Civil Engineering Applications for Marine Sediments Project

Social, geographical, technical, environmental and economic approaches to strengthen marine sediment reuse options through CEAMaS project.

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Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
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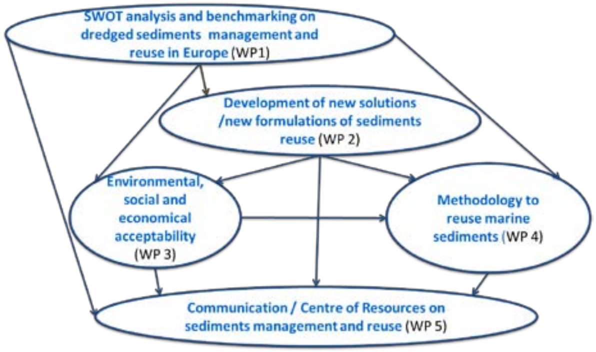
INTERREG IV B PROJECT (2013 – 2015)

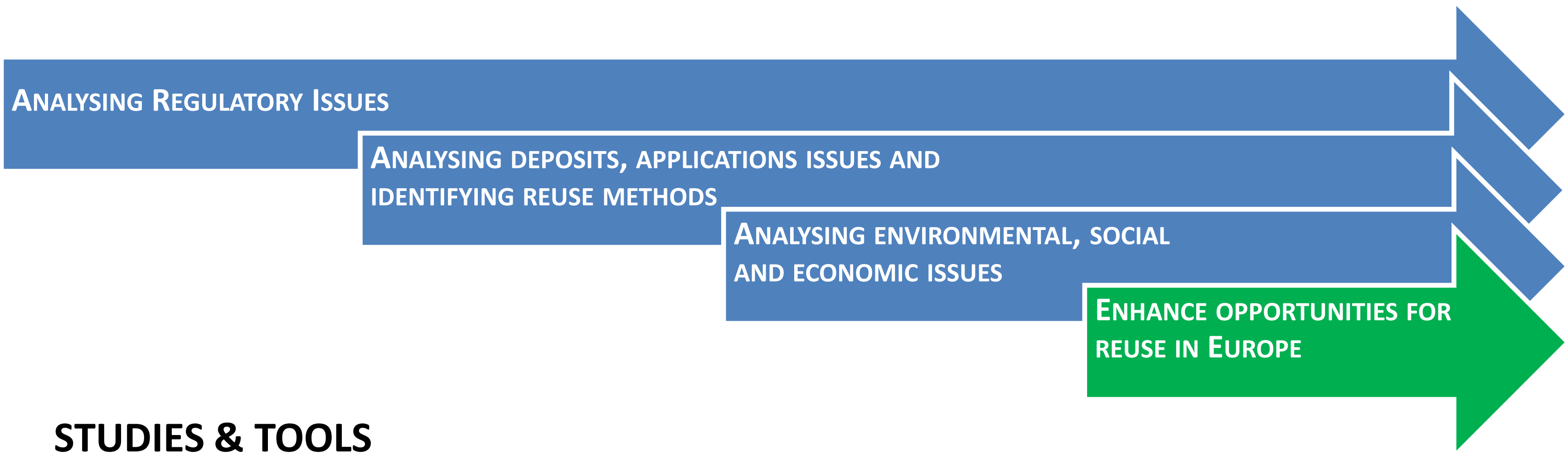
PARTNERS

- France :
  - Cd2e - ***Lead partner***
  - BRGM
  - Ecole Centrale de Lille – ***WP leader***
  - Université de Lille 1
- Ireland:
  - University College of Cork – ***WP leader***
  - Cork Institute of Technology – ***WP leader***
- Belgium
  - Belgian Building Research Institute
- Netherlands
  - TUDelft / Deltares



ACTIONS AND OBJECTIVES

MAINSTREAM SUSTAINABLE REUSE OF DREDGED MARINE SEDIMENTS IN CIVIL ENGINEERING APPLICATIONS



STUDIES & TOOLS

Investing in Opportunities
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STUDIES

- Stakeholders perception of sediment reuse in Europe
- Differences in EU legislation
- Finding location for reuse options by integration of different spatial constraints
- On site characterisation for optimised dredging and sediments reuse
- Life Cycle Assessment applied to sediment reuse

STUDIES

EUROPEAN STAKEHOLDER POINT OF VIEW

- Local context is different everywhere except in The Netherlands and Belgium.
- A better cognition of the local context can make more efficient project
- No common vision on sediment management
- Need to create a user community
- Optimisation of the transport cost
- Working on civil society
- Knowledge gap between stakeholders
- Waste mineral regulation is a key parameter in decision making in each country

Ports
Public services
Academics
Territorial authorities
Civil engineering industries
Consultancies
National study groups
Dredging companies
European projects

STUDIES

DIFFERENCES IN EU LEGISLATION

While the Water Framework Directive has a EU standard for priority substances in water, there is no common sediment standard. This means that for sediments:

- Classification systems (and their implication) differ
- Concentration levels for contaminants differ
- Second tier evaluation methods differ

We have tested one sediment sample for each participating country to see how this variation in legal standards impacts sediment reuse.

STUDIES

DIFFERENCES IN EU LEGISLATION

metals		IRL Low: Irish Lower level – Example 1	Example 2	Example 3	Example 4	Example 5	IRL High: Irish Upper level b – Example 1	Example 2	Example 3	Example 4	Example 5
Antimone	Sb										
Arsenic	As	192%	133%	141%	490%	328%	25%	17%	18%	63%	42%
Barium	Ba										
Cadmium	Cd	295%	81%	160%	908%	539%	49%	14%	27%	151%	90%
Chromium	Cr	138%	29%	43%	230%	164%	81%	17%	25%	134%	96%
Cobalt	Co										
Copper	Cu	131%	98%	155%	190%	133%	48%	36%	57%	69%	48%
Lead	Pb	270%	128%	180%	205%	147%	74%	35%	49%	57%	40%
Molybdenum	Mo										
Nickel	Ni	99%	130%	138%	163%	119%	35%	46%	48%	57%	42%
Selenium	Se										
Tin	Sn										
Vanadium	V										
Zinc	Zn	497%	100%	136%	357%	236%	194%	39%	53%	139%	92%
Classification		497%	133%	180%	908%	[illegible]	194%	46%	57%	151%	96%

metals		BE Low: Flemish free us excavated – Example 1	Example 2	Example 3	Example 4	Example 5	BE High: Flemish secondary resou – Example 1	Example 2	Example 3	Example 4	Example 5
Antimone	Sb										
Arsenic	As	49%	34%	36%	126%	84%	7%	5%	5%	18%	12%
Barium	Ba										
Cadmium	Cd	[illegible]	47%	93%	530%	315%	21%	6%	11%	64%	38%
Chromium	Cr	106%	23%	33%	177%	[illegible]	8%	2%	2%	13%	9%
Cobalt	Co										
Copper	Cu	[illegible]	54%	86%	106%	74%	14%	10%	17%	20%	14%
Lead	Pb	135%	64%	90%	103%	[illegible]	13%	6%	9%	10%	7%
Molybdenum	Mo										
Nickel	Ni	[illegible]	49%	52%	61%	45%	8%	11%	12%	14%	10%
Selenium	Se										
Tin	Sn										
Vanadium	V										
Zinc	Zn	397%	80%	109%	286%	[illegible]	64%	13%	17%	46%	30%
Classification		397%	80%	109%	530%	[illegible]	64%	13%	17%	64%	38%

metals		FR Low: French Level 1 (N1) – Example 1	Example 2	Example 3	Example 4	Example 5	FR High: French Level 2 (N2) – Example 1	Example 2	Example 3	Example 4	Example 5
Antimone	Sb										
Arsenic	As	69%	48%	51%	176%	[illegible]	35%	24%	25%	88%	59%
Barium	Ba										
Cadmium	Cd	172%	47%	93%	530%	315%	86%	24%	47%	265%	157%
Chromium	Cr	107%	23%	33%	179%	128%	54%	11%	17%	89%	64%
Cobalt	Co										
Copper	Cu	117%	87%	138%	169%	118%	58%	43%	69%	85%	59%
Lead	Pb	162%	77%	108%	123%	88%	[illegible]	38%	54%	62%	44%
Molybdenum	Mo										
Nickel	Ni	56%	74%	78%	92%	68%	28%	37%	39%	46%	34%
Selenium	Se										
Tin	Sn										
Vanadium	V										
Zinc	Zn	288%	58%	79%	207%	137%	144%	[illegible]	39%	[illegible]	69%
Classification		288%	87%	138%	530%	315%	144%	43%	69%	[illegible]	157%

metals		NL Low: Dutch (*) Bbk, living (cla – Example 1	Example 2	Example 3	Example 4	Example 5	NL High: Dutch (*) Bbk, industy (clas – Example 1	Example 2	Example 3	Example 4	Example 5	Dutch (** ZBT – Example 1	Example 2	Example 3	Example 4	Example 5
Antimone	Sb						7%	7%	5%	9%	7%					
Arsenic	As	[illegible]	29%	57%	127%	[illegible]	19%	10%	19%	43%	27%	[illegible]	41%	44%	152%	102%
Barium	Ba	[illegible]	26%	6%	12%	8%	4%	17%	4%	7%	5%					
Cadmium	Cd	60%	12%	56%	160%	84%	17%	3%	16%	46%	24%	52%	14%	28%	159%	94%
Chromium	Cr	52%	9%	13%	86%	58%	16%	3%	4%	27%	18%	81%	17%	25%	134%	96%
Cobalt	Co	202%	105%	91%	96%	145%	21%	11%	9%	10%	15%					
Copper	Cu	50%	26%	88%	64%	40%	25%	13%	44%	32%	20%	88%	65%	104%	127%	89%
Lead	Pb	110%	42%	98%	77%	51%	26%	10%	23%	18%	12%	147%	70%	98%	112%	80%
Molybdenum	Mo	45%	54%	31%	27%	19%	1%	1%	1%	1%	0%					
Nickel	Ni	20%	18%	18%	33%	22%	[illegible]	4%	4%	8%	5%	46%	61%	64%	76%	56%
Selenium	Se						[illegible]	2%	2%	4%	[illegible]					
Tin	Sn						0%	0%	0%	0%	0%					
Vanadium	V						14%	3%	4%	19%	14%					
Zinc	Zn	98%	14%	31%	66%	39%	28%	[illegible]	9%	[illegible]	11%	218%	44%	60%	157%	104%
Classification		202%	105%	98%	160%	145%	28%	17%	44%	46%	27%	218%	70%	104%	159%	104%

In Ireland and France,
2 out of 5 sediments can not be reused.

In Flanders and Holland,
5 out of 5 sediments are in potential reusable.

STUDIES

FINDING LOCATION FOR REUSE OPTIONS BY INTEGRATION OF DIFFERENT SPATIAL CONSTRAINTS

- The Spatial DSS is a GIS tool including:
  - Participation (decision makers-public)
  - User defined scenario building
  - Transparent and understandable GIS calculations
  - Adapted to multi-stakeholder decision making
  - Delivering spatial perception of individual environmental values

- This CEAMAS output is a contribution:
  - To the wide community of sediment management
  - To cope with the spatial application of potential sediment re-use solutions

STUDIES

FINDING LOCATION FOR REUSE OPTIONS BY INTEGRATION OF DIFFERENT SPATIAL CONSTRAINTS

- Defining a GIS processing recipe for scenario building
- Stakeholder's ruleset values
  - Selecting GIS layers / contraints
  - Defining the decision level (priority, secondary, not relevant)
  - Defining it the geographical target is attractive or repellent
  - Weigth valuation for each constraint

- **GIS questionnaire sent :**
  - **72 port managers**
  - **100 French territorial stakeholders**

Spatial Decision Support System (DSS) Questionnaire

The Spatial Decision Support System (DSS) calculates the best location available to implement potential dredged sediment re-use. This location should fit any spatial requirement to build a sediment facility (treatment plant, storage area...) or just locate a potential dumping spot. The spatial decision is provided by a Geographical Information System (GIS) model computing all the information (listed in the table below) selected and valued by stakeholders or decision makers in the field of marine sediment management. The spatial decision's principle is based on setting the location according multiple attractive, repulsive, regulatory or economical incentive targets.

Layers	Decision level: Priority (P), Secondary (S) or Not relevant (N)	Attractiveness (A) or Repellence (R)	Value according to your point of view (from 1 to 10)
Urban fabric	P / S / N	A / R	
Airports	P / S / N	A / R	
Storage sites	P / S / N	A / R	
Artificial sites, not agricultural and/or vegetated	P / S / N	A / R	
Arable land	P / S / N	A / R	
Permanent agriculture	P / S / N	A / R	
Pastures	P / S / N	A / R	
Permanent agricultural sites	P / S / N	A / R	
Forests	P / S / N	A / R	
Herbaceous vegetation and heterogeneous	P / S / N	A / R	
Inland wetlands	P / S / N	A / R	
Inland water bodies	P / S / N	A / R	
Dunes, beaches, sand, salt marshes	P / S / N	A / R	
Tidal plains	P / S / N	A / R	
Offshore dumping sites	P / S / N	A / R	
Coastal erosion	P / S / N	A / R	
Special Protected Areas (SPA)	P / S / N	A / R	
National Monuments	P / S / N	A / R	
Spaces re-naturalized	P / S / N	A / R	
Natura 2000 areas	P / S / N	A / R	
Natural reserves	P / S / N	A / R	
Special Areas of Conservation	P / S / N	A / R	
Drinking water wells	P / S / N	A / R	
Protected groundwater area	P / S / N	A / R	
Ports	P / S / N	A / R	
Industrial sites	P / S / N	A / R	
Active quarries	P / S / N	A / R	
Geological/natural aggregates	P / S / N	A / R	
Waterways	P / S / N	A / R	
Roads Network	P / S / N	A / R	
Regulatory area	P / S / N	A / R	
Economical incentive area	P / S / N	A / R	
Suggestion 1 (if relevant)	P / S / N	A / R	
Suggestion 2(if relevant)	P / S / N	A / R	

Legend:

Priority Level: Information interest in the decision making process with Priority (P), Secondary (S) or Not relevant (N).
Attractiveness: Explains the intention to locate a dredged sediment reuse close to (attractiveness) or far from (Repellence) each information listed.
Value: Give the value of interest from 0 (no interest) to 10 (crucial interest) with 5 as a moderate interest. For each information, values have to be given according to your own viewpoint considering the importance you would give to each information when trying to locate the best area of interest with the lowest level of constraint to implement a dredged sediment reuse.

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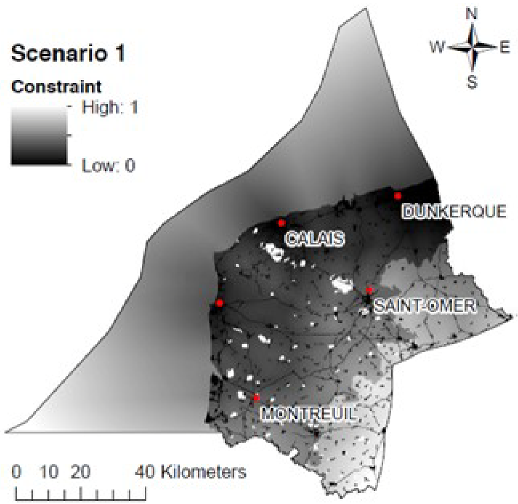
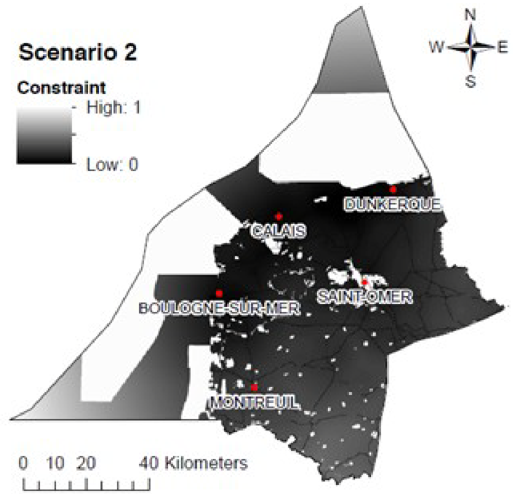
STUDIES

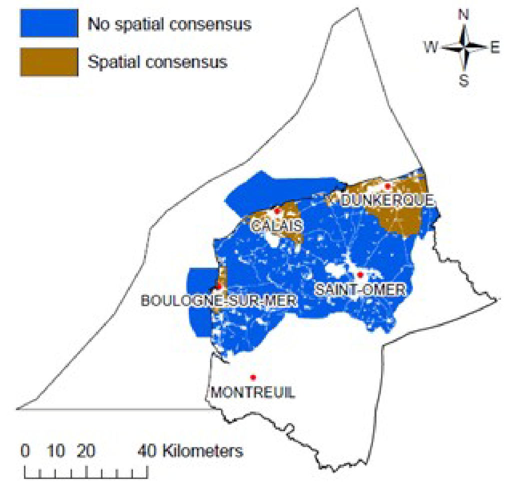
FINDING LOCATION FOR REUSE OPTIONS BY INTEGRATION OF DIFFERENT SPATIAL CONSTRAINTS



Scenario 1, where ports, roads, urban and coastal development fund are positive constraints, with respective weights of 0.3; 0.2; 0.1 and 0.1, and where aggregate quarries are negative constraints, with a weight of 0.3. Drinking wells protection perimeters are excluded from the area of interest (i.e. maximal constraint value of 1).



Scenario 2, where ports, roads, waterways and quarries are positive constraints, with, respectively, weights of 0.3, 0.2, 0.2 and 0.3. Drinking wells protection perimeters, Ramsar and Natura 2000 sites are excluded from the area of interest (i.e maximal constraint value of 1).



Spatial consensus. Here the spatial consensus is the result of a combination of both scenarios where a [0-0.2[constraint threshold has been applied for validation in each scenario.

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STUDIES

ON SITE CHARACTERISATION FOR OPTIMISED DREDGING AND SEDIMENTS REUSE

- Sampling at Dunkerque settling pond

- On site analysis for samples control
- Spatial heterogeneity of measurements did not exceed ±20%, to the exception of Pb, for which one local anomaly was measured.
- Vertical heterogeneity is slightly higher but does not exceed ±25%

STUDIES

LIFE CYCLE ASSESSMENT APPLIED TO SEDIMENT REUSE

- LCA applied to sediment management strategy and reuse options:

CEAMaS Partner Countries	Scenarios						
	Wetland Creation/ Building with Nature	Brick Manufacture	Road SubBase Construction	Amoras	Slufter/ Disposal on Land	Underwater Cell	Dumping at Sea
Belgium				●			
France		●	●		●		
Ireland	●						●
The Netherlands					●	●	

- Modelisation done using data from real projects, completed by LCA databases as needed
  - Impact of processes in different countries
  - Impact of reuse options

- Functional Unit: **The management of 1 cubic meter (m3) of dredged sediments in North-West Europe in 2014**

STUDIES

LIFE CYCLE ASSESSMENT APPLIED TO SEDIMENT REUSE

- Scenario comparison in each country
- Process impacts
- Common Process assessment: Means of Transportation, dredging
- Reuse option / classic option with conventional process

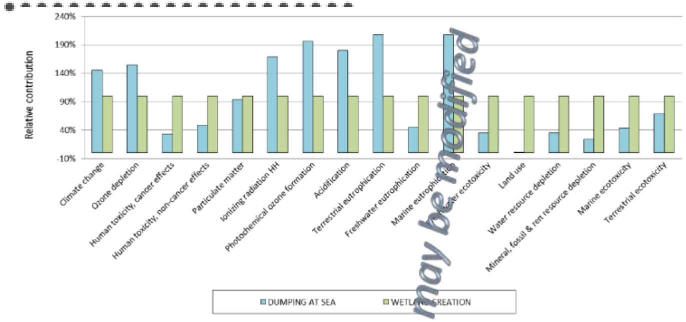


Figure 34 – Comparison of Irish scenarios impact assessments

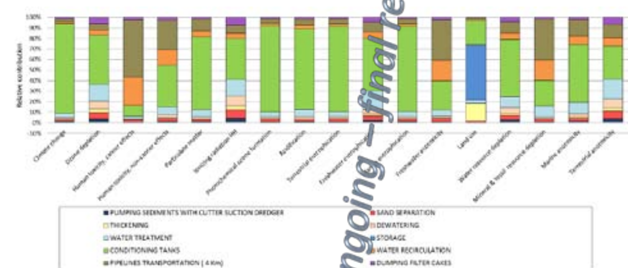


Figure 23 – BE1AMORAS scenario contribution analysis

Impact category	Unit	[illegible]	France (Lorry)	France (Barge)	Ireland (Hopper)	Netherlands (Hopper)
Climate change	kg CO2 eq	[illegible]	1,01E+01	2,87E+00	1,85E+00	1,12E+00
Ozone depletion	kg CFC-11 eq	8,25E-07	7,01E-07	1,86E-09	1,20E-07	7,31E-08
Human toxicity, cancer effects	CTUh	[illegible]	8,98E-08	1,20E-10	1,36E-09	7,30E-09
Human toxicity, non-cancer effects	CTUh	[illegible]	6,73E-07	1,50E-08	2,47E-08	2,80E-08
Particulate matter	kg PM2.5 eq	[illegible]	3,64E-03	6,40E-04	5,27E-04	5,49E-04
Ionizing radiation HH	kBq U235 eq	[illegible]	5,73E-01	1,47E-03	9,39E-02	5,70E-02
Photochemical ozone formation	kg NMVOC eq	[illegible]	6,33E-02	4,50E-02	2,68E-02	4,05E-03
Acidification	molc H+ eq	[illegible]	5,37E-02	3,35E-02	2,04E-02	2,58E-03
Terrestrial eutrophication	molc N eq	[illegible]	2,17E-01	1,88E-01	1,07E-01	7,33E-03
Freshwater eutrophication	kg P eq	5,83E-04	1,75E-04	3,11E-08	3,03E-06	6,02E-06
Marine eutrophication	kg N eq	[illegible]	1,57E-02	1,72E-02	9,72E-03	6,60E-04
Freshwater ecotoxicity	CTUe	[illegible]	6,03E+00	5,24E-02	1,11E-01	1,53E-01
Land use	kg C deficit	1,27E+01	2,12E-01	1,60E-02	1,03E+00	6,63E-01
Water resource depletion	m3 water eq	2,68E+01	2,41E+00	9,52E-04	8,17E-02	1,19E-01
Mineral, fossil & ren resource depletion	kg Sb eq	2,54E-03	4,39E-04	6,47E-08	4,00E-06	5,76E-06
Marine ecotoxicity	kg 1,4-DB eq	3,54E-02	1,48E-02	6,35E-04	1,39E-03	8,39E-04
Terrestrial ecotoxicity	kg 1,4-DB eq	3,51E-03	1,02E-03	9,52E-06	2,08E-05	2,58E-05

Table 28. Impact of transportation means (1 m3 over 40 km)

TOOLS

- “What if ” multi-criteria decision tool
- WEBGIS
- Economic modeling
- Database of sediments characteristics

GLOBAL VISION THROUGH MULTI-CRITERIA DECISION TOOL

A "WHAT-IF" TOOL

- A « what-if » decision support environment :
  - to simulate the various consequences of available management options
  - to take into account possible options in Belgium, France, Ireland and the Netherlands
  - Indirect benefits for options that would not be retained in a local tendering process (widened system boundaries)

=> Exchange and sharing for return on experience between each country

- Targeted users:
  - students and communities, all technical background
  - port decision makers and territorial authorities

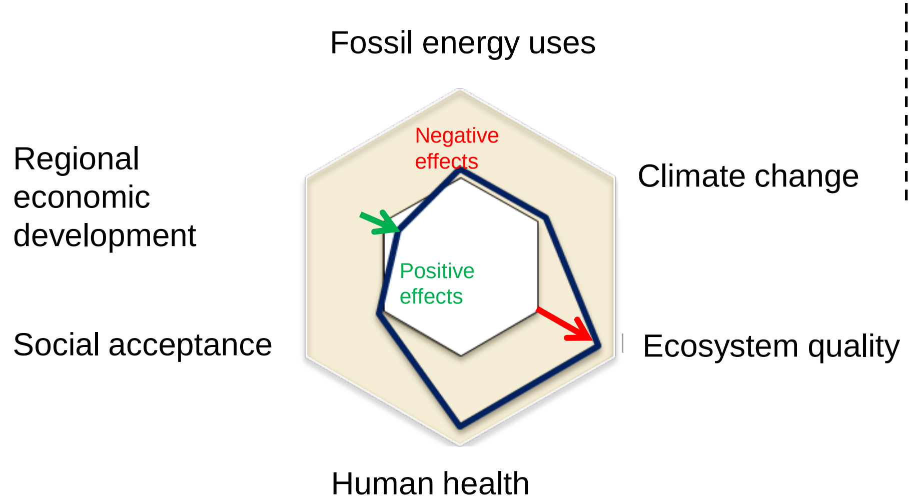
GLOBAL VISION THROUGH MULTI-CRITERIA DECISION TOOL

EXAMPLE OF RESULTS

100% reference scale = « worst » scenario

Decision risk level
note

Cost assessment
k€



Improvement due to sediment management

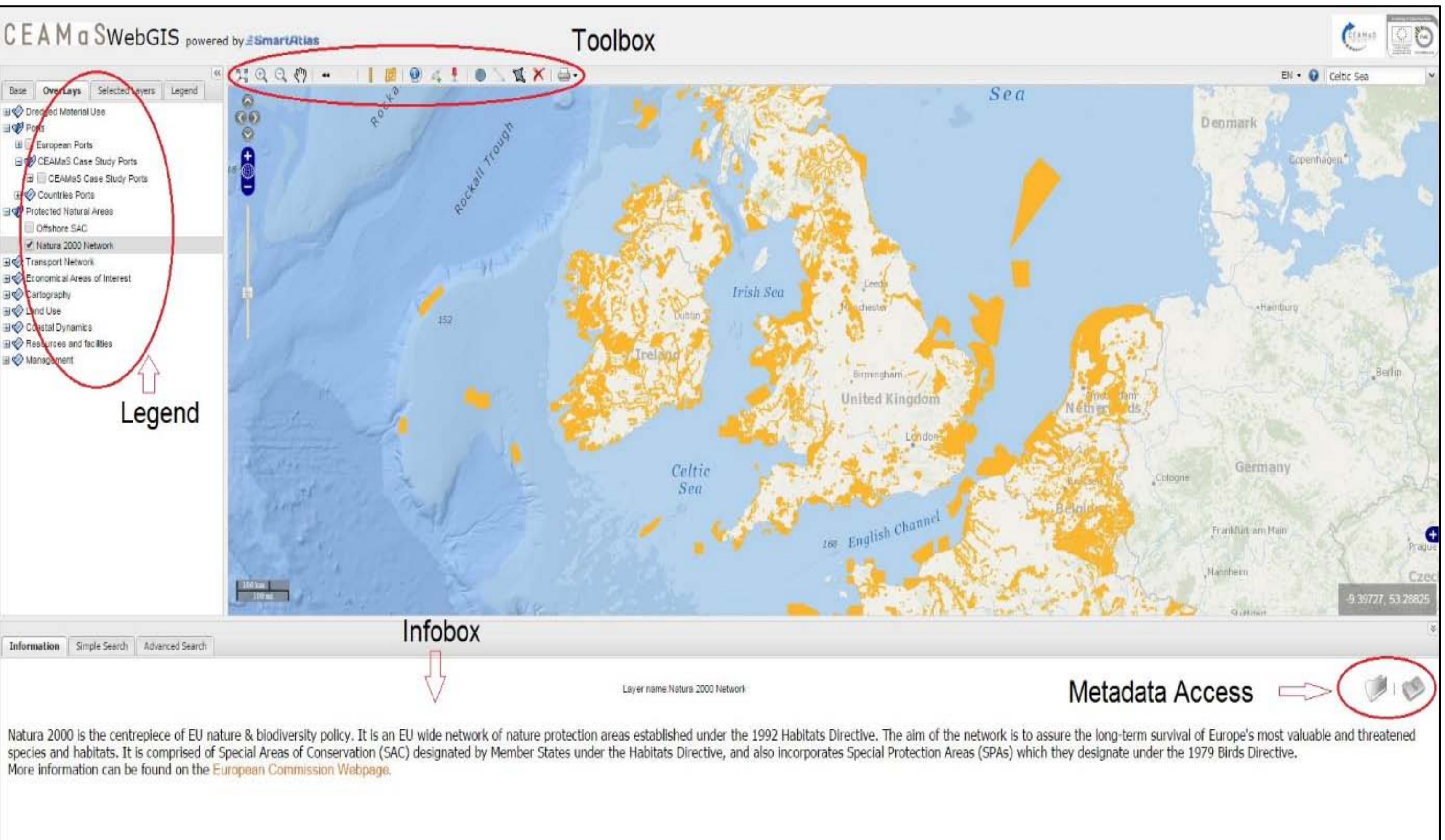
Damage due to sediment management

Compared to the « nothing done » option

CEAMAS WEBGIS TOOL

OVERVIEW

- A GIS in an online format is delivered as a platform to display the analyses and processes carried in the project.
- Providing an online catalogue for CEAMAS GIS products



Overview from CEAMaS web-GIS highlighting the toolset and the legend

CEAMaS
Civil Engineering Applications for Marine Sediments

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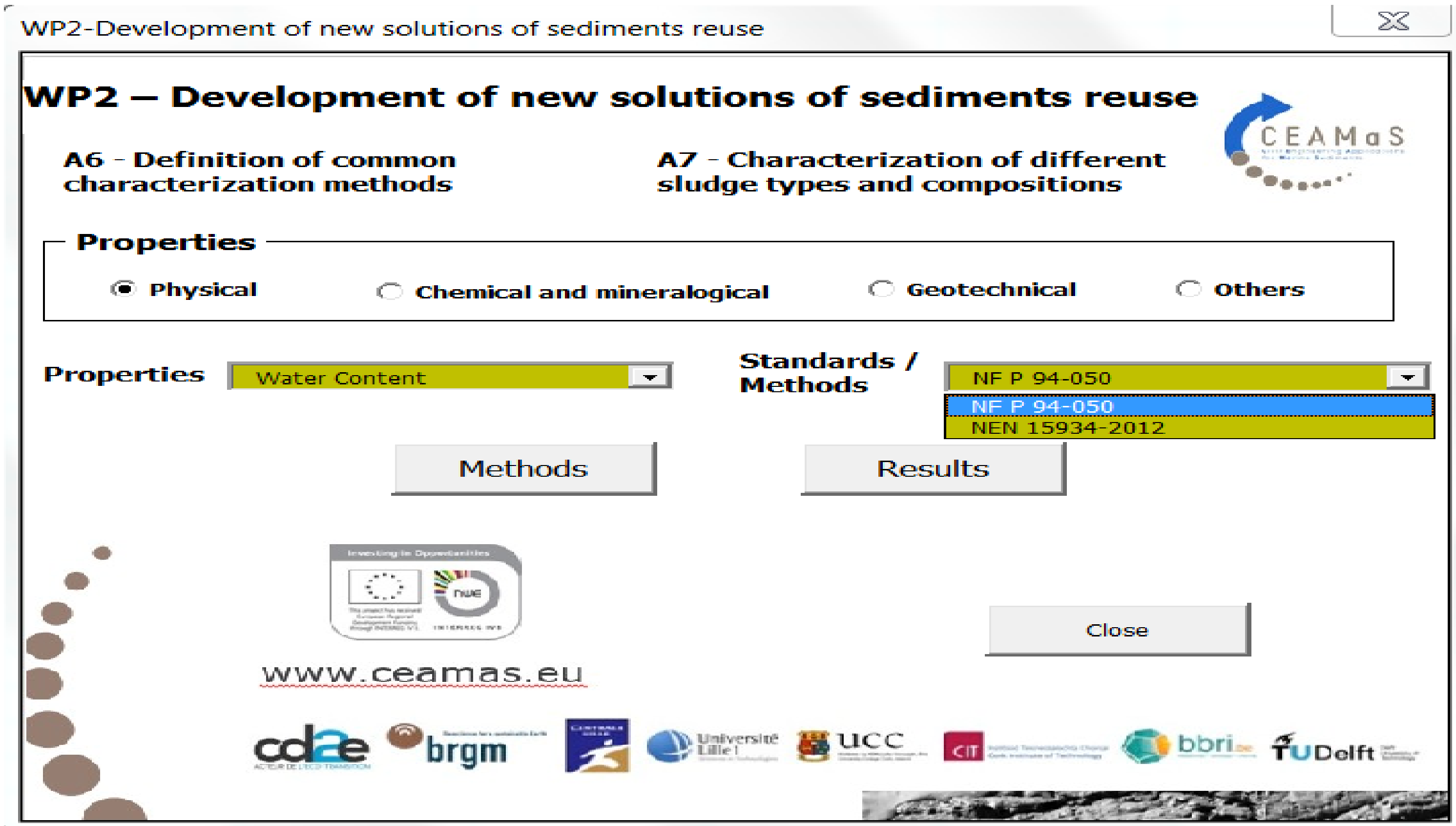
TECHNICAL ISSUES FOR REUSE

SEDIMENT CHARACTERISATION TECHNIQUES FOR REUSE

Database of sediments characteristics



HOW TO SHARE ?

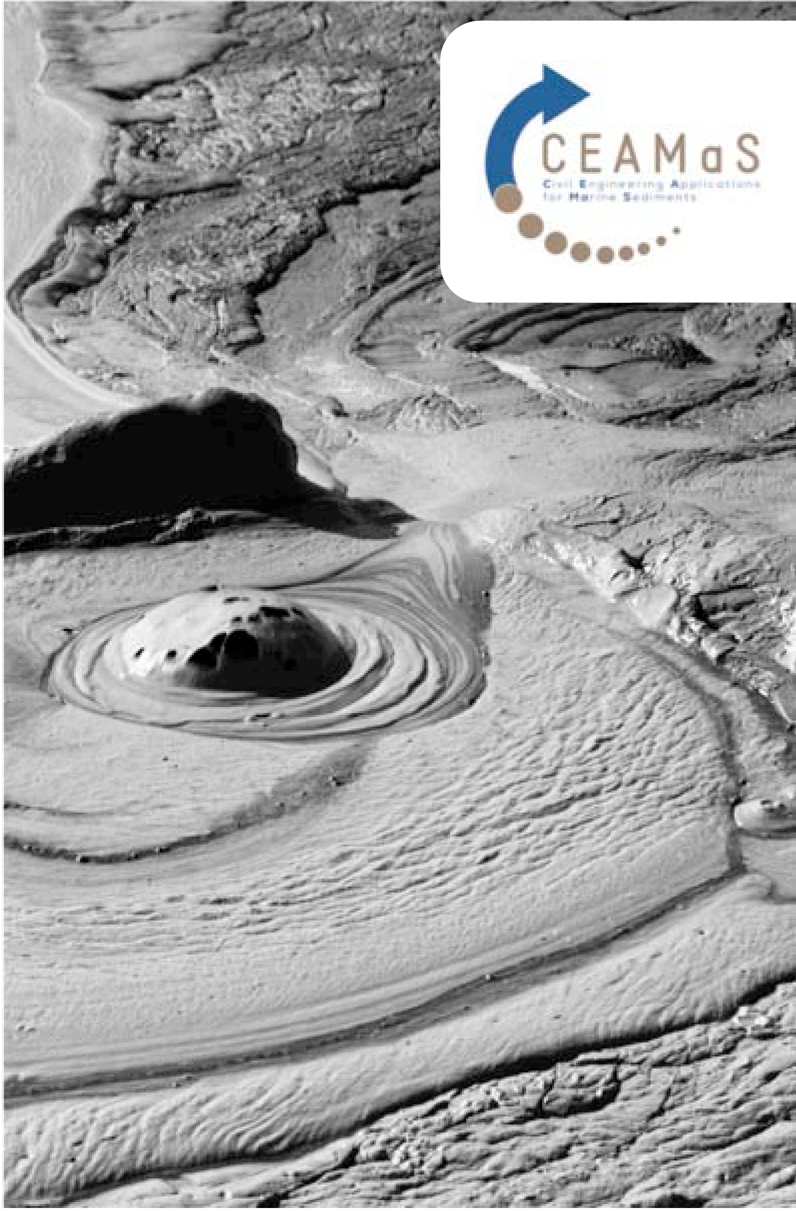
WWW.CEAMAS.EU

CONTEXT & OPPORTUNITY

- Sediment management
  - a major issue in Europe (cost – volume – environmental risk)
- Diffuse sediment expertise
  - associations, networks, public agencies, academics, operators, sites owners, users...
- Networks & competence centres specialised in
  - techniques/ science
  - sediment management / legislation issues
- No network focusing on territorial development and economic global vision

Opportunity for a network/resource centre for circular economy development with sediment reuse

Thanks for your attention



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