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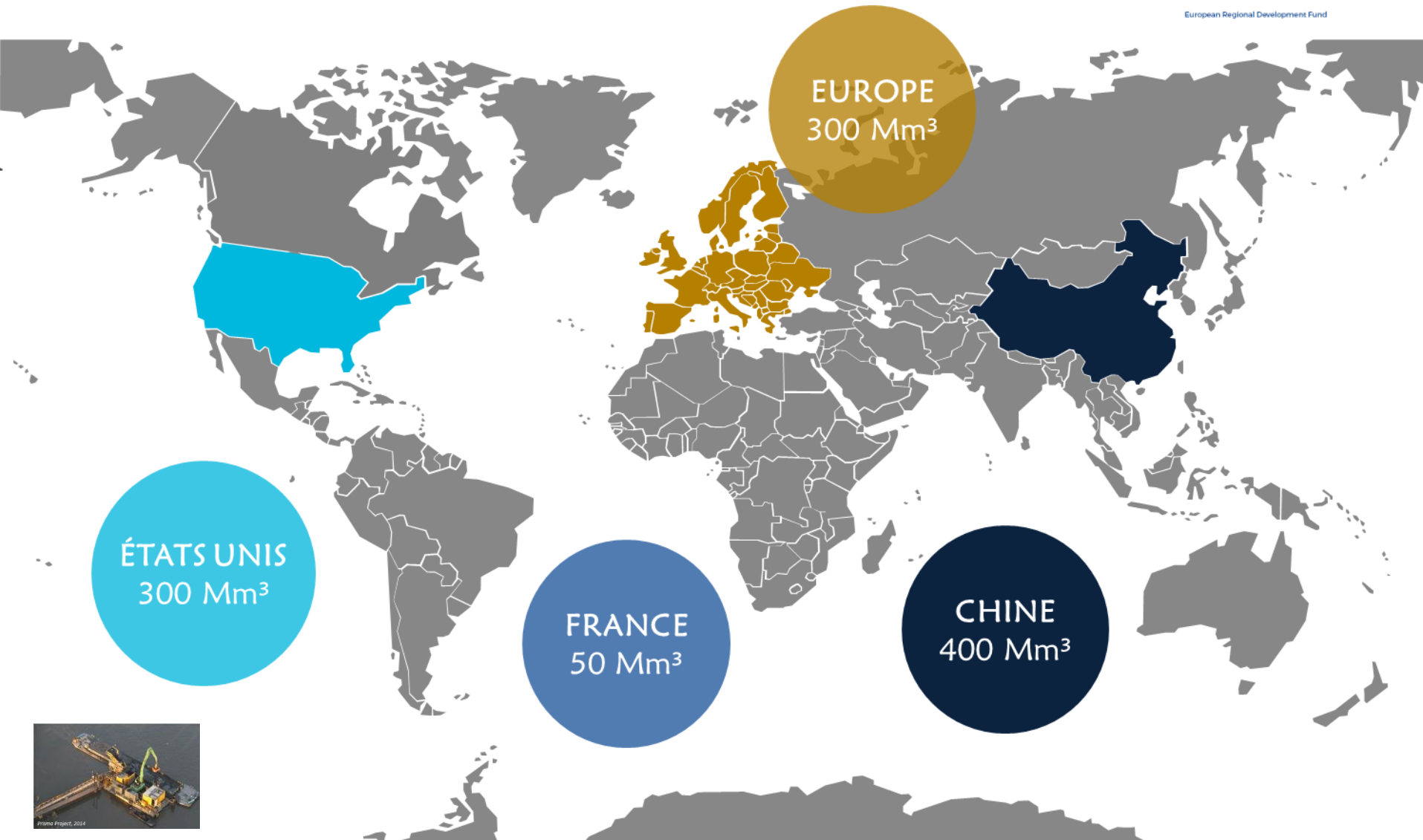
Using Sediment As a Resource

WikiSed & Operational Sediment Management System “OSMS”

October 13 & 14, 2020

A. ZERAOUI, M. BENZERZOUR, N-E. ABRIAK, W. MAHERZI & R. MANSI

Using sediment as a resource



Context

In France, dredging operations generate more than 50 Mm³ of sediment per year.

Dredged sediments



Consequences

- *Siltation of waterways*
- *Flood risk*
- *Environmental issues*
- *Economic issues*

Sediments management

Immersion

Storage

*Saturation of storage centers
Possible treatment before storage*

Need to find alternatives that are part of a sustainable sediment management approach



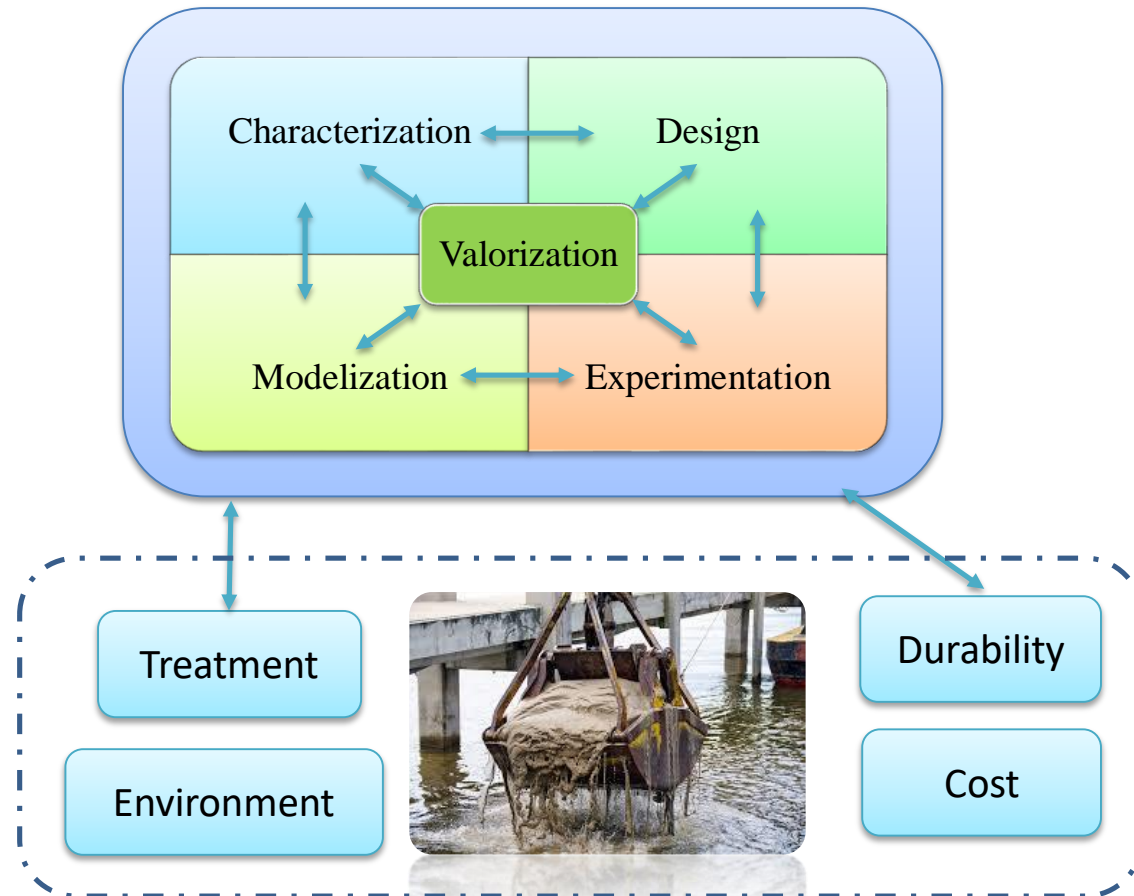
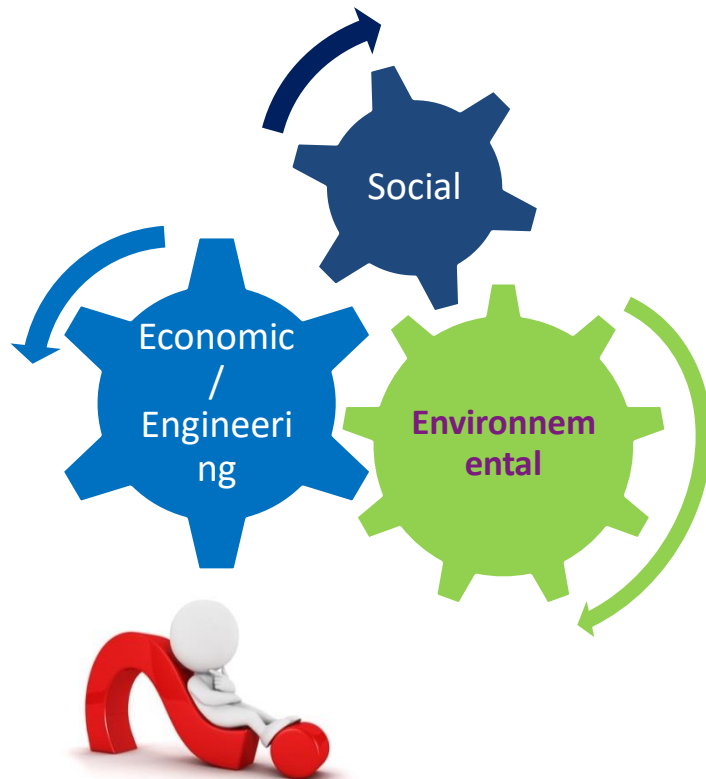
Valorization

*Which field?
How?
Technical feasibility?
Environmental acceptability?
cost?*

➔ **USAR** Projet (**U**sing **S**ediment **A**s a **R**esource) : Promote the use of sediment, namely in civil engineering

Using sediment as a resource

Complex decision
multi parameters





Inventory catalog

WikiSed

Software



Help users
and
decision
makers

OSMS

Web Link : <http://wikised.phenixmat.com/>

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- ALL DOCUMENTS
- PROJECT AND STRUCTURE
- PARAMETERS AND CHARACTERISTICS
- REGULATIONS
- ACADEMIC RESEARCH
- ECONOMIC ASPECT

The document list in the center shows the following entries:

Year	Author	Title	Icon
2013	REGINALD	REVIEW OF THE MECHANICAL AND LEACHING PERFORMANCE OF STABILIZED/ SOLIDIFIED CONTAMINATED SOILS	
2016	WILLIAM COULET, WILL MANNING HUGO EKKELENKA	BENEFICIAL REUSE OF DREDGED MATERIAL IN A BREAKWATER OF GEOTEXTILE BAGS	
2000	ROLAND B	RAGAGE ET REJET EN MER	
2009	TRAN NGO	ALORISATION DE SEDIMENTS MARINS ET FLUVIAUX EN TECHNIQUE ROUTIERE	
1999	CLAUDE AL	RAGAGES ET ENVIRONNEMENT MARIN	
2004	CONSEIL DE	DREDGING PROTOCOL	
2002	STÉPHANE	GUIDE D'ÉCHANTILLONNAGE DES SÉDIMENTS DU SAINT-LAURENT POUR LES PROJETS DE DRAGAGE ET DE GÉNIE MARITIME VOLUME 2 : MANUEL DU PRATICIEN DE TERRAIN	
2009	LIFE, EVIVO, AGENCE DE L'EAU	INVENTAIRE DÉTAILLÉ DES TECHNIQUES DE CURAGE, TRANSPORT, TRAITEMENT ET USAGES DES SÉDIMENTS	
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Year	Author	Title
2013	REGINALD B. KOGBARA	A REVIEW OF THE MECHANICAL AND LEACHING PERFORMANCE OF STABILIZED/ SOLIDIFIED C
2016	WILLIAM COULET, WILL MANNING HUGO EKKELENKAMP AND ELDERT BESSELING	BENEFICIAL REUSE OF DREDGED MATERIAL IN A BREAKWATER OF GEOTEXTILE BAGS
2000	ROLAND BOUTIN	DRAGAGE ET REJET EN MER
2009	TRAN NGOC THANH	VALORISATION DE SEDIMENTS MARINS ET FLUVIAUX EN TECHNIQUE ROUTIERE
1999	CLAUDE ALZIEU ET AL	DRAGAGES ET ENVIRONNEMENT MARIN
2004	CONSEIL DE DISTRICT DE CARRICK	DREDGING PROTOCOL

ALL DOCUMENTS

PROJECT AND STRUCTURE

PARAMETERS AND CHARACTERS

REGULATIONS

ACADEMIC RESEARCH

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Using Sediment As A Resource

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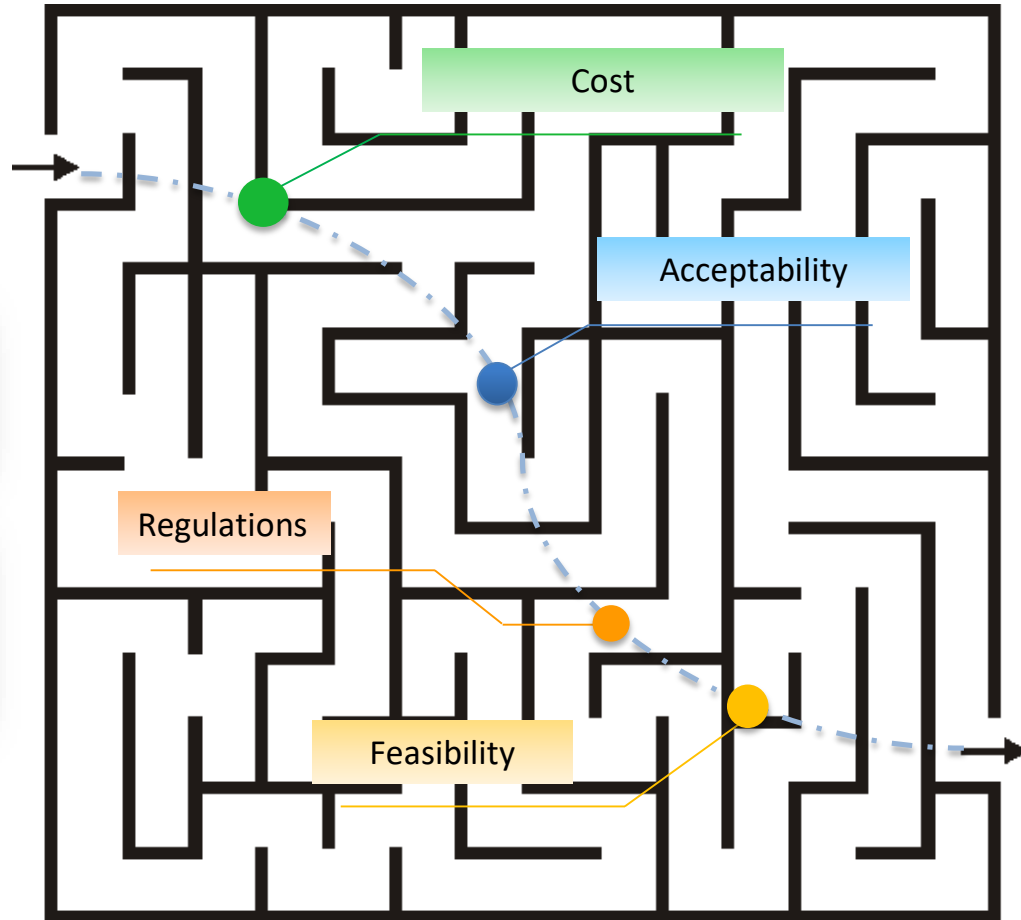
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Operational Sediment Management System (OSMS)

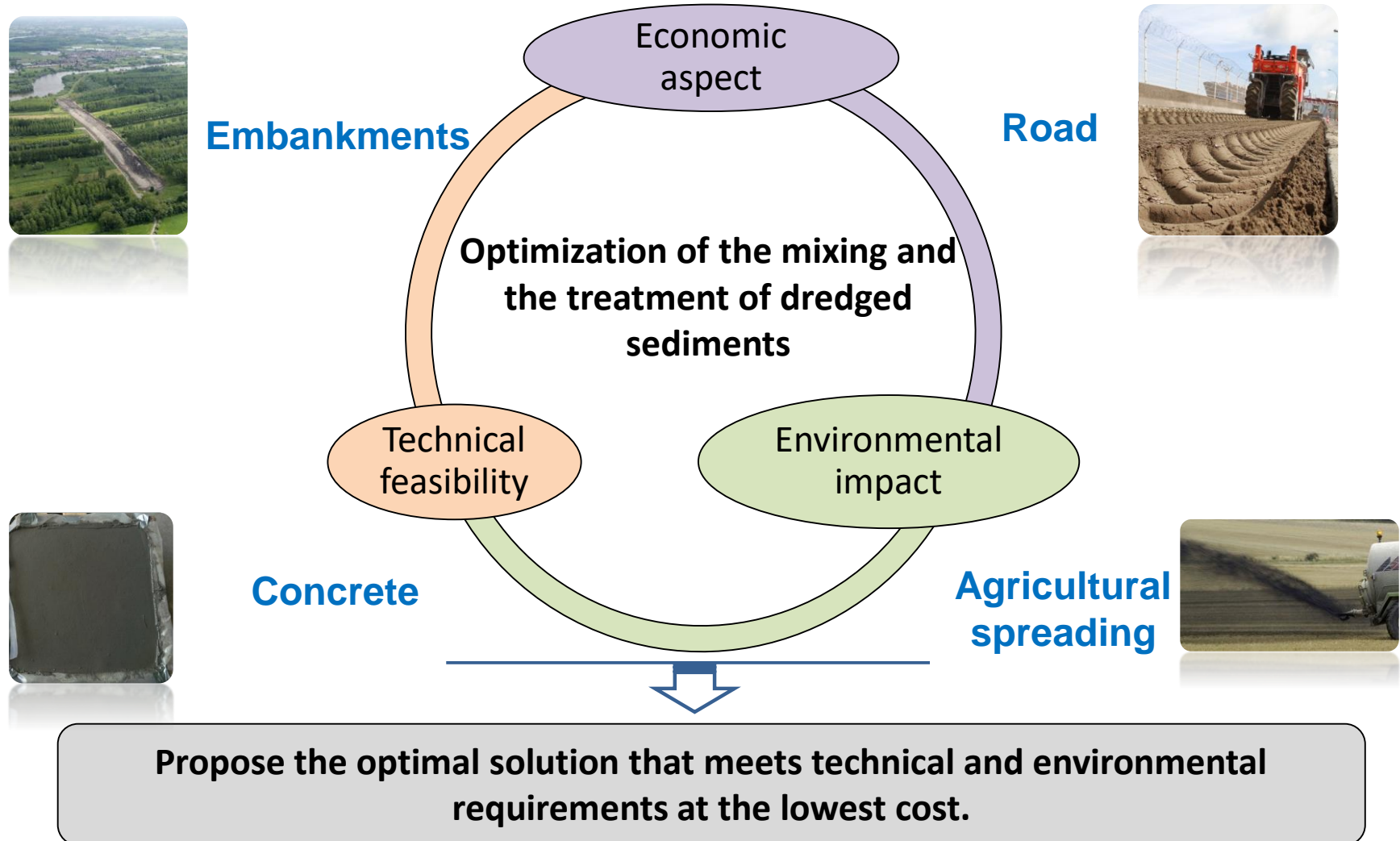
Sediment
« Waste »



Materials,
products

Using Sediment As A Resource

OSMS Optimization process



$$\text{Min} \left(\sum_{i=1}^n C_i x_i + \sum_{j=1}^m C_j S_j + \sum_{i=1}^n \sum_{t=1}^{|T|} C_{ti} T_{ti} \right)$$

Sédiments

Transport

Centres de stockage

Réglementation

Ouvrages

Centres de traitement

Minimiser $F(\langle X \rangle)$
 $g_j(\langle X \rangle) \leq 0$
 $h_j(\langle X \rangle) = 0$
 $\langle X \rangle = \langle X_1, \dots, X_n \rangle$

Optimisation / Valorisation / Eco-matériaux

Objective Function : Lower cost for optimal valuation

Using Sediment As A Resource

Software : Input data

Sediment

- Name
- Type of sample
- *Characteristics*
 - . *Chemical (as, zn, ...)*
 - . *Mechanical (GTR)*
- Centre of studies
- dredging date
- dredging location
- *GPS coordinates*
- *Transport costs* T / km
- Operating costs
- Notes

Treatment center

- Unit name
- Type of treatment
- **For each type:**
 - . *Name of treatment*
 - . *Cost € / T*
 - . *Impact on polluting element%*
- Address of the center
- GPS coordinates
- Notes

Storage areas

- Zone Name
- *Type (Inert, Not dangerous, Dangerous)*
- *GPS coordinates*
- *Storage costs € / T*
- Notes

Materials

- Name
- *GPS coordinates*
- *Transportation cost*
- *Operating cost (or purchase)*
- *Characteristics*
 - . *chemical*
 - . *mechanics*
- Notes



Mathematical model : Constraints

Environmental constraints : Heavy metals

$$e_{si} \left(1 - \sum_{t=1}^{|T|} \hat{e}_{sit} T_{ti} \right) \leq e_s + (1 - x_i)M$$

Environmental constraints : Organic matter

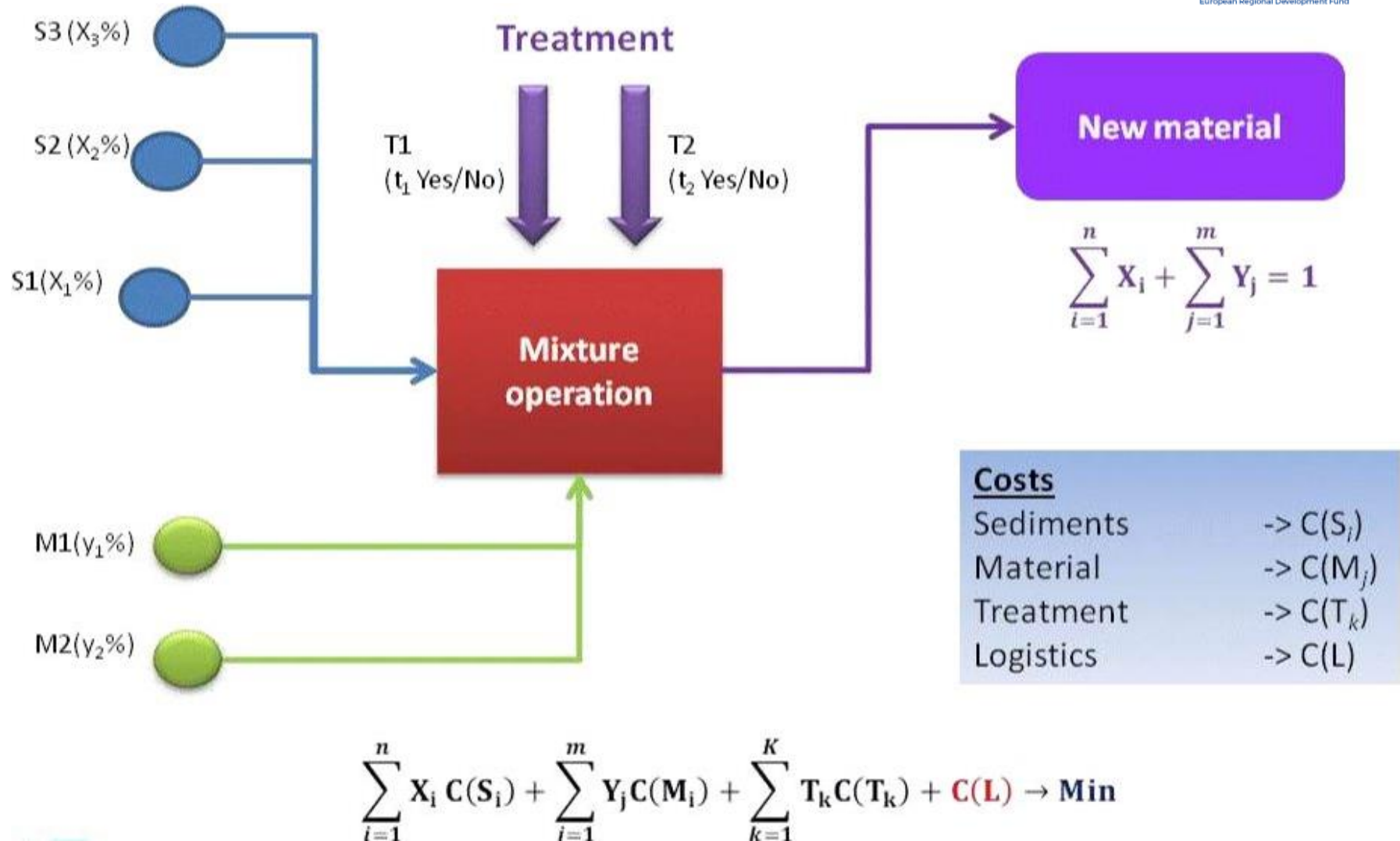
$$e_{Mi} \left(1 - \sum_{t=1}^{|T|} \hat{e}_{Mit} T_{ti} \right) \leq e_M \left(1 + \sum_{j=1}^m S_j \right) + (1 - x_i)M$$

Mechanical constraints

$$\hat{P}_d^{0.4} \left(\sum_{i=1}^n x_i + \sum_{j=1}^m S_j \right) \leq \sum_{i=1}^n (P_{id} \times x_i) + \sum_{j=1}^m (P_{jd} \times S_j) \leq \hat{P}_d^{0.25} \left(\sum_{i=1}^n x_i + \sum_{j=1}^m S_j \right)$$

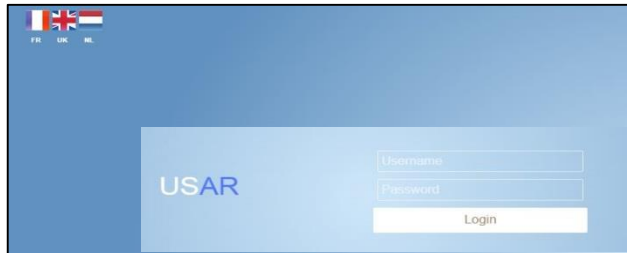
$P_{id} (P_{jd})$: associated percentage to the diameter d in sediment i (material j)

Mathematical model

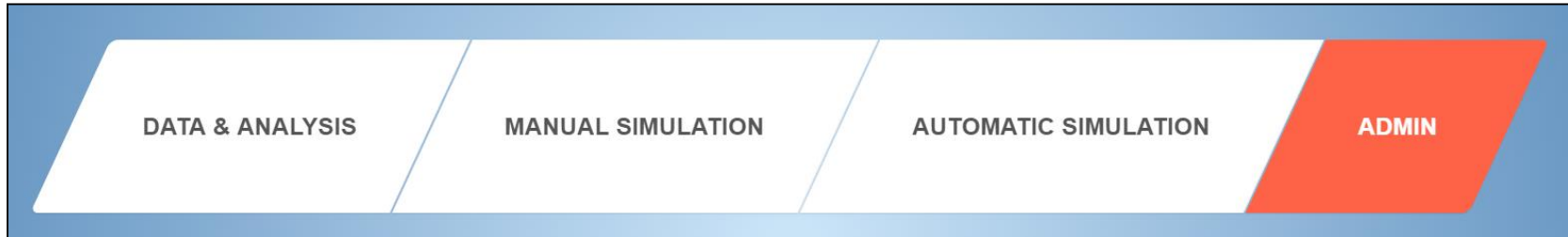










OSMS softwar

Home page



1. **Admin** import the data, define the constraints, insert the costs, etc.
2. **Data & Analysis** display on the map the position of the different sediments, quarries, treatment centers, etc.
3. **Manual simulation** create a project and start a manual analysis
4. **Automatic simulation** create a project and start automatic analysis



	USER Rights management
	SEDIMENT Import & Export
	MATERIALS Import & Export
	PARAMETERS Chemical and Mechanical
	CLASSIFICATION Normes & Legislation
	TREATMENTS Import & Export
	STORAGE AREA Décharges & Ports
	TRANSPORT Terrestrial & marine

- GPS coordinates, characterization and cost
- Sand, gravel, lime, fly ash etc., GPS position, characteristics, costs
- Physical, chemical and geotechnical parameters
- Classification of sediments
- Add a treatment center, GPS coordinates, costs, etc.
- GPS coordinates, acceptability criteria, costs
- Type of transport, costs

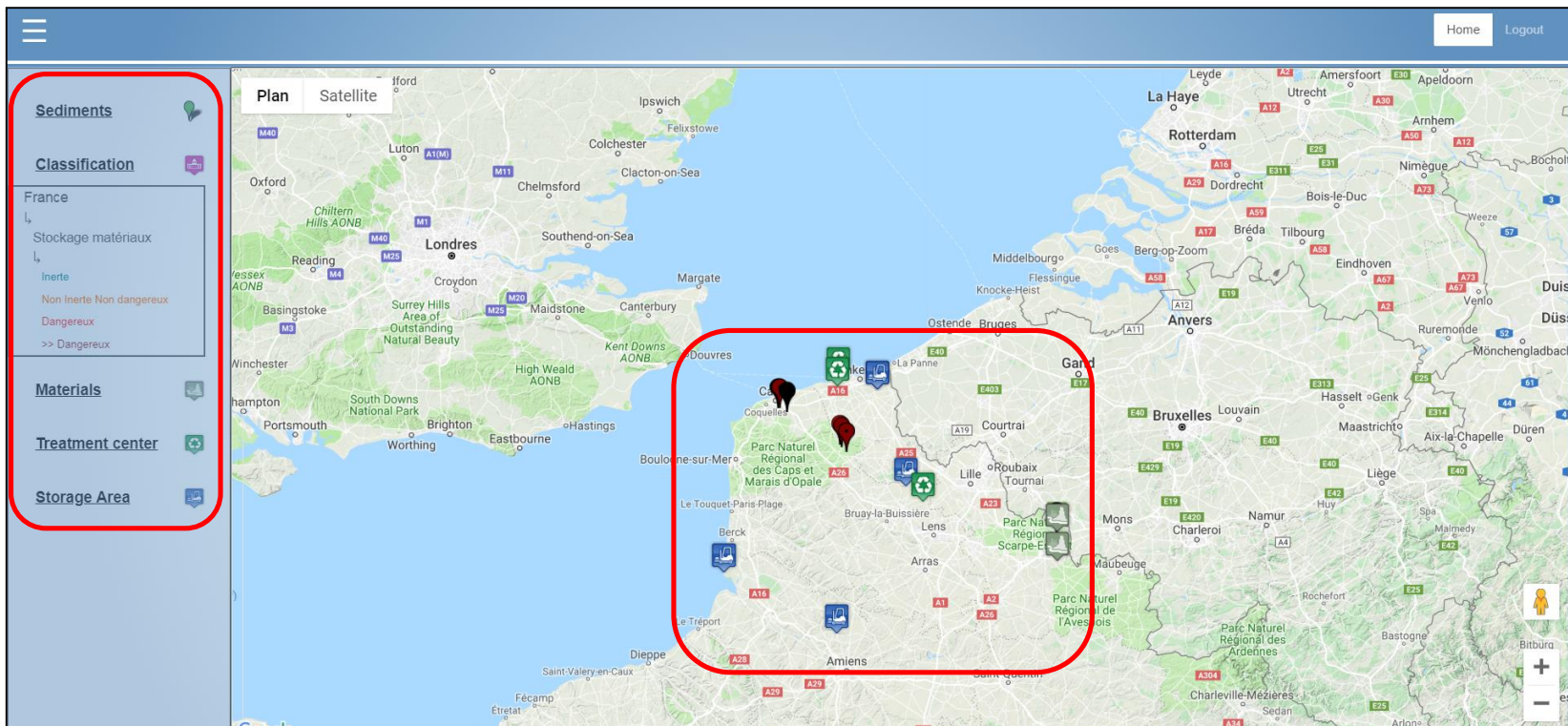
DATA & ANALYSIS

MANUAL SIMULATION

AUTOMATIC SIMULATION

ADMIN

The GPS coordinates of the project, the sediments, the additive, the materials, treatment centers and storage centers are displayed on the map



Using Sediment As A Resource

Classification environnementale

Paramètre	Symbole	Unité (MOV)	Unité (MOV)	Min Obs.	Max Obs.	Valeur
Granulométrie						
Fraction 0 à 2 µm	Fraction_2	%	%	2.53	5.22	4.98
Fraction 0 à 20 µm	Fraction_20	%	%	19.82	45.75	45
Fraction 0 à 50 µm	Fraction_50	%	%	39.36	83.21	64.08
Fraction 0 à 60 µm	Fraction_60	%	%	41.32	88	67.28
Fraction 2 à 60 µm	Fraction_2_60	%	%	38.33	83.82	62.3
Fraction 0 à 200 µm	Fraction_200	%	%	59.7	98.65	91.67
Fraction 0 à 2000 µm	Fraction_2000	%	%	100	100	100
Fraction 0 à 4000 µm	Fraction_4000	%	%	100	100	100
Fraction 0 à 5000 µm	Fraction_5000	%	%	100	100	100
Fraction 60 à 2000 µm	Fraction_60_2000	%	%	12	58.68	32.72
Fraction 2000 µm à DMax	Fraction_2000_DMax	%	µm	0	0	0
DMax	DMax	µm	µm	2000	2000	2000
Limite Atterberg						
WL	WL	%	%	40	65	48.67
WP	WP	%	%	33	48	33.34
Ip	Ip	%	%	7	21	15.33
Ic	Ic	%	%	1.57	3.42	1.57
Naturel						
Wn	Wn	%		87.9	169.9	106.13
Hydraulique						
Perméabilité	K	m/s	m/s	0.000001	0.000001	0.000001
Organique						
MO	MO	%	%	4.4	9.4	6.5
Géotechnique						
IPI	IPI	-	-	17	22	22
VBS	VBS	-	-	1	1.99	2.03
Chimique						
Arsenic	As	mg/kg	mg/kg	5.15	14.8	7.06
Cadmium	Cd	mg/kg	mg/kg	0.4	15.6	0.4
Chrome Tot	Cr Tot	mg/kg	mg/kg	13.7	88.4	16
Cuivre	Cu	mg/kg	mg/kg	14.6	439	14.6
Mercuré	Hg	mg/kg	mg/kg	0.1	3.09	0.75
Nickel	Ni	mg/kg	mg/kg	8.49	25.7	9.53
Plomb	Pb	mg/kg	mg/kg	32.2	274	34.4
Zinc	Zn	mg/kg	mg/kg	112	1460	112
Carbone Organique Total	COT	mg/kg	mg/kg	13400	44200	20000
Polychlorobiphényles	PCB	mg/kg	mg/kg	0.07	0.07	0.07
Hydrocarbures Totaux	HCT	mg/kg	mg/kg	0	19166	7661
o-Xylène	o-Xylene	mg/kg	mg/kg	0.05	0.09	0.07
Toluène	Toluene	mg/kg	mg/kg	0.05	1.31	0.07
Ethylbenzene	Ethylbenzene	mg/kg	mg/kg	0.05	0.09	0.07
Benzène	Benzene	mg/kg	mg/kg	0.05	0.05	0.05
Naphthalène	Naphthalene	mg/kg	mg/kg	0.012	0.554	0.041
Acénaphthylène	Acenaphthylene	mg/kg	mg/kg	0.068	0.619	0.194
Acénaphthène	Acenaphthene	mg/kg	mg/kg	0.037	4.08	0.051
Fluorène	Fluorene	mg/kg	mg/kg	0.058	1.77	0.64
Phénanthrène	Phenanthrene	mg/kg	mg/kg	0.216	2	0.354
Anthracène	Anthracene	mg/kg	mg/kg	0.125	1.36	0.242
Fluoranthène	Fluoranthene	mg/kg	mg/kg	0.458	6.61	1.14
Pyrène	Pyrene	mg/kg	mg/kg	0.405	5.33	0.749
Chrysène	Chrysene	mg/kg	mg/kg	0.348	3.48	0.668
Benzo[a]pyrène	Benzo[a]pyrene	mg/kg	mg/kg	0.335	3.34	0.613
Indeno[1,2,3-c,d]pyrène	Indeno[1,2,3-c,d]pyrene	mg/kg	mg/kg	0.311	3.56	0.444
Dibenzo[a,h]anthracène	Dibenzo[a,h]anthracene	mg/kg	mg/kg	0.063	0.739	0.207

... Pays

... France

... Stockage matériaux

- ... Immersion fluvial

- ... Immersion marin

... Maroc

... déchet

Inerte Non Iner... Dangere... >>Dange...

S >>S

N1 N2 >>N2

inert dang >>dang

characteristics and classifications

Granularité

Tamiséat 80 µm :	Tamiséat 2 mm :	Frac 0/50 mm(%) :
29	5	
Dmax :	D60 :	D30 :
0.2	66	29
D10 :	Cu :	Cc :
5		

Indice de plasticité | Bleu de méthylène

IP :	VBS :
19	2

Etat

Wn % :	Wopn :

Limites d'Atterberg

Wl % :	Wp % :	Ic :
55	40	2.5

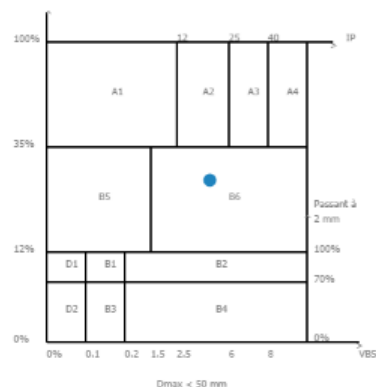
Comportement mécanique

LA :	MDE :	FS :

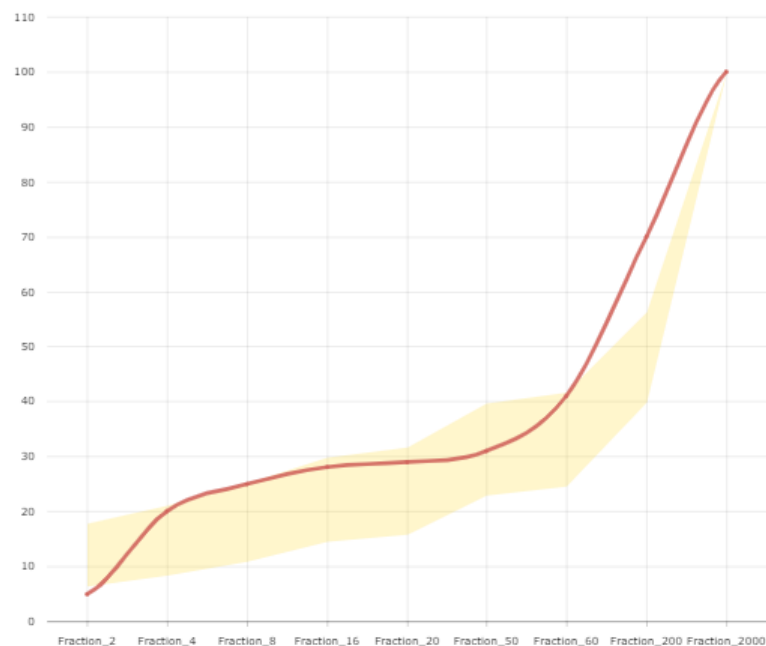
Indice portant immédiat | Matière organique

IPI :	MO :
	5

Classification

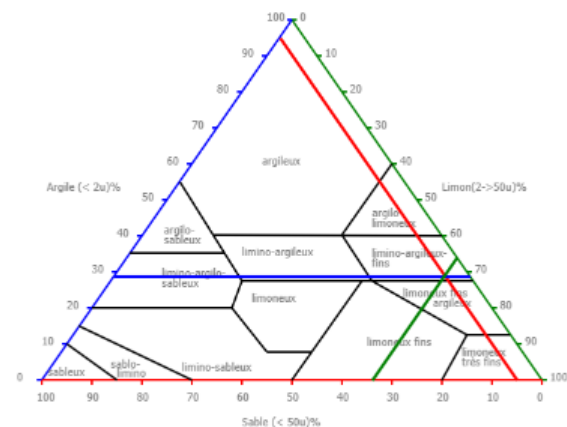
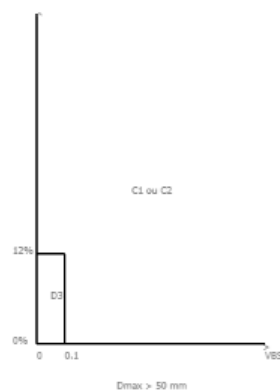


Graphe de granulométrie



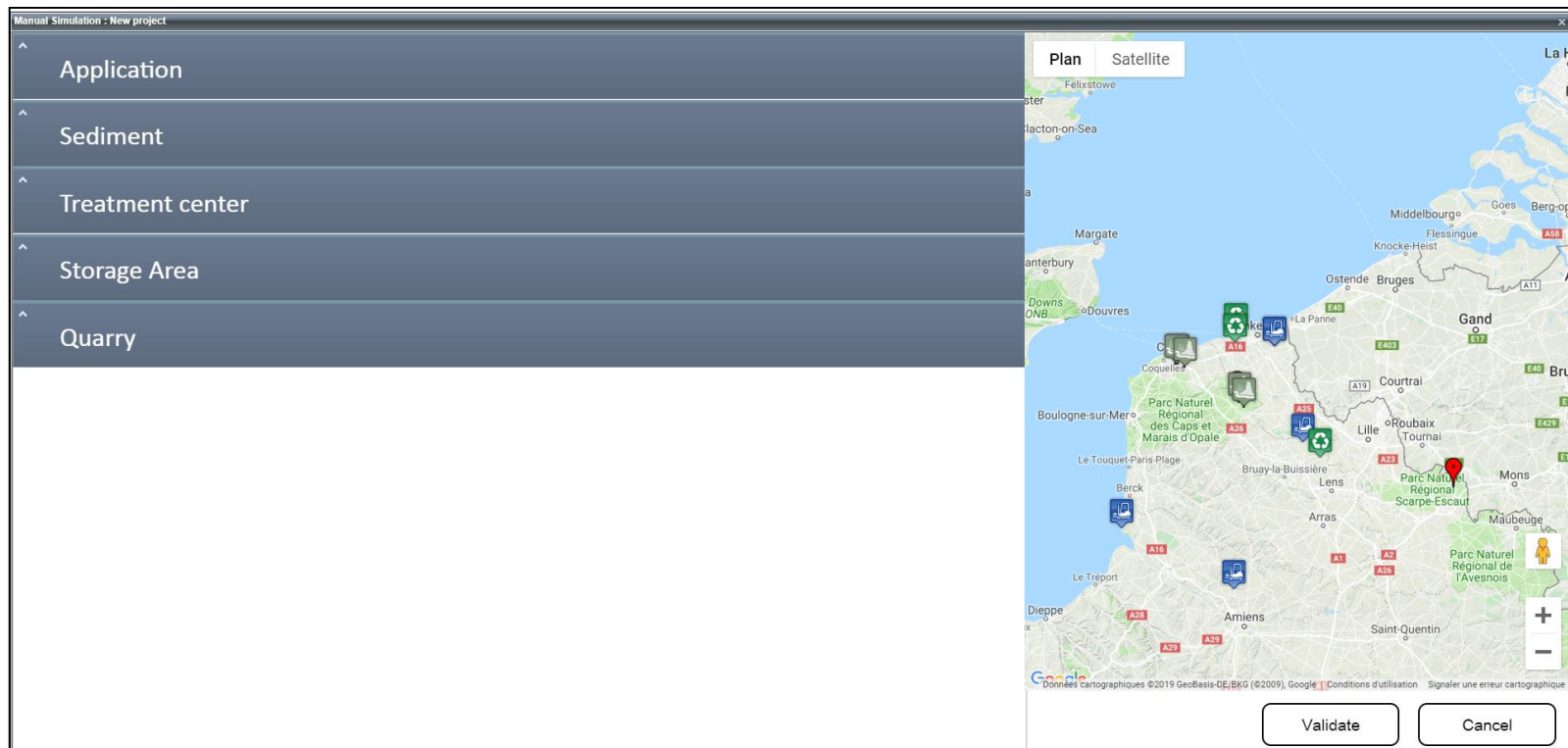
Classement selon la nature - B : Sols sableux et graveleux avec fines. - Sous-classe fonction de la nature - B6 : Sables et graves argileux à très argileux.

F11 : Matériaux faiblement organiques (terres végétales, vases, ...)





Create a new project and select its characteristics: type of application, sediments, quarries, storage and treatment centers etc.



Using Sediment As A Resource

Example of results, Road application -1-

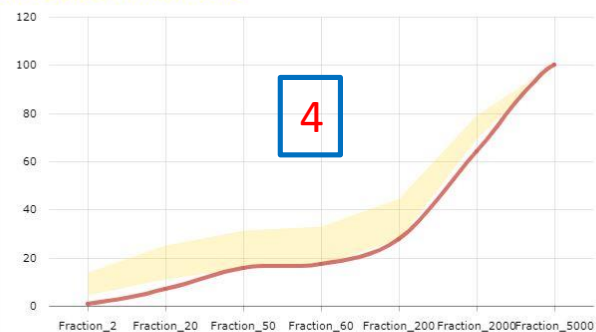
↑ | **Editor Projet** |

Code	Symbole	Min	Max
Limite Atterberg			
✓ Ic	Ic	0.6	✓
Organique			
✓ MO	MO	3	✓
Géotechnique			
✓ IPI	IPI	20	✓
Chimique			
✓ Mercure	Hg	0.2	✓
✓ Molybdène	Mo	10	✓
✓ Nickel	Ni	10	✓
✓ Plomb	Pb	10	✓
✓ Antimoine	Sb	0.7	✓
✓ Sélénium	Se	0.5	✓
✓ Zinc	Zn	50	✓
✓ Fluorure	F-	150	✓
✓ Chlorure	Cl-	15000	✓
✓ Sulfate	SO4-	20000	✓
✓ Carbone Organique T...	COT	30000	✓
✓ Hydrocarbures Arom...	HAP	50	✓
✓ Polychlorobiphényles	PCB	1	✓
✓ Hydrocarbures Totaux	HCT	500	✓
✓ Arsenic	As	2	✓
✓ Barium	Ba	100	✓
✓ Cadmium	Cd	1	✓
✓ Chrome Tot	Cr Tot	10	✓
✓ Cuivre	Cu	50	✓

Nouveau matériau 11.08(€)

	%	% Max	Coût(€)
Sédiments			
B3	15.14	100.0	1.05
C2	5.37	100.0	0.48
Matériaux			
M2	79.47	100.0	9.53

Graphe de granulométrie



Code	Symbole	Valeur
Limite Atterberg		
Ic	Ic	0.47 ✓
Organique		
MO	MO	1.6 ✓
Géotechnique		
IPI	IPI	✓
Chimique		
Arsenic	As	1.41 ✓
Barium	Ba	0 ✓
Cadmium	Cd	0.2 ✓
Chrome Tot	Cr Tot	10 ✓

1 → Limit values of acceptability

2 → Mix design

3 → Costs

4 → Characteristics of the new material

5 → New parameters values

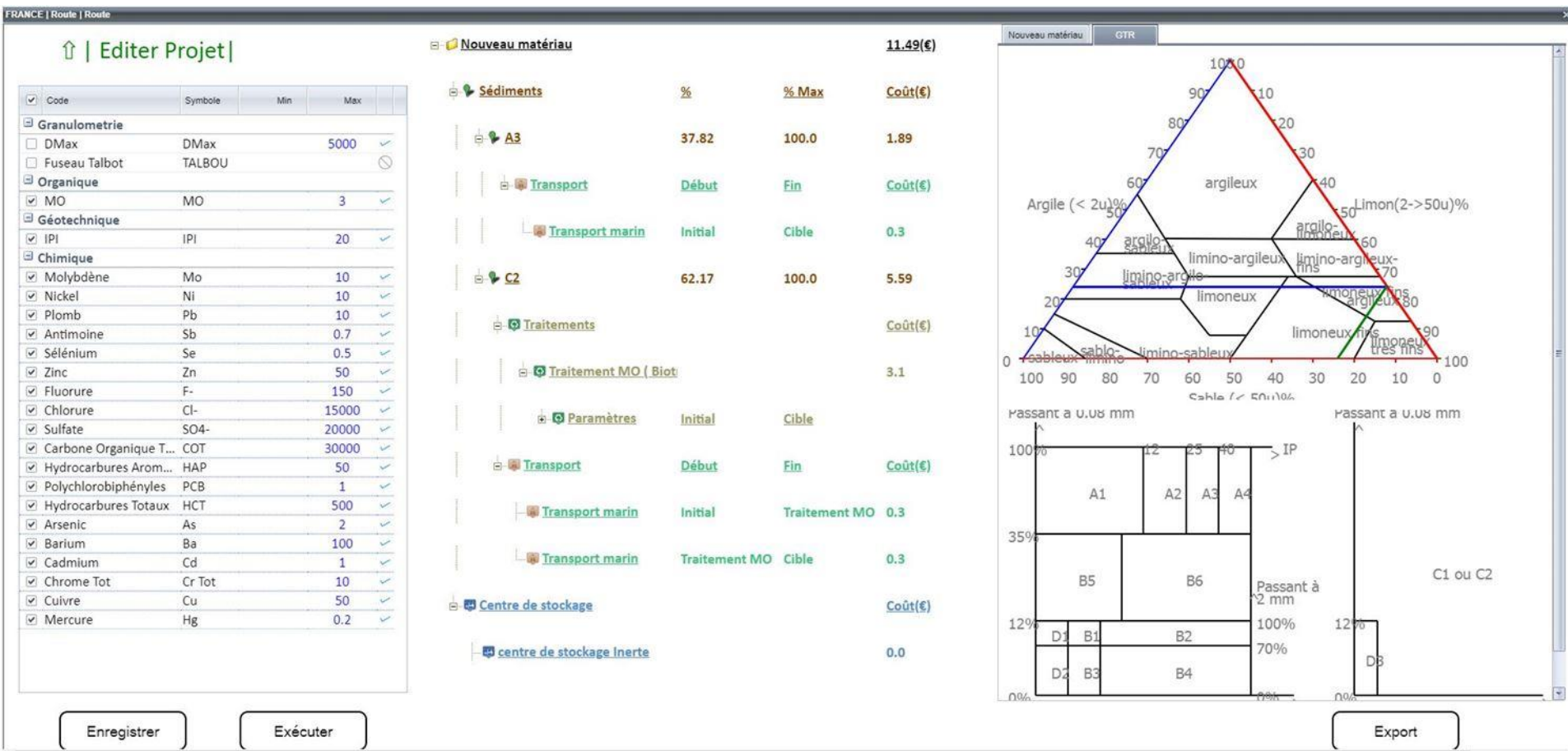
Enregistrer

Exécuter

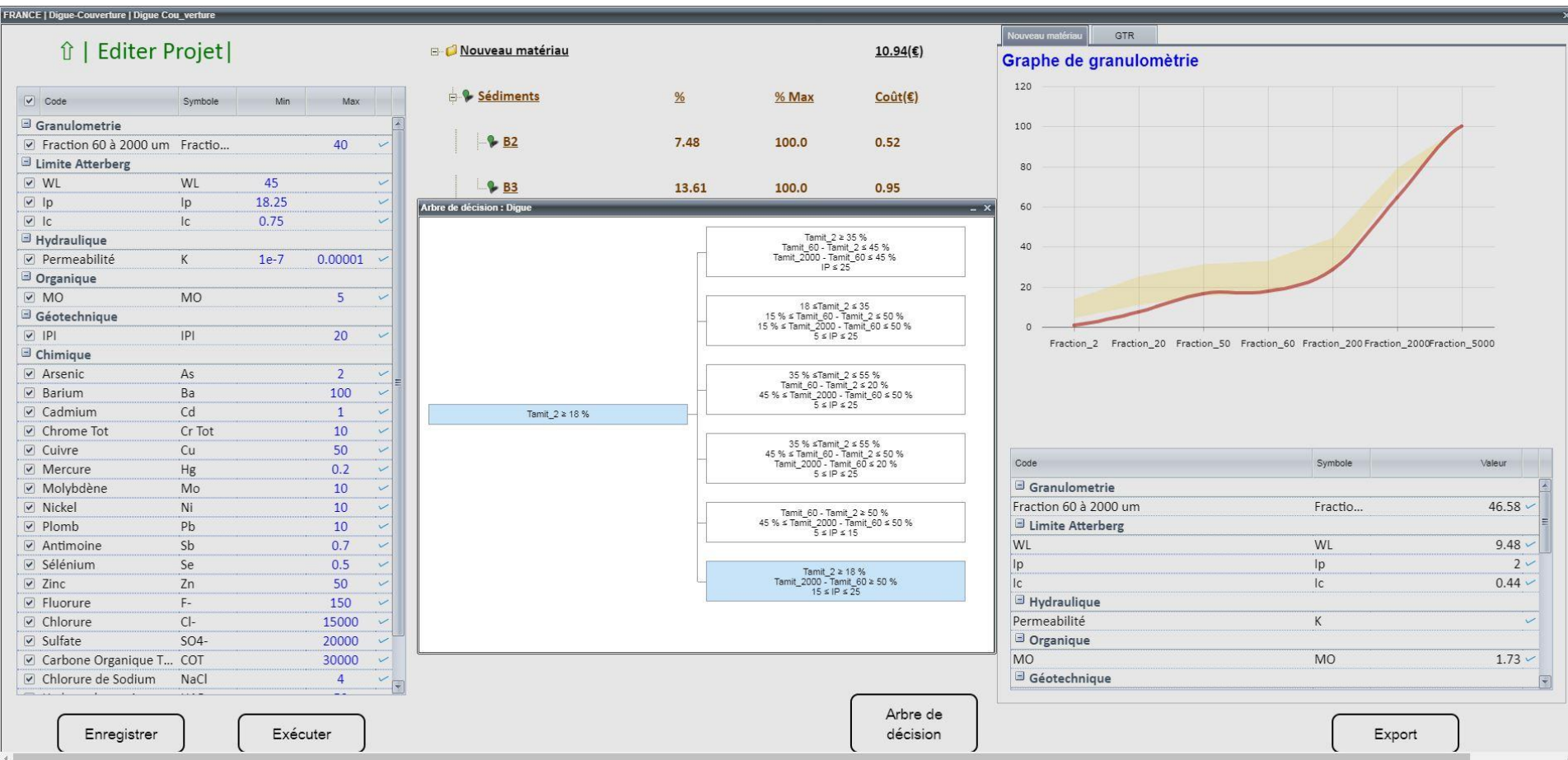
Arbre de décision

Export

Example of results, Road application -2-



Example of results, Embankments



Using Sediment As A Resource

Thank you for your attention

Contact: ahmed.zeraoui@imt-lille-douai.fr