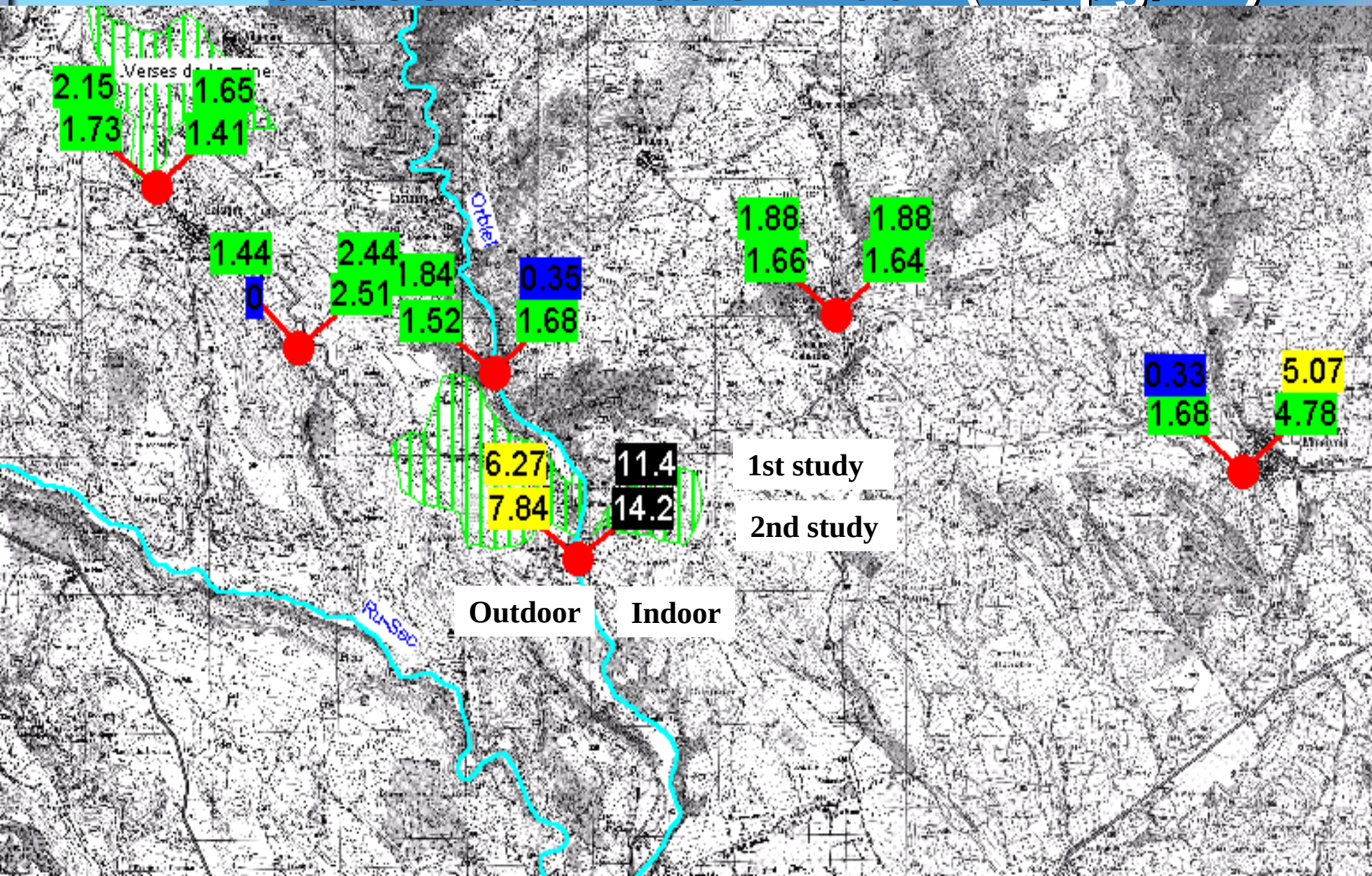
Run off water



Pollution peak in the river



Dust contamination 2001 (As µg/m^3)



Risk assessment

Carcinogenic effects

	Oral route			Breathing route		
Risk	Resident	Farmer	Fisherman	Resident	Farmer	Fisherman
Adult	1,7.10-3	2,4.10-3	2,1.10-3	2,5.10-3	3,6.10-3	3,3.10-3
Children	3,3.10-3	3,4.10-3	3,6.10-3	1,9.10-3	1,9.10-3	1,9.10-3

Noncarcinogenic effects

	Breathing route : toxic total			Breathing route : nervous system		
Hazard index	Resident	Farmer	Fisherman	Resident	Farmer	Fisherman
Adult	1,74	2,25	2,14	5,28	6,74	6,42
Children	2,17	2,17	2,17	6,55	6,55	6,55

Salsigne – La Combe du Saut

1999 / 2005

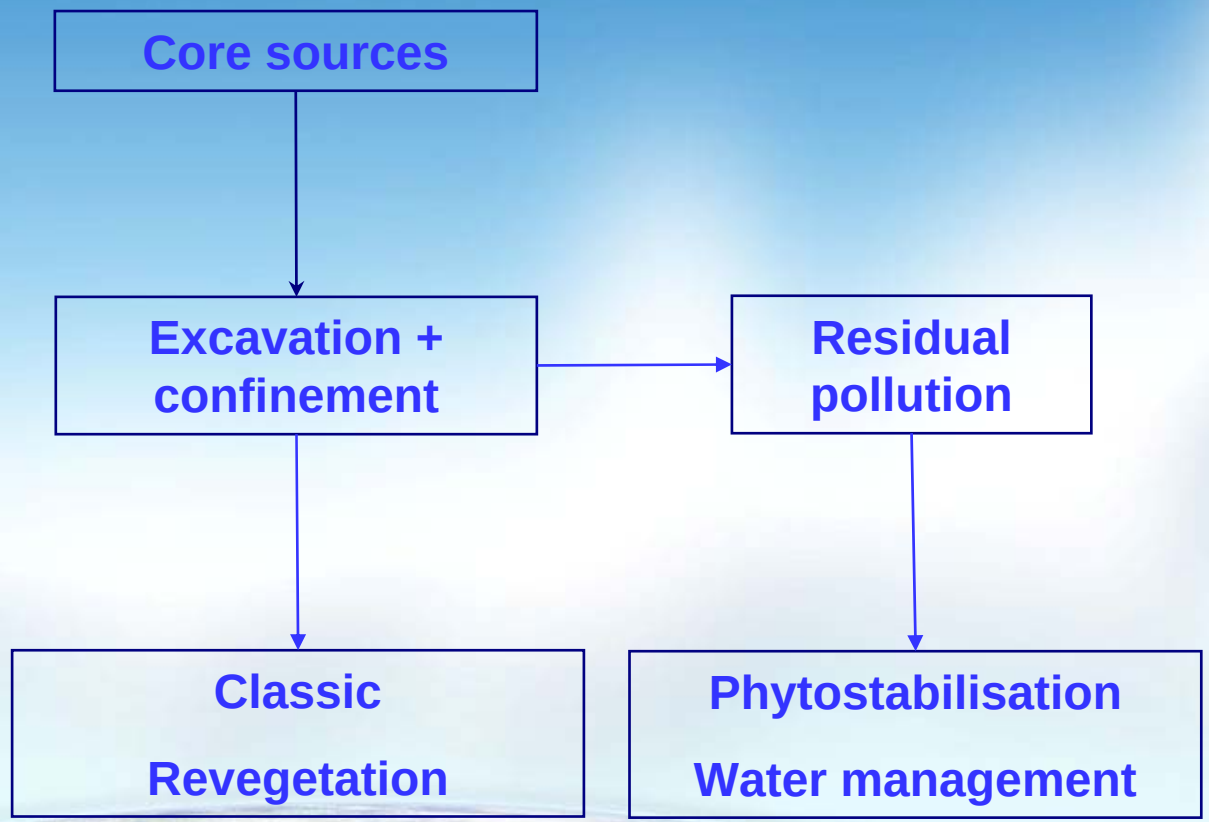
Total cost : work done between 1999 and 2004 (millions of euros)

Operation	Cost
Monitoring and water treatment :	3.5
Waste management :	3.0
Demolition :	3.5
Watertight area :	1.0
Studies and prime constructor :	1.5
Total Cost :	12.5

Evaluation of total cost / quantity of polluted soil with conventional techniques (Million of euros)

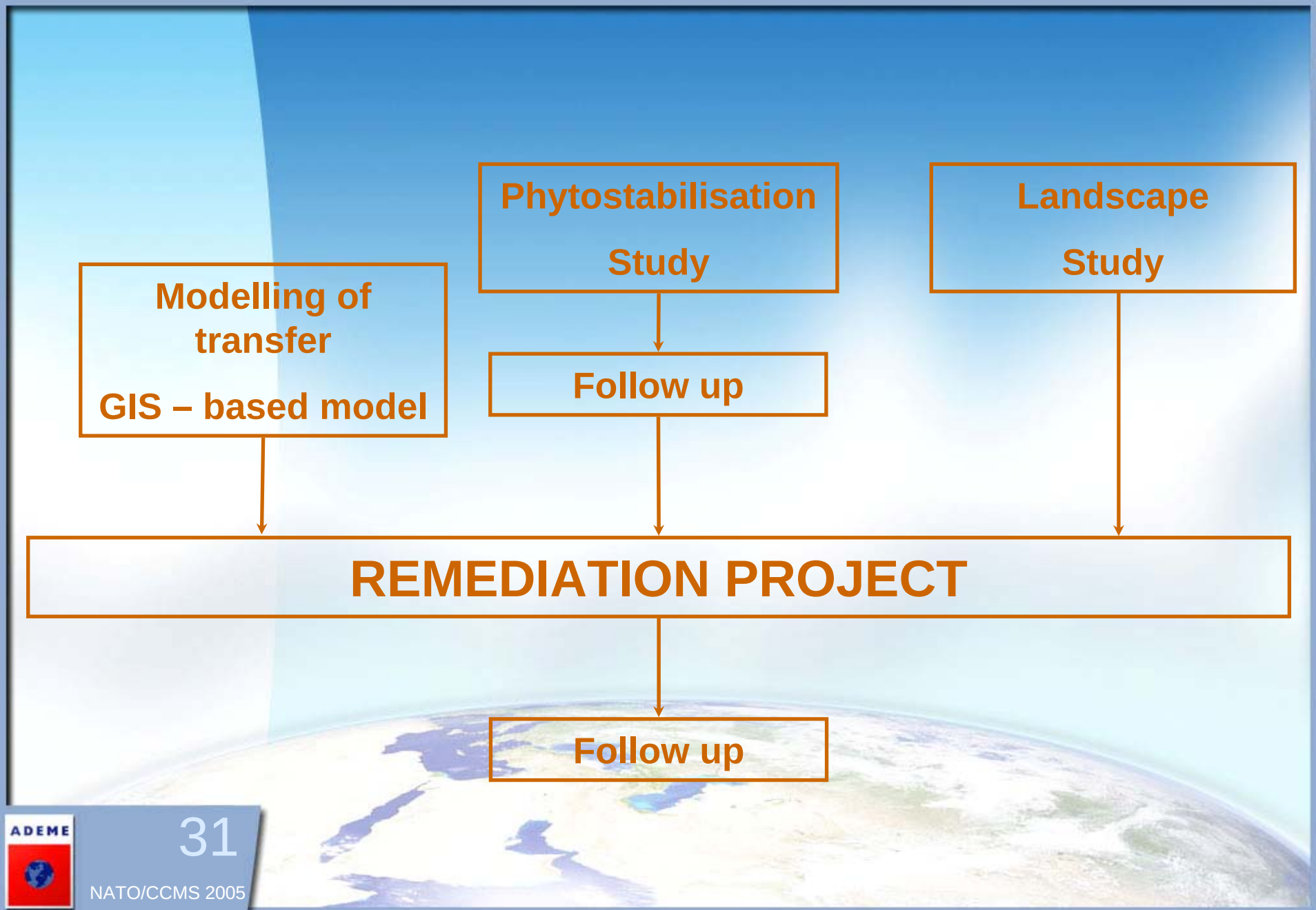
Type of treatment	euro/m3	500 000 m3
Excavation	3	1,5
Confinement Min	15	7,5
Confinement Max	30	15
Stabilisation	300	150
Landfilling (stabilisation)	500	250

Remediation project

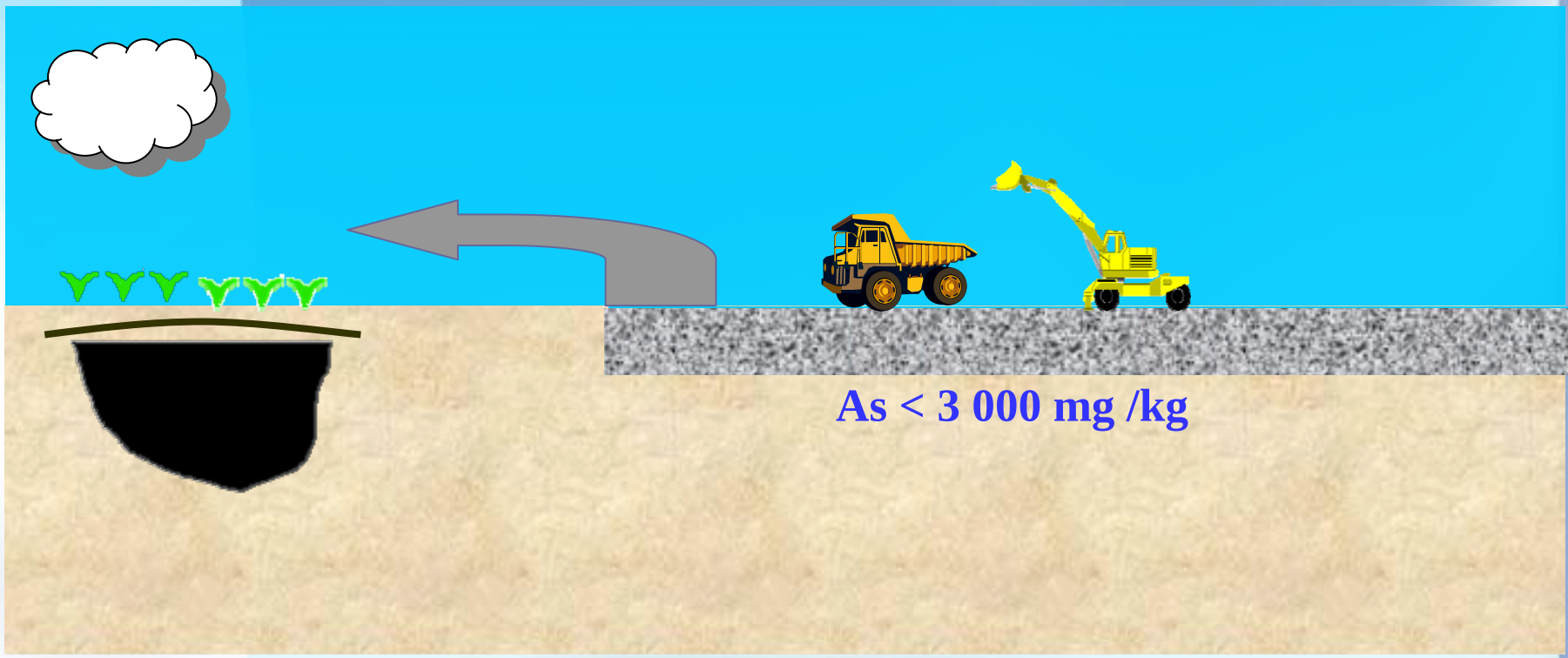


Comparison between confinement and phytostabilisation

	Confinement		Phytostabilisation	
	Efficiency	Limiting factors	Efficiency	Limiting factors
Contact with the soil	+++	Soil use restriction Long-term monitoring	-	Soil use restriction Long-term monitoring
Dust emission	++		- /+	
Water concentration	++		- /+	
Cost / m^2 / 20 cm depth	- /+ (6 euros)		+++ (2 euros)	


Phytostabilisation Study
Landscape Study
Modelling of transfer
GIS – based model
Follow up
REMEDIATION PROJECT
Follow up

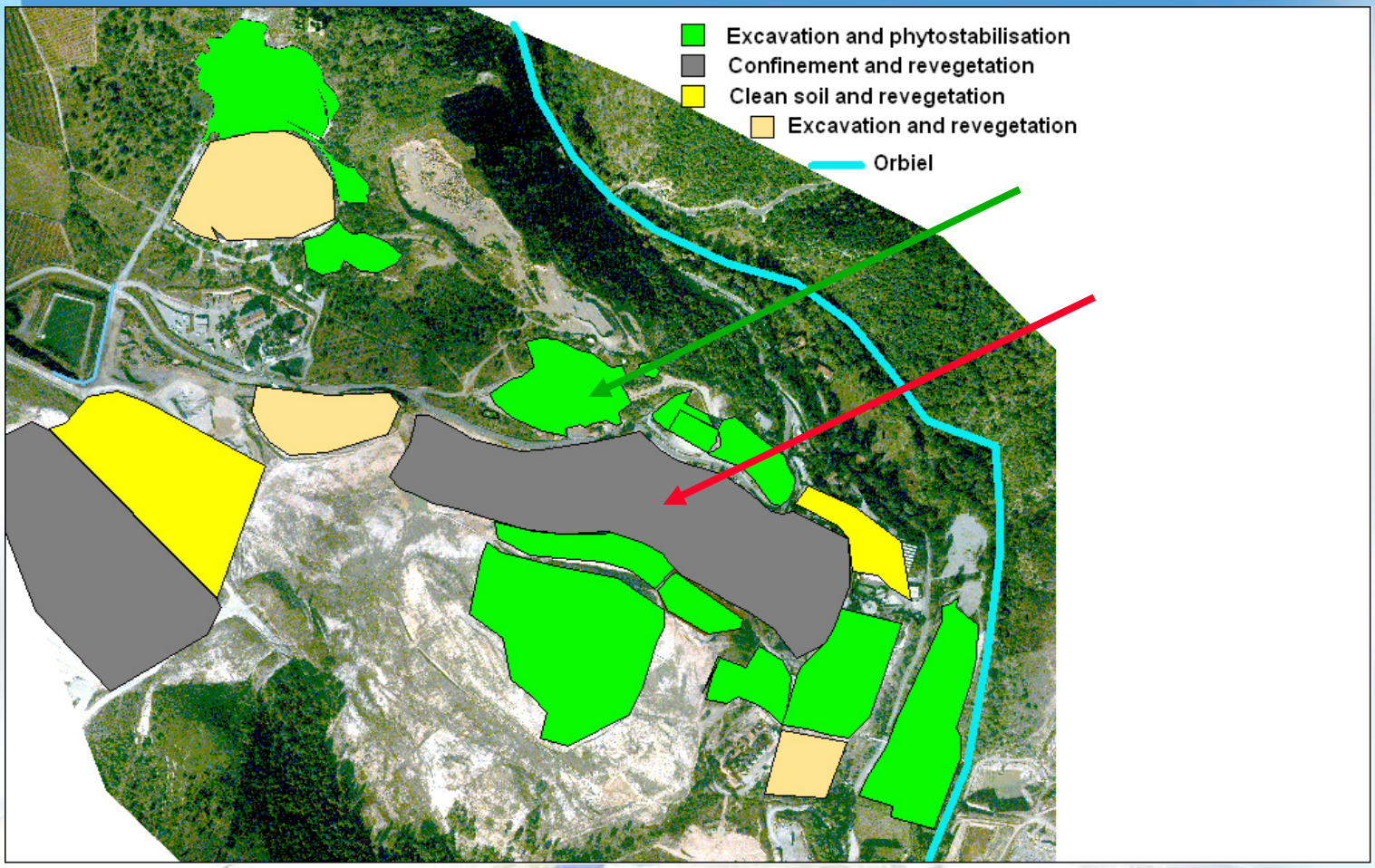
1. Excavation



Confinement area

2. Phytostabilisation

Remediation programme



Remediation programme (million of euros)

Operation	Cost
Excavation and transportation of waste and soil into the confinement area	2,5
Stabilisation of waste	1
Protection with a geomembrane (110 000 m^2)	4
Water management systems	1,5
Phytostabilisation	0,5
Prime constructor	1
Monitoring and water treatment	1
Other	1
TOTAL	12,5

	2005			2006			
	TR2	TR3	TR4	TR1	TR2	TR3	TR4
Excavation	■	■					
Call for tender (Phase 2)	■	■					
Capping			■	■	■		
Phytostabilisation					■	■	

Phytostabilisation (Difpolmine)

Laboratory experiments

Selection of seed mixture

↓

Field plots 100 m^2

↓

Large scale phytostabilisation

20 ha

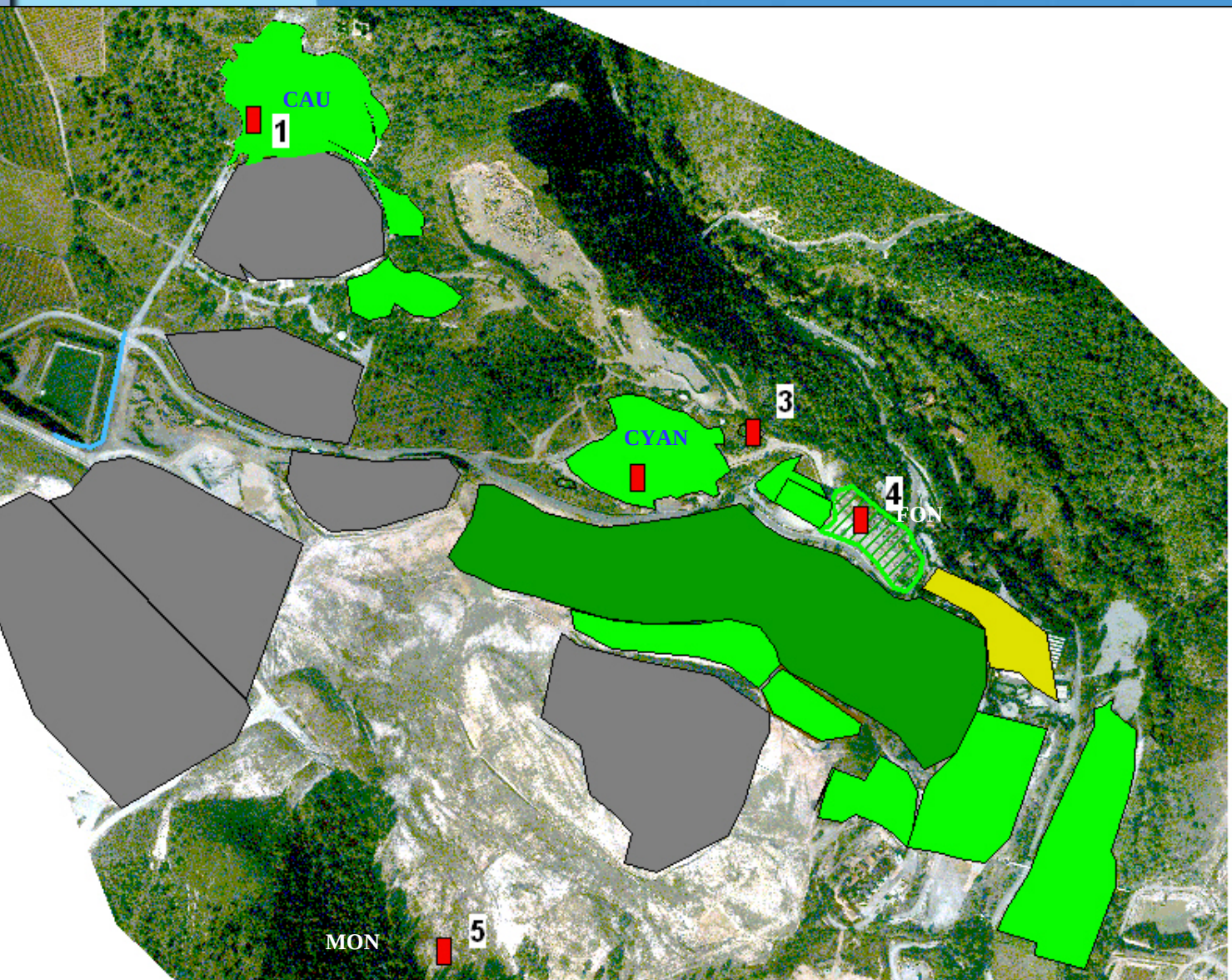
Laboratory experiments

Location	Steel shots addition	Water soluble As (mg/kg DM)	% reduction
Control		<0.25	
Caunette	no	584 ± 112	
	yes	360 ± 44	39%
Cyanuration	no	1.6 ± 0.1	
	yes	0.29 ± 0.07	82%
Cyanuration2	no	7.1 ± 0.3	
	yes	4.5 ± 0.4	36%
Fonde	no	17.6 ± 0.4	
	yes	3.6 ± 0.6	79%
Monitoring	no	8.3 ± 0.2	
	yes	0.4 ± 0.1	95%

Laboratory experiments

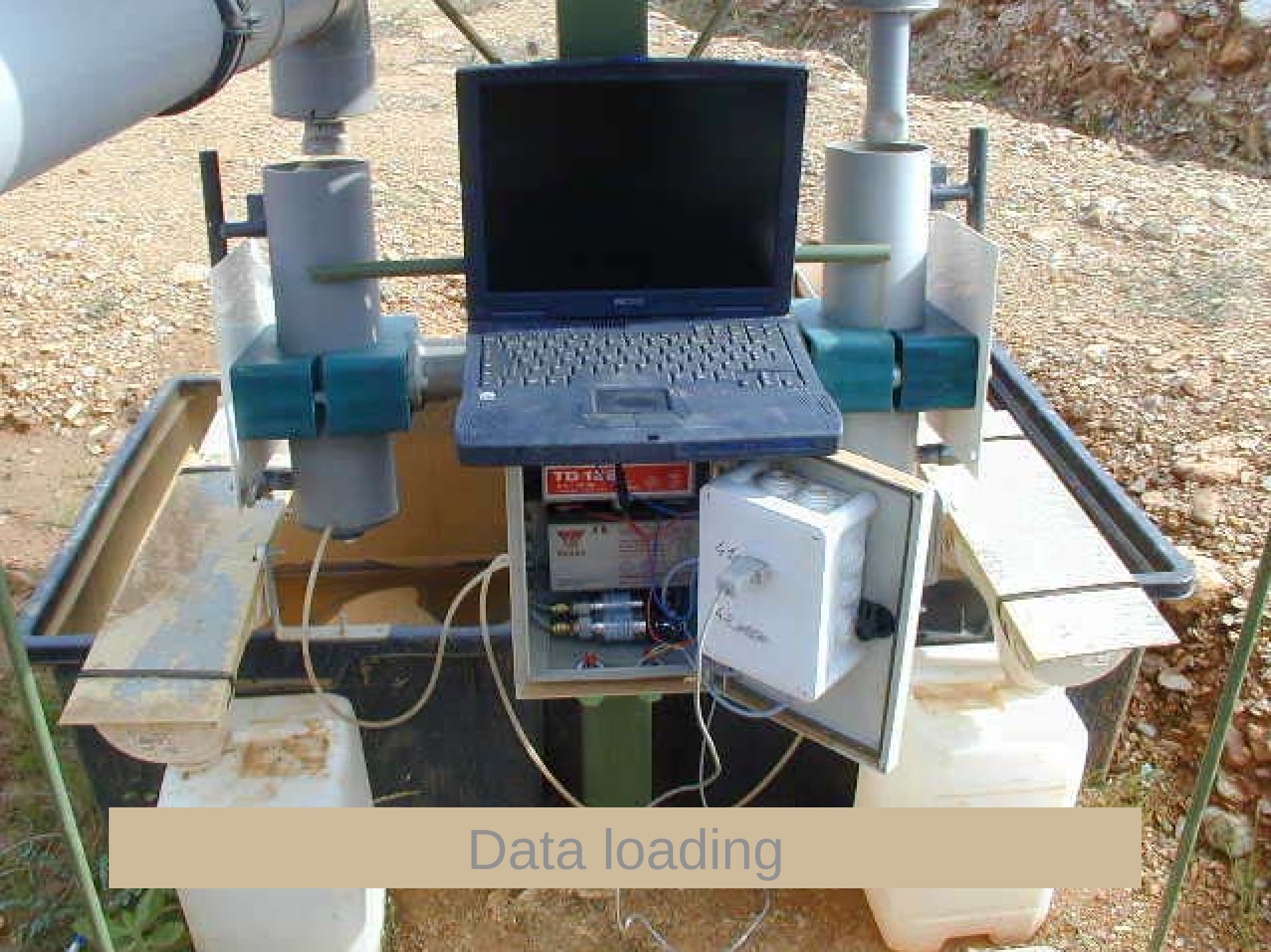
	Subplot 4.1 (untreated)	Subplot 4.2 (steel shots+seed mixture)
Total As (*aqua regia*) (mg kg DW -1)	**815**	
Water Soluble As (mg kg DW -1)	**17.6 ± 0.4**	**3.6 ± 0.6**
Biomass aerial parts bean plants (g/plant) (control value=1.18 ±0.24)	**0.76 ±0.16**	**1.13 ±0.35**
Root weight bean plants (g/plant) (control value=1.03 ±0.20)	**0.3 ±0.1**	**0.93 ±0.43**
GPOD capacity in leaves (mU g FW-1) (control value=708 ±39)	**1084 ±334**	**803 ±244**
GPOD capacity in roots (mU g FW-1) (control value=4050 ±728)	**8195 ±1714**	**4644 ±841**

Location of the field plots



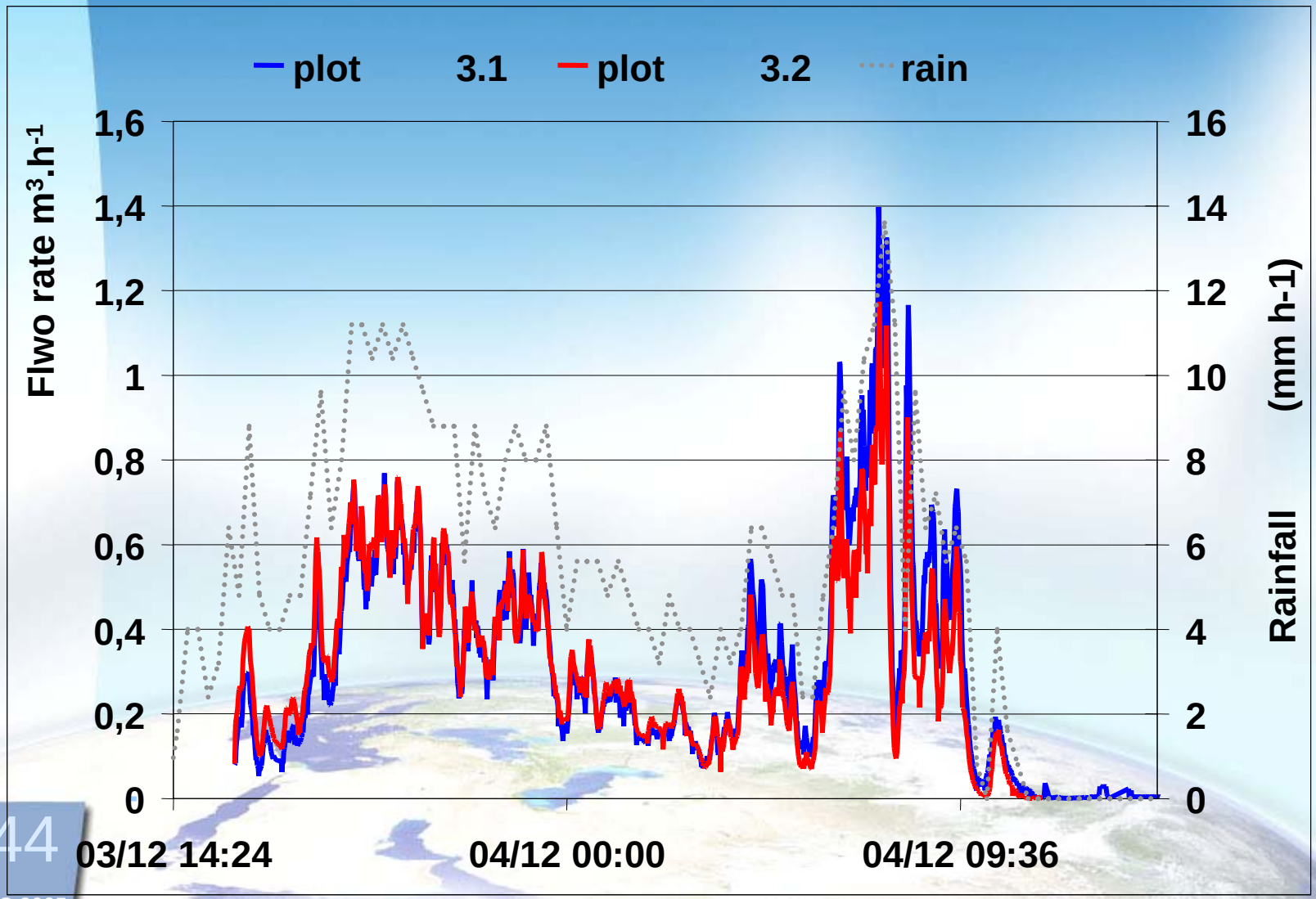
Phytostabilisation field plots

Water monitoring system

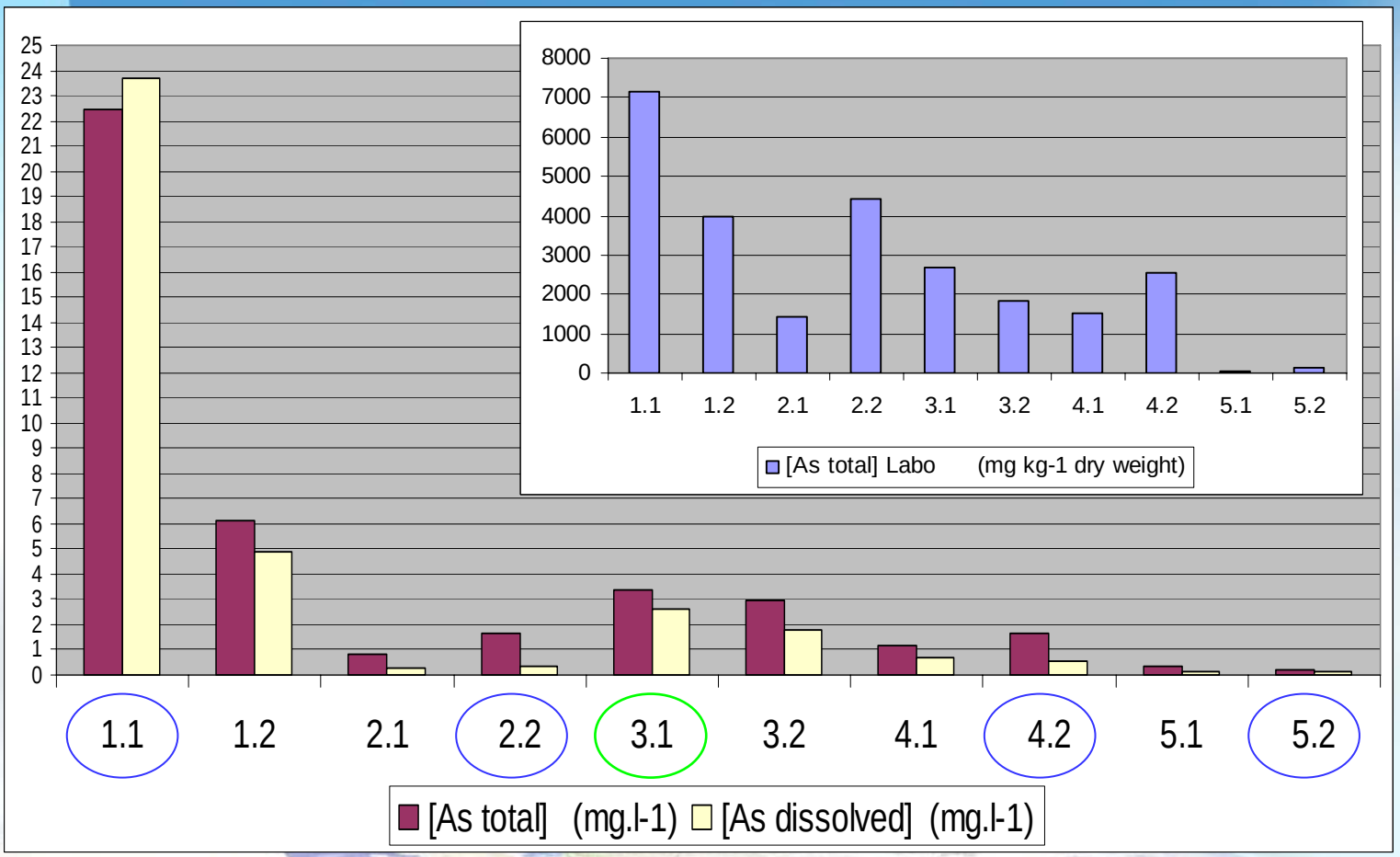


Data loading

Follow up of the waterflow



Follow up of As concentration in water



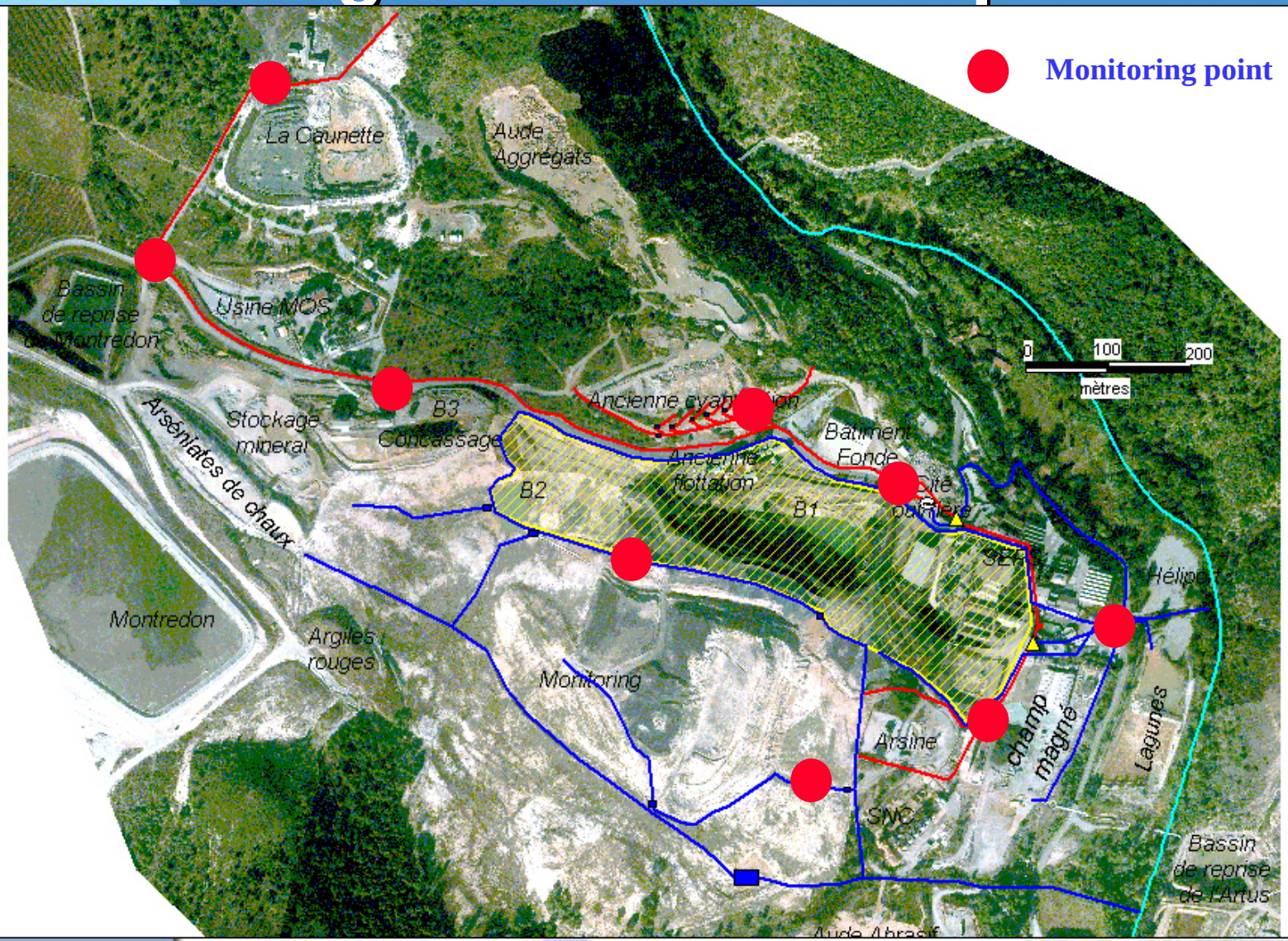
Steel shots + seed mixture

Seed mixture only

Field plots 4 in April 2005

Field plots 1 in April 2005

Large scale follow up



Conclusion

- Large metal polluted site remediation is very costly
- Cost effective technique like phytostabilisation have to be evaluated

La Combe du Saut :

- Laboratory experiments : positive results
- Field plots : operational water follow up system
- Future work : large scale phytostabilisation follow up

Thank you for your attention

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