



SEDNET CONFERENCE

6 November - LISBOA

European project SETARMS

Sustainable, Environmental Treatment And Reuse of Marine
Sediments
(2009-2013)



Nathalie DUMAY, APLM- dumaynathalie@cg22.fr





SOMMAIRE

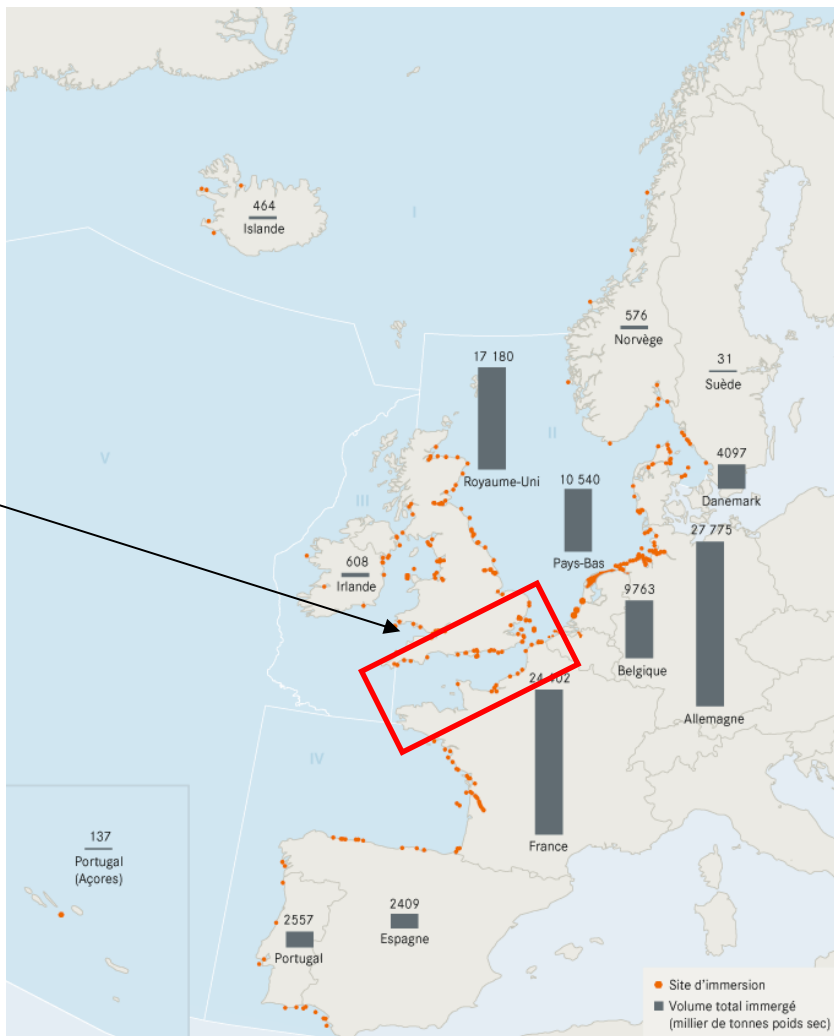
- Introduction
- Main objectives
- Partnership
- Work Packages (WP)
- Results



Introduction

Volumes of sediments dredged in Europe

Channel area



By Ospar Committee

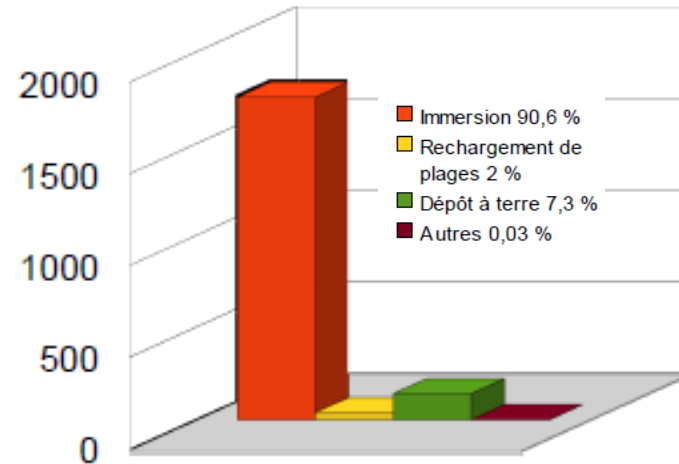




Introduction

Background in France

- 50 Mm³/year
- 90,6% dumped at sea
- 7,3% stored on land
- 3% beach nourishment
- 25 dumping sites in the Channel



Background in England

- 19,4 Mm³/year
- More than 95% dumped at sea
- 1% stored on land
- 27 immersion sites in the channel





Introduction

Today, the dredging operations, have to confront difficulties such as:

- ➡ **Regulations** (more and more detailed and strict)
- ➡ **Financial** (cost of the dredging operations and treatment if needed)
- ➡ **Environmental** (Thresholds of contamination, New Protected Marine Areas...)
- ➡ **Scientific and Technical** (*treatment and means of re-use*)
- ➡ **Social** (strong opposites of the fishers and the Environmental Association against the dredging operations,...)



Main objectives

- Have a better knowledge of the dredged sediments in the Channel and beyond
- Develop and promote the sustainable practices of the sediments management at economical, environmental and sociological levels -> re-used in sublayer road
- Develop and provide crossborder management tools
- Create a center of excellence and long-term relationships between all the partners.



Presentation

The SETARMS project:

- The Setarms project was selected under the European Cross-border Cooperation Programme INTERREG IV A France (Channel) – England
- Match-funded by the European Regional Development Funding

A Project which brings together most of the stakeholders concerning by the dredging operations in the Channel:

- *Scientists, School of Engineers*
- *Local authorities*
- *Port authorities*
- *Industrial business*

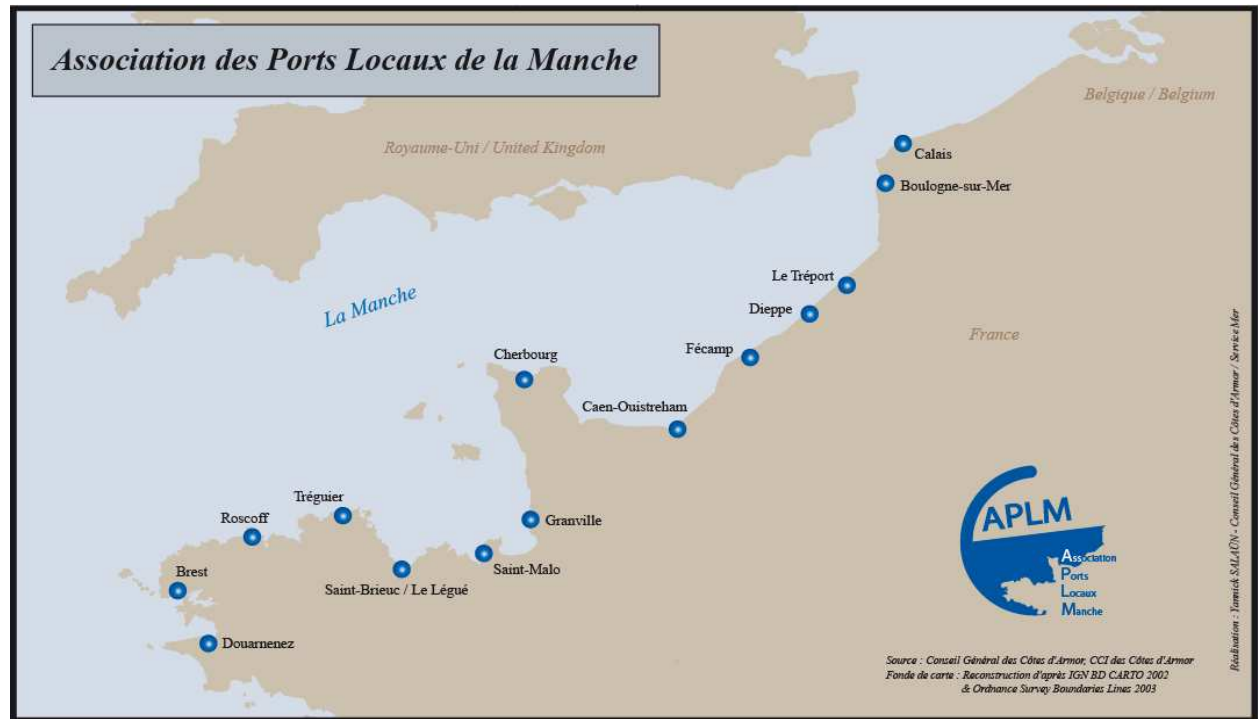


SETARMS budget: **5.2 M €**
(2009-2014)



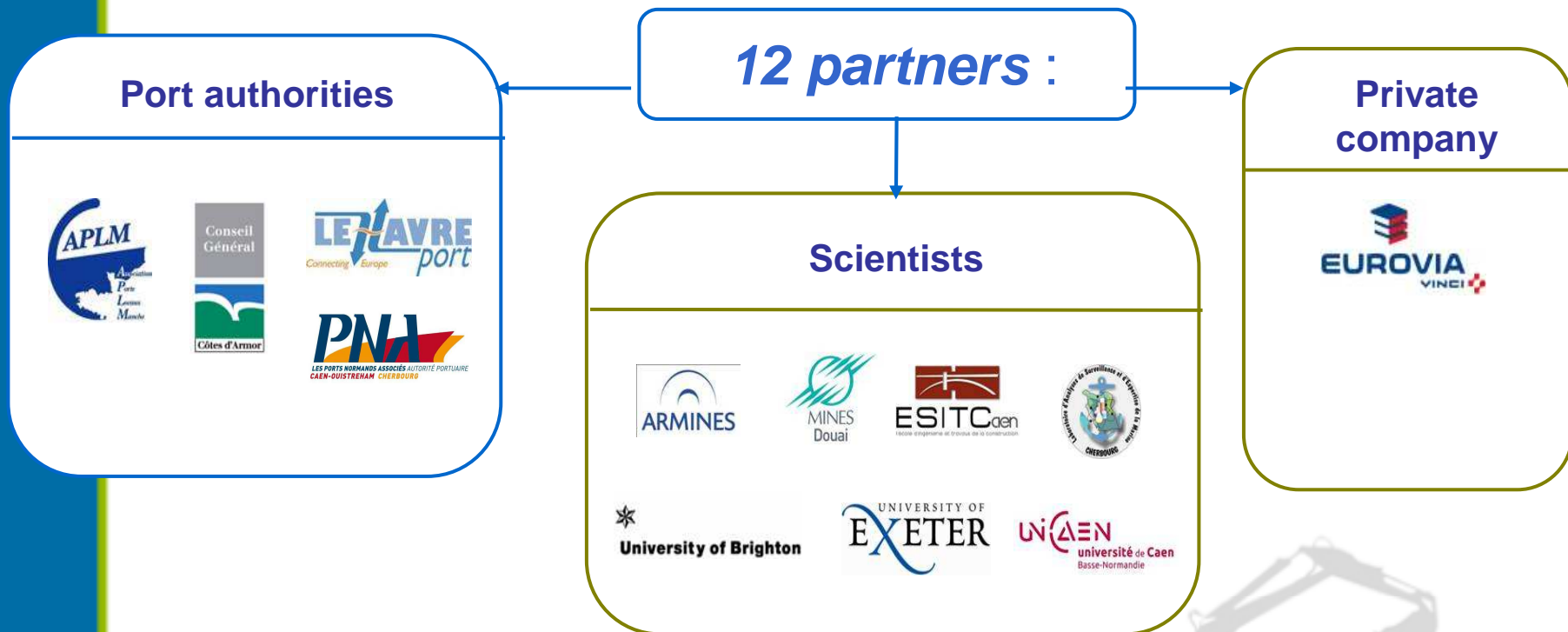
The partnership: the lead partner

- **14 ports of commerce**
- **Members:**
 - 8 local authorities
 - 11 port operators
(chambers of commerce)
- **Traffic: 55 millions tonnes**





The partnership





4 Work packages

➔ **WP1: Overview of the dredging in the Channel**

WP leader: APLM

➔ **WP2: Sediment Characterisation**

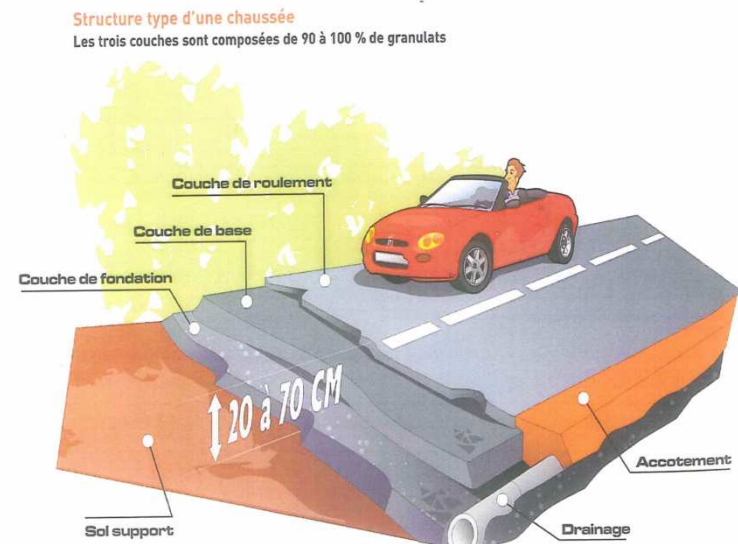
WP leader: University of Brighton

➔ **WP3: Sediments re-used**

WP leader: ESITC

➔ **WP4: Communication**

WP leader: APLM



État des lieux du dragage en Manche / Overview of the dredging in the Channel

État des lieux du dragage en Manche

Overview of dredging in the Channel

- des fréquences variables selon les ports
- Variable frequencies according to ports
- des distances entre les sites d'immersion et le port hétérogènes et en augmentation
- Heterogeneous and increasing distances between the dumping sites and the ports
- Matériel mixte principalement utilisé
- Mixed equipment usually used
- Valorisation seulement sur des opérations uniques avec de faibles volumes
- Re-use only on single operations with low volume



Comparaison des réglementations françaises et anglaises

Comparison of French and English regulations

- Réglementation de plus en plus dense au niveau européen
- Ever denser regulations at European level
- Paramètres analysés différents entre la France et l'Angleterre
- Different parameters analysed in France and England
- Des sites d'immersion gérés différemment en France et en Angleterre
- Different management of the dumping sites in France and England
- Une réglementation en constante évolution
- A constantly evolving regulation

Potentiel de mutualisation

Evaluation of the potential for future collaboration

- Pré-requis technico-économiques à prendre en compte:
- Technical and economic prerequisites to take into account:
 - > Configuration portuaire (choix des engins) / Port outline (dredging equipment selection)
 - > Contraintes de calendrier: période d'immersion restreinte / Calendar constraints: short time window for dumping at sea
 - > Fréquence de dragage... Dredging frequencies...

- Achat en commun de matériel de dragage / Joint purchase of dredging devices
 - > Structures juridiques appropriées: syndicats mixtes et sociétés d'économie mixte
 - Appropriate juridical structures: syndical mixte et Sociétés d'Économie Mixte

| Type de matériel / Kind of equipment | DAM 1 000m ³ | DAM 500m ³ | Pontons + chaland |
|--|-------------------------|-----------------------|-------------------|
| Point mort théorique moyen (m ³) Theoretical break-even point | 500-628 000 | 329-408 000 | 284-360 000 |

- Marché commun de dragage / Joint tendering for dredging services
 - > Structures juridiques porteuses: centrale d'achat et groupement de commandes
 - Appropriate juridical structures: central purchasing bodies and tendering pools

| Zone / Area | Volumes (m ³) annualisés / per year | Coût par m ³ / Cost per m ³ | | |
|--------------------------------|---|---|----------|-----------|
| | | S.E. | T.E. | S.E. |
| Manche Est / Eastern Channel | 1 416 000 | 8 496 k€ | 9 912 k€ | 11 328 k€ |
| Manche Ouest / Western Channel | 188 487 | 1 133 k€ | 1 319 k€ | 1 588 k€ |

Enjeux environnementaux

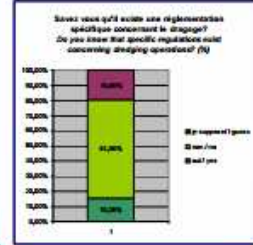
Environmental issues

- Pas de consensus en Europe sur les méthodes pour caractériser la dangerosité d'un sédiment
- No consensus in Europe on how to determine the hazard of sediment
- Prise en compte de plus en plus forte des enjeux environnementaux
- Increasing Consideration of environmental issues
- Durcissement de la réglementation concernant l'immersion des sédiments en France
- Tightening of regulations regarding disposal of sediments in France
- Grande variabilité sur la transposition des Directives européennes dans les différents pays européens
- Variability on the transposition of EU directives in the different European countries

Étude sociologique sur les opérations de dragage

Social Impact

- Méconnaissance du public sur la réglementation liée au dragage
- Lack of awareness of the public on dredging regulation
- Attente en termes d'information
- More information is expected



2010

2011

2012

2013

2014

Études bibliographiques

Bibliography

1er Échantillonnage: 11 ports échantillonnés

1st Sampling: 11 ports

Caractérisation géotechnique et géochimique

Geotechnical & geochemical characterization

Test d'une formulation en laboratoire

Laboratory Formulation

Réalisation d'une typologie des sédiments

Realization of a typology of the sediments

2ème échantillonnage: 4 ports sélectionnés

2nd sampling: 4 ports selected

Caractérisation géotechnique et géochimique

Geotechnical and geochemical characterization

Recherche de formulations en laboratoire et choix des formulations

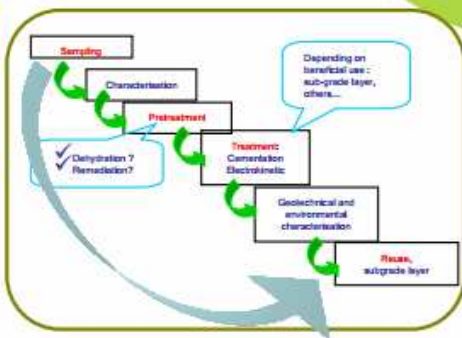
Research of formulations in laboratory and choice of the formulations

Mise en place de la voirie routière sur le site pilote

Implementation of the road in the field test

Suivi scientifique: Suivi géotechnique, Suivi chimique, Suivi minéralogique

Scientist monitoring: Geotechnical monitoring, Chemical monitoring, Mineralogical monitoring



Caractérisation chimique de sédiments bruts / geochemical characterization of the raw sediments

| | CEPAL | GEODE | ASH | SOET | COF | DAET | FOY | WDF |
|----|-------|-------|-----|------|-----|------|------|------|
| Cd | 0,4 | 2,4 | 8,5 | 15,4 | 2,8 | 15,4 | 6,75 | 0,69 |
| Cr | 49 | 186 | 23 | 1076 | 87 | 71 | 24 | 51 |
| Cu | 48 | 90 | 38 | 38 | 48 | 11 | 100 | 70 |
| Hg | 0,3 | 8,8 | 8,7 | 9,2 | 6,9 | 1,7 | 0,4 | 6,2 |
| Ni | 38 | 74 | 27 | 14 | 51 | 20 | 30 | 27 |
| Pb | 38 | 200 | 62 | 47 | 112 | 187 | 88 | 118 |
| Zn | 130 | 552 | 138 | 183 | 315 | 389 | 313 | 223 |

Classes de classification: silty loam, silty loam, silty loam, silty loam, sandy loam, sandy loam

- concentration below AL1
- Concentration between AL1 and N2
- Concentration exceeding N3

Formulation optimale / Optimum formulation

| composants | sediments | | sediment F |
|---|-----------|------|------------|
| | A | G | |
| Sédiment | 70% | 100% | |
| Correcteur granulaire / Particle size correction (sable / sand) | 30% | 0% | |
| Ciment / Cement | +15% | +6% | |
| Chaux / Lime | +3% | +3% | |



Caractérisation et Valorisation des sédiments en sous couche routière / Characterization and Re-use of the sediments in road sublayer



WP1: Overview in the dredging in the Channel

OBJECTIVES

- Define sustainable practices
- Suggest pooling solutions
- Suggest solutions to improve the knowledge of the general public on the dredging operations



WP1: Overview in the dredging in the Channel

ACTIONS

2010-2011

Action 1: Overview

- Study 1: Report of the Dredging methods and sediment re-used opportunities & Study of the Sediment typology, characterisation of the disposal at sea site (dumping site)
- Study 2: Compare French and English regulations and study of the differences of interpretation between all organisations in charge of regulations

2012

Action 2: Assessment of co-operation potential

Study 3: Identification of current and future needs and Assessment of the potential to share material and means

2013

Action 3: Study the environmental consequences and constraints of dredging as well as their social impact

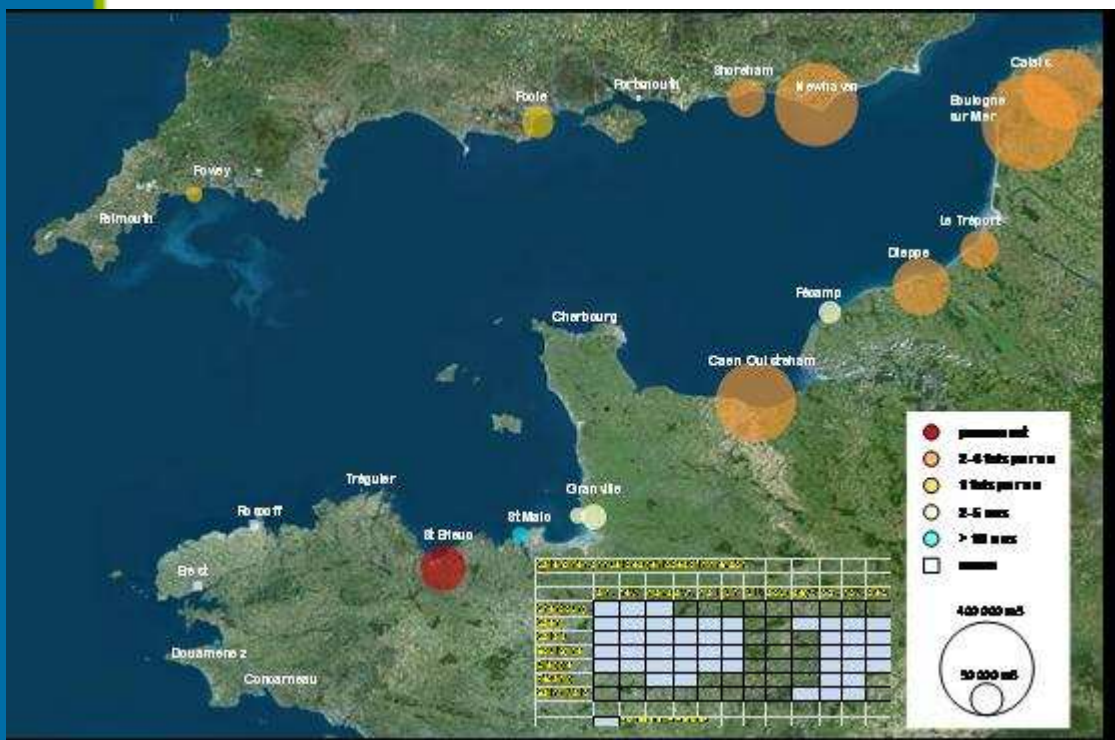
- Study 4 Study of the environmental stakes related to the dredging operations
- Study 5: Sociological study on the dredging operations.



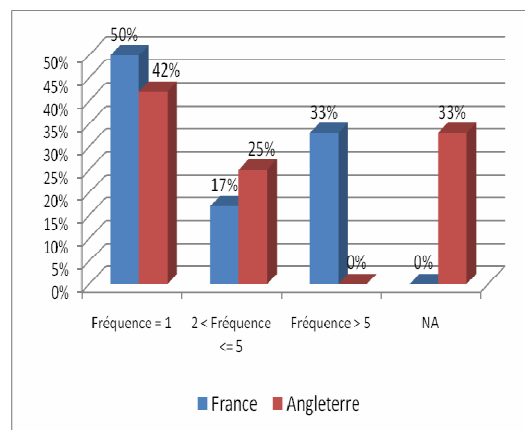


WP1: Overview in the dredging in the Channel

S-1-> Dredging methods



- Maintenance dredging frequency :



⇒ Information required to precise:

-> possibilities for the ports to pool their means

-> improvement of the dredging operations management regarding the maintenance dredging



WP1: Overview in the dredging in the Channel

S-1 -> Dredging methods

- Average Cost :

| Equipment used | FRANCE | England |
|------------------------------|---------------------|-------------|
| IMMERSION | | |
| Dragage Mécanique | [5-18] euros/m3 | |
| Dragage Hydraulique | [2,69- 20] euros/m3 | |
| Dragage Mixte | [2,29- 20] euros/m3 | |
| Storage on land | | |
| Rechargement de plage | | |
| Confinement (si à proximité) | 70 euros /m3 | 63 euros/m3 |
| Décharge de classe 1 | [200-300] euros/m3 | |

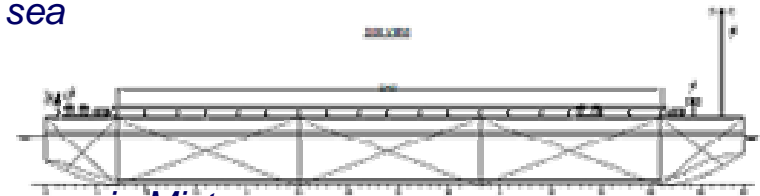


WP1: Overview in the dredging in the Channel

S-3 -> Assessment of the potential for future collaboration

-Technical and economic prerequisites to take into account:

- > Port outline (dredging equipment selection)
- > Calendar constraints : short time window for dumping at sea
- > Dredging frequencies...



1- Joint purchase of dredging devices

> Appropriate juridical structures : syndicat mixte et Sociétés d'Économie Mixte

| Type de matériel / kind of equipment | DAM 1 000m3 | DAM 500m3 | Ponton + chaland |
|---|----------------|--------------|---------------------|
| Point mort théorique moyen (m3) Theoretical break-even point | 500-628 000 | 329-408 000 | 284-360 000 |

2- Joint tendering for dredging services

> Appropriate juridical structures : central purchasing bodies and tendering pools

| Zone / Area | Volumes (m3) annualisés / per year | Coût par m3 / Cost per m3 | | |
|--------------------------------|--|-------------------------------|----------|----------|
| | | 6 € | 7 € | 8 € |
| | | Montant global / Total amount | | |
| Manche Est / Eastern Channel | 1 416 000 | 8 496 k€ | 9 912 k€ | 11 328k€ |
| Manche Ouest / Western Channel | 188 467 | 1 131 k€ | 1 319 k€ | 1 508 k€ |



WP1: Overview in the dredging in the Channel

| | Thresholds | Dumping at sea Marine Ecotoxicology | In land Management of the hazardous sediment |
|-----------------|---|--|---|
| Germany | 2 thresholds : North Sea Baltic sea | Yes (algues marines, bactéries luminescentes, amphipodes) | No validated protocol. Management case by case |
| The Netherlands | 1 threshold (except for 2 parameters) | Not used | No feedback |
| Belgium | 2 thresholds (with exclusion) | Yes (according to the international protocol) | No feedback |
| United Kingdom | 2 thresholds | Not used | No validated protocol. Management case by case |
| Ireland | 2 thresholds | Not used | No feedback |
| Norway | 4 thresholds | No feedback | Management case by case |
| Denmark | 2 2 thresholds (with exclusion) | Not used | Management case by case |
| Spain | 2 thresholds | Yes (palourdes, larves d'oursin, polychètes, copépodes, bactéries luminescentes) | No H14 protocol validated. |





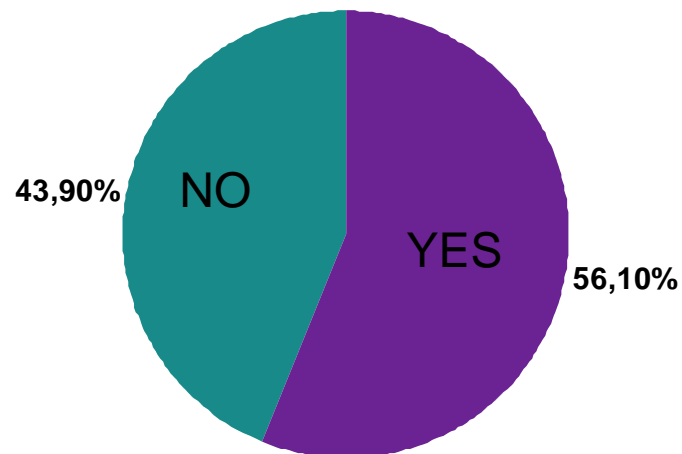
WP1: Overview in the dredging in the Channel

S-5 : Sociological study

- Methodology and Objectives

- Knowledge on what the French general public knows on the dredging
- Vox pop interviews of the general public (inhabitants of the municipality or in the neighbouring communes) (120 interviews)

- Question 1: Do you know what a dredging operation is?



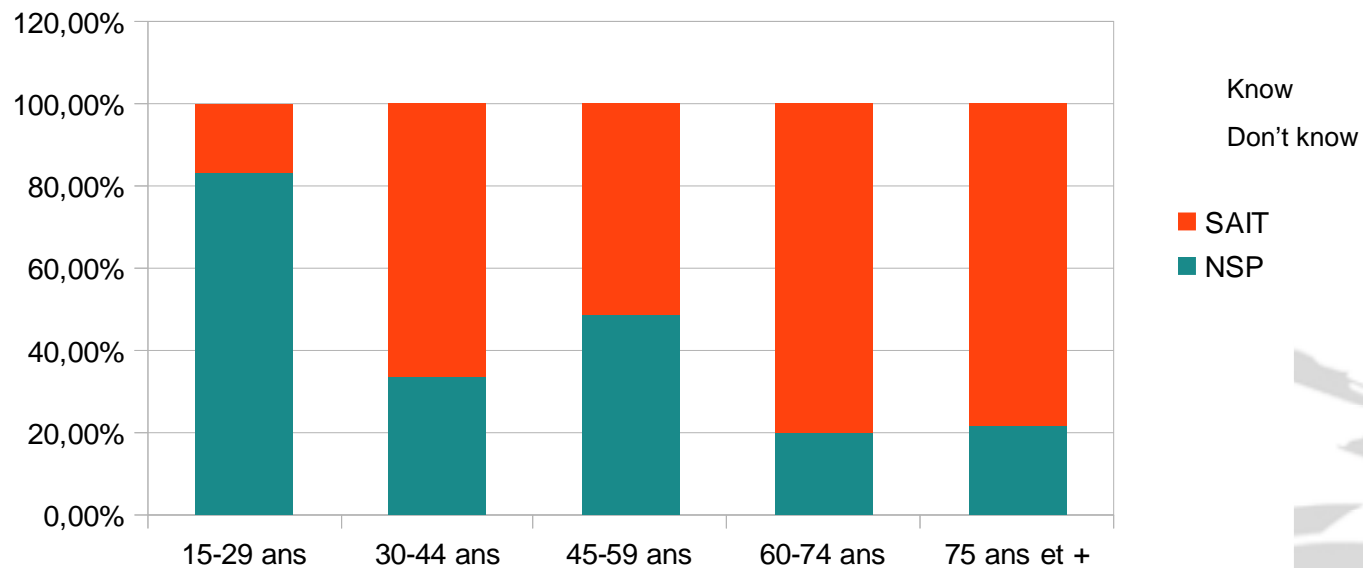


WP1: Overview in the dredging in the Channel

S-5 : Sociological study

- Question 2: Influence of the socio-economic variables?

Example of the age factor (%)



And the site investigation doesn't affect the answers



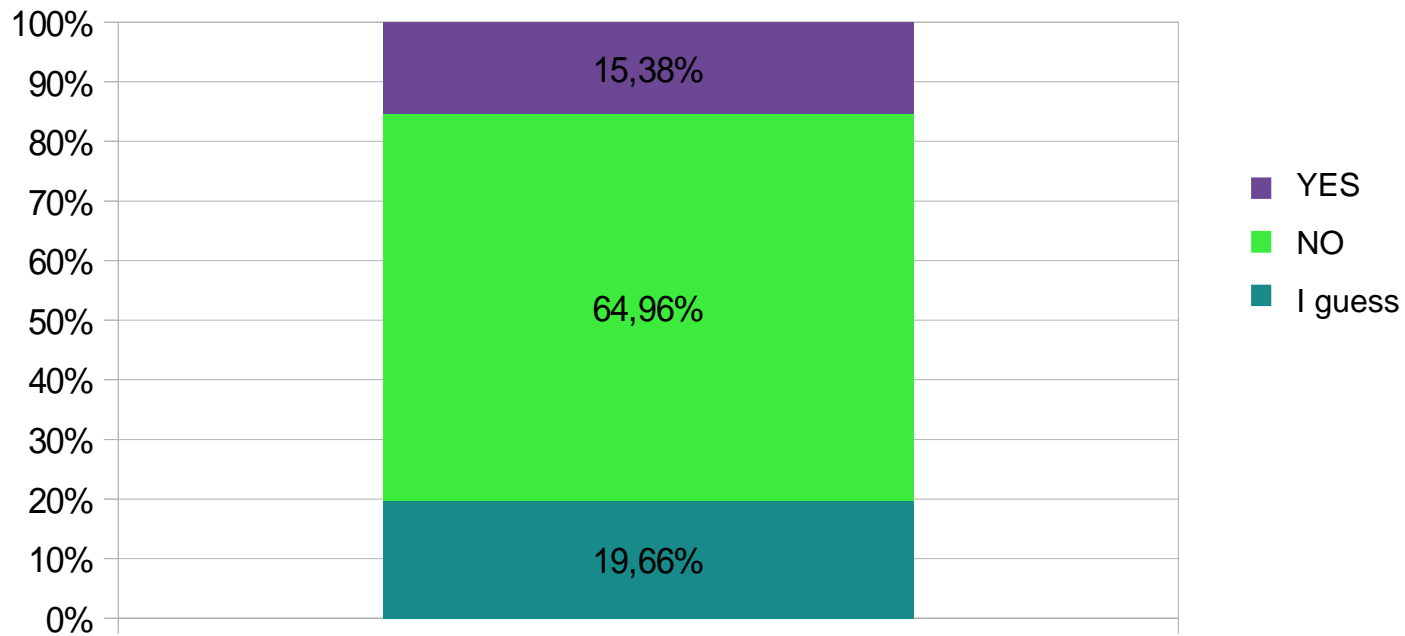


WP1: Overview in the dredging in the Channel

S-5 : Sociological study

- Question 4: Knowledge on the regulation?

Do you know that there is a specific regulation regarding the Dredging operations

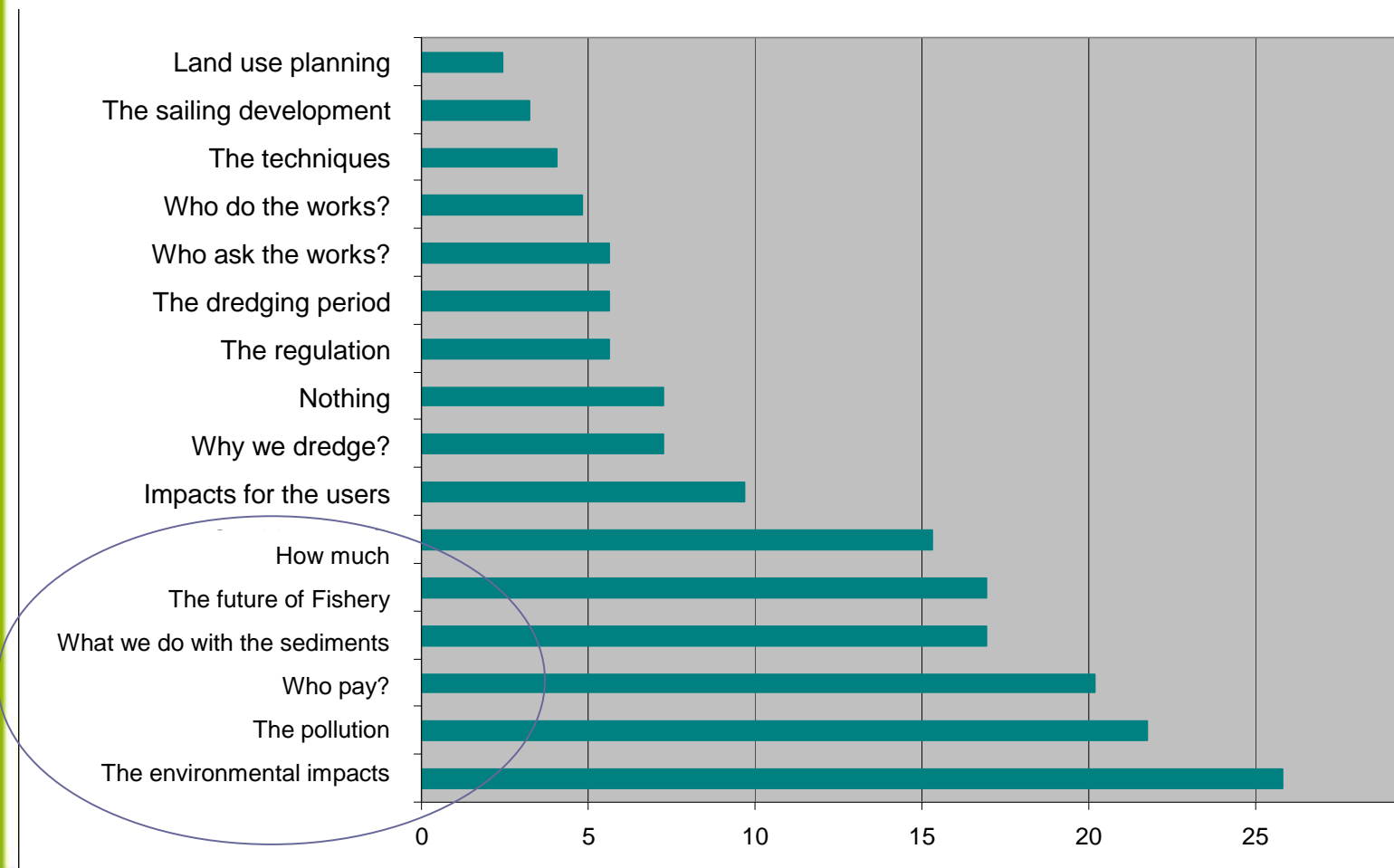




WP1: Overview in the dredging in the Channel

S-5 : Sociological study

- Question 8: You wish to be informed on....(%)?



The French needs in quarry materials

The french needs of quarry materials: 400 MT/year

Either:

-More 1 MT/day

- 7 tonnes/inhabitant/ year

-20 kg/inhabitants/days



WP₂ & WP₃: Characterisation and reused of the marine sediment



✓ *Les résultats présentés ici sont dus a différentes contributions / The results presented here come from different contributions.*



University of Brighton

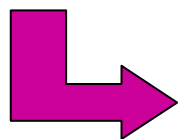


WP₂ & WP₃: Characterisation and reused of the marine sediment

setarms

Re-used of the contaminated sediment – Which difficulties ?

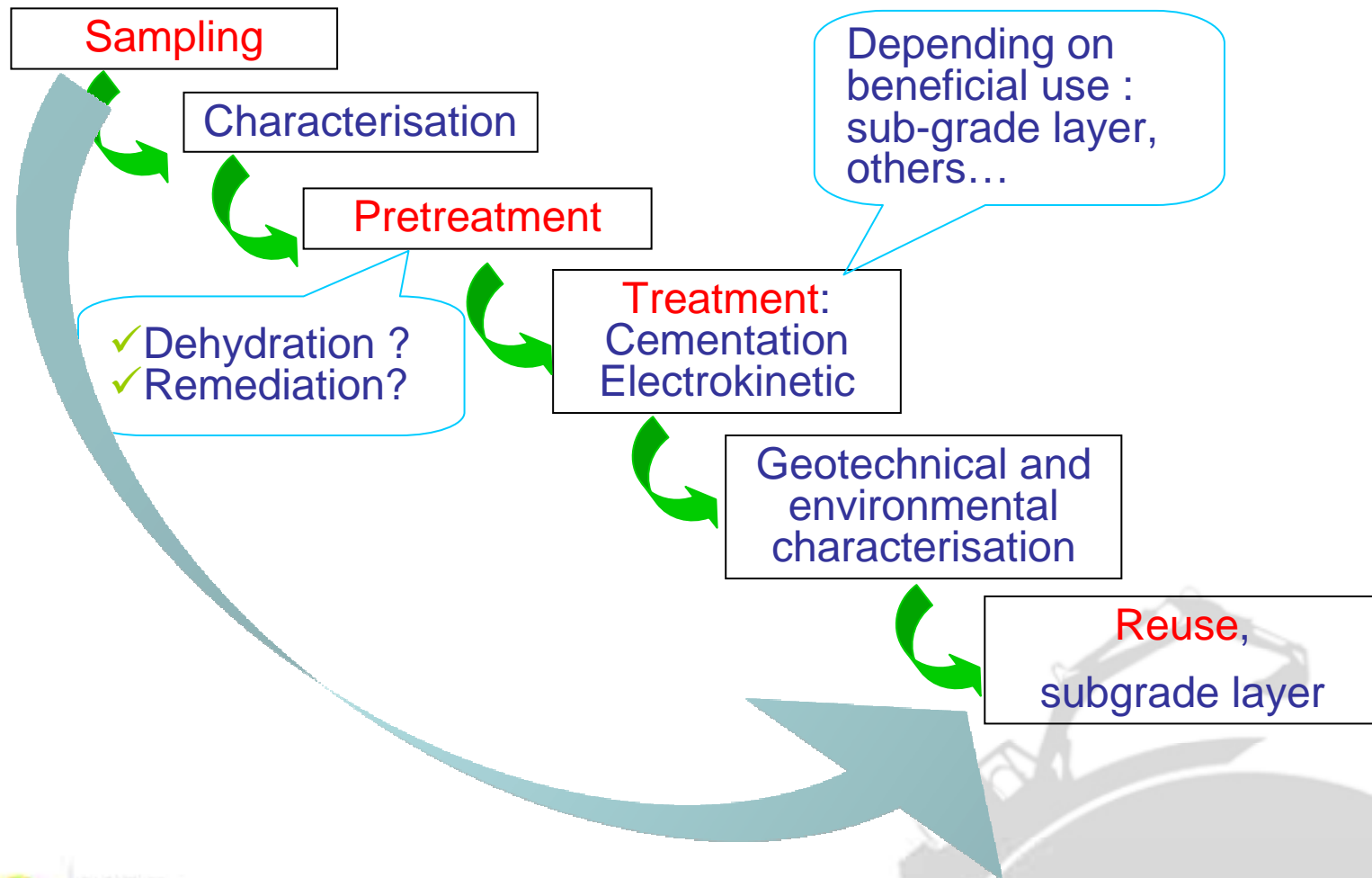
- Competition between the contaminated sediment and the high quality material => quality protocol required
- Availability of the material (when, where?)
- Proximity with the port required regarding the potential market ?
- Transport and handling costs?
- Refusal to use this material for some private companies (no wase in their project)



Need of having a better knowledge on our sediment to develop sustainable streams of reused.

WP₂ & WP₃: Characterisation and reused of the marine sediment

setarms



WP₂ & WP₃: Characterisation and reused of the marine sediment

setarms

**Sampling 1: 13 ports –
Sampling 2: 4 ports selected**



WP₂ & WP₃: Characterisation and reused of the marine sediment

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SETARMS Methodology (1/2)

✓ Sampling

0

Sed. A

Sed. B

Sed. ...

Sed. X

✓ Geochemical
charact. (WP2)
✓ Geotechnical
charact.(WP3)

1

1st level of classification, data base on sampled sediments:

- ✓ GEODE Levels (FR), CEFAS (UK) (WP1 et WP2)
- ✓ Circulaire 4 juillet 2008 (WP1 et WP2)
- ✓ Guides GTR, GTS (WP3)
- ✓ French guide on reuse of alternative materials Nov. 2010... (WP1, WP2 et WP3)
- ✓

WP₂ & WP₃: Characterisation and reused of the marine sediment

setarms

SETARMS Methodology (2/2)

- ✓ Step 1 results analysis
- ✓ Treatments and formulations (WP3)
- ✓ Geochemical analysis (WP2)

2

- 1 formulation : 3 % Lime + 6 % CEM II/B 32.5
- ✓ Pretreatment: sieving 0/20 mm, dehydration, lime fixation point, Proctor test, suitability test (WP3)
 - ✓ Mechanical behavior (subgrade layer, GTS 2000) (WP3)
 - ✓ Environmental impact (WP2)
 - ✓ Additional analysis: DRX, MEB, geotechnical... (WP2 et WP3)

- ✓ Step 2 results analysis
- ✓ Selection and sed/treatm choice

3

- Sediments or mix of sediments eligible
- Adapted pretreatment
- Adapted formulation in the lab
- Pilot site preparation: experimental road.

WP₂ & WP₃: Characterisation and reused of the marine sediment



Geochemical methodology

REGULATION APPROACH

- ✓ **FRACTION < 2 MM**
- ✓ **CLASSIFICATION ACCORDING TO CEFAS ET GEODE**
- ✓ **CLASSIFICATION ACCORDING TO THE THRESHOLDS used for the landfills**
- ✓ **SETRA : GUIDE REGARDING THE ENVIRONMENTAL ACCEPTABILITY OF THE ALTERNATIVES MATERIALS IN ROAD TECHNIQUES**

EXPERIMENTAL APPROACH :

- ✓ **CHEMICO PHYSICAL AND MINERALOGICAL CHARACTERISTICS**
- ✓ **STDY OF THE MOBILITY OF POLLUTANTS BY THE CHEMICAL EXTRACTIONS**



Résultats géochimiques

Geochemical results on raw sediment



setarms

- ✓ Paramètres physico-chimiques de base
- ✓ Physicochemical parameters

| Paramètres | Unité | A001 | B001 | C001 | D001 | E001 | F001 | G001 | M001 |
|--|-------|---|---|---|---|---|---|---|---|
| Azote Kjeldahl <i>NitrogenTK</i> | g/kg | 2,5 | 1,4 | 3,6 | 1,1 | 4,9 | 5,3 | 1,8 | 6,6 |
| Phosphore <i>Phosphorus</i> | g/kg | 1,2 | 0,5 | 1,9 | 0,7 | 1,2 | 2,7 | 0,7 | 1,5 |
| Casagrande classification | | Limon fin / <i>silty loam</i> | Limon fin / <i>silty loam</i> | Limon fin / <i>silty loam</i> | Limon fin / <i>silty loam</i> | Limon fin / <i>silty loam</i> | Limon sableux / <i>sandy loam</i> | Limon fin / <i>silty loam</i> | Limon sableux / <i>sandy loam</i> |

Résultats géochimiques

Geochemical results on raw sediment



setarms

- ✓ Classification : GEODE
- ✓ Sediment classification according French regulation

| mg/kg MS | GEODE N1 | GEODE N2 | A001 | B001 | C001 | D001 | E001 | F001 | G001 | M001 |
|----------|----------|----------|------|------|------|------|------|------|------|------|
| Cd | 1,2 | 2,4 | 0,5 | <0,4 | 2,0 | <0,4 | 0,80 | 0,75 | <0,4 | 0,69 |
| Cr | 90 | 180 | 52 | 259 | 87 | 34 | 38 | 54 | 32 | 31 |
| Cu | 45 | 90 | 38 | 26 | 68 | 91 | 121 | 121 | 73 | 70 |
| Hg | 0,4 | 0,8 | 0,7 | <0,1 | 0,3 | 2,7 | 0,2 | 0,4 | 0,2 | 0,2 |
| Ni | 37 | 74 | 27 | 14 | 51 | 20 | 24 | 30 | 23 | 27 |
| Pb | 100 | 200 | 62 | 47 | 112 | 187 | 88 | 88 | 61 | 110 |
| Zn | 276 | 552 | 138 | 103 | 315 | 208 | 427 | 313 | 137 | 223 |



Concentration < N1
 N1 < Concentration < N2
 Concentration > N2

4 sédiments avec dépassement niveaux N2
 4 sediments : concentrations exceeding N2

Résultats géochimiques

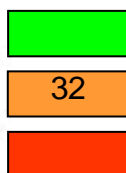
Geochemical results on raw sediment



setarms

- ✓ Classification : CEFAS
- ✓ Sediment classification according english regulation

| mg/kg MS | AL1 | AL2 | A001 | B001 | C001 | D001 | E001 | F001 | G001 | M001 |
|----------|-----|-----|------|------|------|------|------|------|------|------|
| Cd | 0,4 | 5 | 0,5 | <0,4 | 2,0 | <0,4 | 0,80 | 0,75 | <0,4 | 0,69 |
| Cr | 40 | 400 | 52 | 259 | 87 | 34 | 38 | 54 | 32 | 31 |
| Cu | 40 | 400 | 38 | 26 | 68 | 91 | 121 | 121 | 73 | 70 |
| Hg | 0,3 | 3 | 0,7 | <0,1 | 0,3 | 2,7 | 0,2 | 0,4 | 0,2 | 0,2 |
| Ni | 20 | 200 | 27 | 14 | 51 | 20 | 24 | 30 | 23 | 27 |
| Pb | 50 | 500 | 62 | 47 | 112 | 187 | 88 | 88 | 61 | 110 |
| Zn | 130 | 800 | 138 | 103 | 315 | 208 | 427 | 313 | 137 | 223 |



Concentration < AL1
 AL1 < Concentration < AL2
 Concentration > AL2

Pas de dépassement seuils AL2
 No concentrations exceeding AL2

Résultats géochimiques

Geochemical results on raw sediment



setarms

- ✓ Classification : GEODE (pas de niveaux CEFAS)
- ✓ Sediment classification according French regulations (no CEFAS levels)

| µg/kg MS | GEODE N1 | GEODE N2 | A001 | B001 | C001 | D001 | E001 | F001 | G001 | M001 |
|------------|----------|----------|------|------|------|------|------|------|------|------|
| PCB28 | 25 | 50 | <8 | <7 | <7 | <8 | 10 | <7 | <7 | <7 |
| PCB52 | 25 | 50 | <8 | <8 | 20 | <8 | 60 | 14 | 9 | <7 |
| PCB101 | 50 | 100 | 14 | <8 | 25 | 12 | 90 | 25 | 17 | 7 |
| PCB118 | 25 | 50 | 11 | <7 | 13 | 8 | 80 | 24 | 12 | <7 |
| PCB138 | 50 | 100 | 13 | <8 | 23 | 17 | 80 | 34 | 23 | 8 |
| PCB153 | 50 | 100 | 19 | 9 | 28 | 21 | 90 | 39 | 27 | 10 |
| PCB180 | 25 | 50 | 8 | <8 | 16 | 13 | 50 | 30 | 13 | 7 |
| PCB totaux | 500 | 1000 | 73 | 28 | 66 | 44 | 460 | 170 | 105 | 43 |

| | |
|--|-------------------------|
| | Concentration < N1 |
| | N1 < Concentration < N2 |
| | Concentration > N2 |

1 sédiment : dépassement niveaux N2
 1 sediment : concentrations exceeding N2



Résultats géochimiques

Geochemical results on raw sediment

setarms

- ✓ Classification : IFREMER (pas de niveaux CEFAS)
- ✓ Sediment classification according French levels (no levels CEFAS)



Accréditation
n°1-1669

| mg/kg MS | N1 | N2 | A001 | B001 | C001 | D001 | E001 | F001 | G001 | M001 |
|------------------------|------|----|------|------|------|------|------|------|-------|------|
| Acénaphène | 0,11 | | 0,03 | 0,03 | 0,14 | 0,35 | 0,06 | 0,05 | 0,05 | 0,08 |
| Anthracène | 0,51 | | 0,12 | 0,05 | 0,20 | 0,63 | 0,10 | 0,13 | 0,06 | 0,11 |
| Benzo(a)anthracène | 0,71 | | 0,22 | 0,26 | 0,94 | 2,26 | 0,32 | 0,33 | 0,27 | 0,73 |
| Benzo(a)pyrène | 0,20 | 1 | 0,26 | 0,31 | 0,91 | 2,93 | 0,31 | 0,36 | 0,34 | 0,73 |
| Benzo(b)fluoranthène | 0,30 | 3 | 0,31 | 0,30 | 1,07 | 2,78 | 0,27 | 0,47 | 0,32 | 1,33 |
| Benzo(ghi)pérylène | 0,20 | 1 | 0,22 | 0,24 | 0,59 | 1,89 | 0,17 | 0,30 | 0,25 | 0,63 |
| Benzo(k)fluoranthène | 0,20 | 2 | 0,13 | 0,17 | 0,48 | 1,11 | 0,15 | 0,18 | 0,17 | 0,44 |
| Chrysène | 1,01 | | 0,20 | 0,27 | 1,02 | 2,45 | 0,36 | 0,34 | 0,31 | 0,92 |
| Dibenzo(ah)anthracène | 0,10 | | 0,05 | 0,04 | 0,11 | 0,38 | 0,03 | 0,03 | 0,04 | 0,12 |
| Fluoranthène | 0,40 | 5 | 0,49 | 0,48 | 1,99 | 5,68 | 0,70 | 0,78 | 0,54 | 1,70 |
| Fluorène | 0,17 | | 0,03 | 0,06 | 0,33 | / | 0,10 | 0,15 | 0,07 | 0,21 |
| Indéno(1,2,3,cd)pyrène | 0,20 | 1 | / | 0,29 | 0,63 | 1,92 | 0,26 | 0,26 | 0,27 | 0,67 |
| Naphtalène | 0,21 | | 0,05 | 0,10 | 0,16 | 0,67 | 0,31 | 0,25 | 0,04 | 0,04 |
| Phénanthrène | 1,01 | | 0,17 | 0,23 | 1,05 | 3,28 | 0,38 | 0,57 | <0,03 | 0,67 |
| Pyrène | 1,51 | | 0,32 | 0,40 | 1,55 | 4,55 | 0,63 | 0,61 | 0,47 | 1,21 |



Concentration < N1
N1 < Concentration < N2
Concentration > N2

1 sédiment : dépassement niveaux N2
1 sediment : concentrations exceeding AL2



Conclusion



- ✓ Métaux : concentrations $> N2$ pour 4 sédiments – pas de dépassement AL2
- ✓ Metals : concentrations $> N2$ for 4 sediments – no concentration $> AL2$
- ✓ PCB : faible niveau de concentrations à l'exception d'un port (concentrations $> N2$)
- ✓ PCB : low level of concentrations, except one harbour (concentrations $> N2$)
- ✓ HAP : concentrations $> N1$ et $> N2$ pour un port
- ✓ PAH : concentrations $> N1$ and $> N2$ for one harbour





Conclusion



- ✓ Concentrations en polluants des 8 sédiments dépendent de facteurs :
- ✓ Présence d'activité industrielle
- ✓ Type de zone de prélèvement (fermée ou ouverte sur la mer)
- ✓ Moyens de prélèvement (profondeur)
- ✓ Fréquence des opérations de dragage
- ✓ Granulométrie

- ✓ Contaminants concentration of 8 sediments are variable and depends of :
- ✓ Industrial activity
- ✓ Type of sampling area (closed or opened)
- ✓ Sampling methods (depth)
- ✓ Frequency of sediments dredging
- ✓ Grain size



Résultats de l'étude de mobilité

Mobility study results on raw sediment

SIMPLES EXTRACTIONS

PRECAUTIONNARY
PRINCIPLE :
IDENTIFICATION of the
most aggressive
extractants

Cd, Cr, Ni ET Zn : **HCl**

AS : **HCl** ET **NaOH**

Cu ET Pb : **EDTA**

SEQUENTIAL EXTRACTION

Compounds are mainly
located in in the acid
soluble fraction, oxydable
and reducible.

So suggest that th mobility
of the sediment is closely
linked to conditions of the
pH and redox potential

KINETIC EXTRACTION

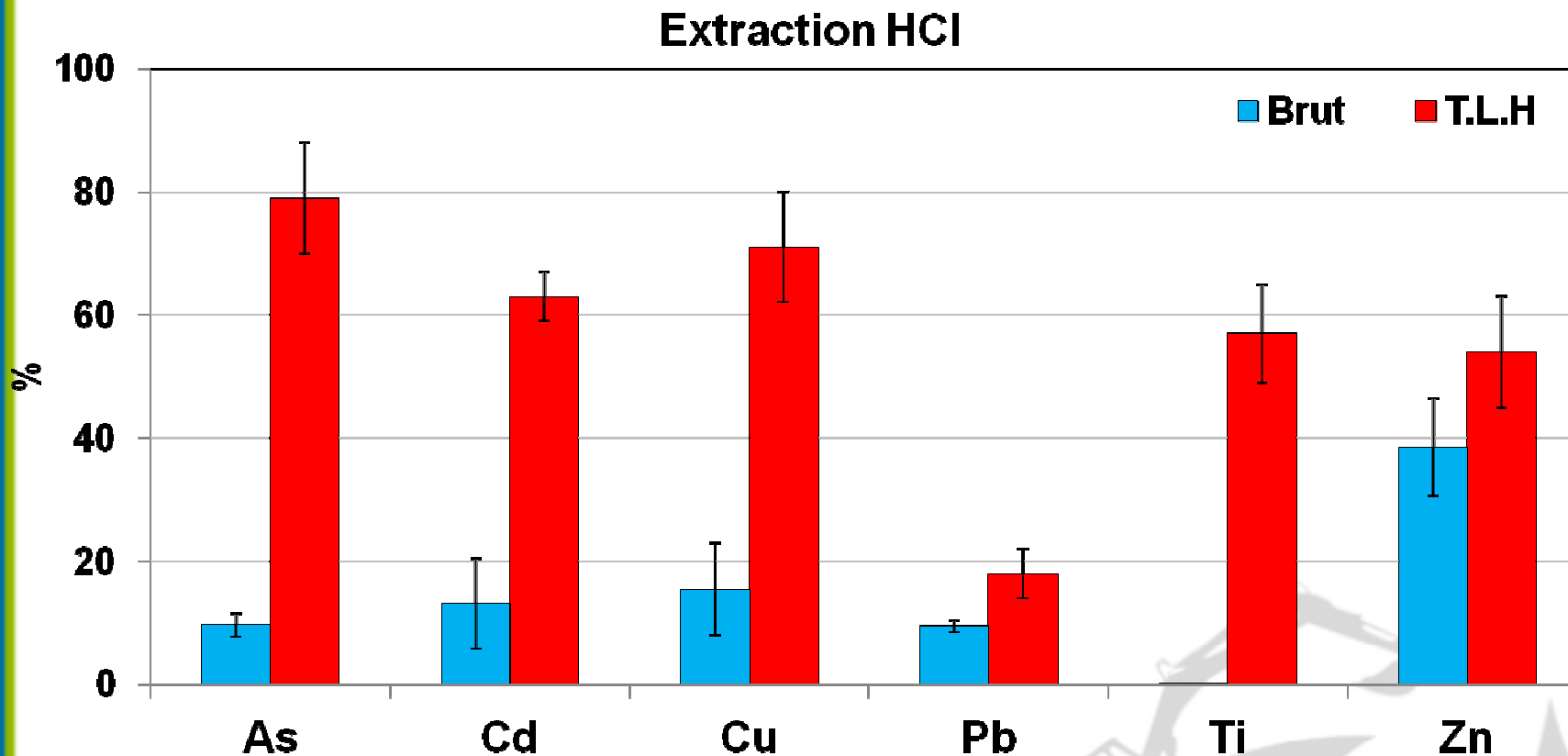
THE TIME CRITERIA TO
ASSESS THE MOBILITY
OF THE ELEMENTS

THIS RESULTS
SHOWS an
understatement of the
mobility and potentially
a higher risk on the
long term

**As, Cu, Lead and Zinc present the most important
mobilities.**



After 180 days of treatment: D 001 monitoring : Chlorine hydroxyde extraction (HCl)



The compounds mobility increase after the hydraulic binders handling (180 days) on the D001 sediment.



Résultats géotechniques

Geotechnical results on raw sediments

GTR classification

Ranking

Fine soils, Class A :

A001, A002, B001, C001, C002, D001, E001, F001,
G001, G002, M001

Fine soils with bid with large elements
Class C :

F002

Sub classes

Sub classes

A₁ :

B001, C001,
D001, E001,
G001, G002,
M001

A₃ :

A001

A₄ :

A002, C002,
F001

C₁B₅ :

F002



Results on raw sediment and methodology regarding the handlings

- Reminder of the detailed ranking obtained :
 - Class A_1F_{11} : B001, D001, G001, G002
 - Class A_1F_{12} : C001, E001, M001
 - Class A_3F_{12} : A001
 - Class A_4F_{11} : A002
 - Class A_4F_{12} : C002, F001
 - Class C_1B_5 : F002

- Methodology :
 - Choose a formulation to apply to all sediments of the first sampling (X001)
 - Define one or more optimal formulations
 - Apply to the sediments (X002) to check their relevance before the pilot site implementation.





Première formulation First treatment

- Determination of the attachment point of the lime allowing the hydrates formation
→ 3 % Proviacal[®] DS Lime (Lhoist)
- GTR Recommendation : 7 % for the class A soils
→ 6 % cement CEMII/B (S-LL) 32,5R (Calcia)



WP₂ & WP₃: Characterisation and reused of the marine sediment

setarms

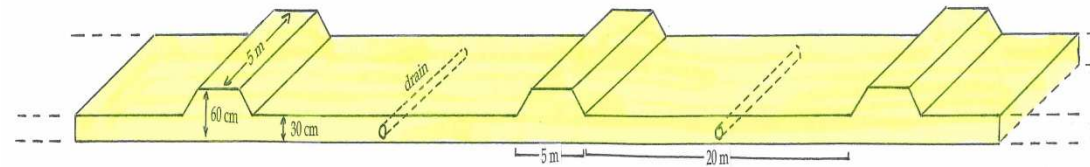
Results on the Formulation studies on the 4 selected sediments A002, C002, F002 et G002 :

- The formulation 70% Sed + 30% Sand + 3% lime + 15% cement- ROLAC allow to obtain the best results on A001, C001 et G001 sediments:
- The formulation 100% Sed + 6% cement- ROLAC allow to obtain the best results on F001 sediment

WP2 et WP3: Field test -> different cells

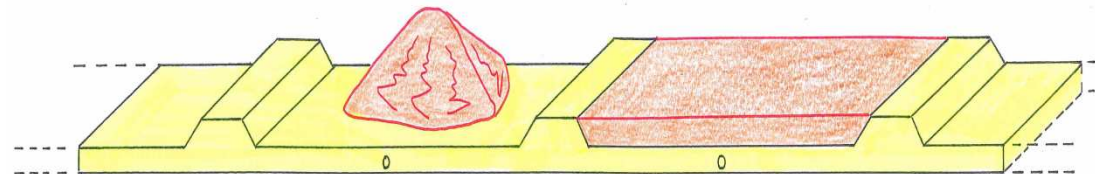


1 Préparation du terrain support : décapage, mise en œuvre de matériaux, compactage puis mise en place d'une couche de 30 cm de sable « neutre » et incompressible avec création des emplacements des futures planches d'essai équipées d'un drain.

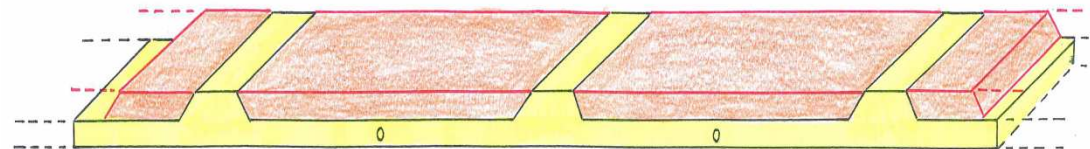


2 Stockage des sédiments.

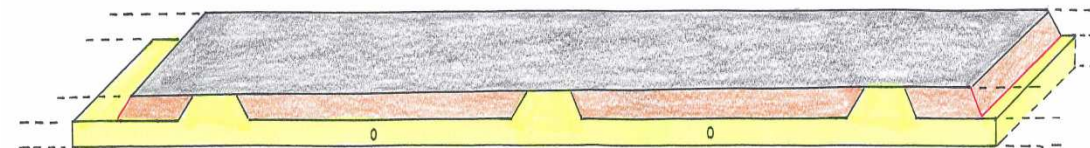
3 Régalez des sédiments dans chaque planche d'essai.



4 Ajout d'une couche de sable correcteur si nécessaire puis apport de liant et malaxage par atelier de traitement de sol.



5 Réalisation d'un enduit bicouche à l'émulsion pour 5 planches d'essai et d'un enrobé drainant pour une planche, puis contrôles géotechniques (essais de portance ...).





2
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Préparation du site / Site preparation



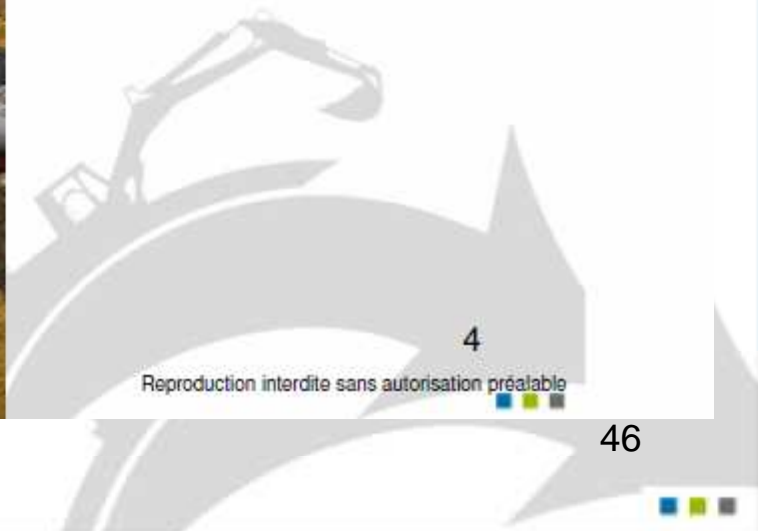
3

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Intel(R) Wi



Drainage / Drainage



Chaulage / Liming



- 
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5
Reproduction interdite sans autorisation préalable



Mixing procedure



Levelling operation



Compactage puis protection /
Compaction then protection



10
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FIELD TESTS

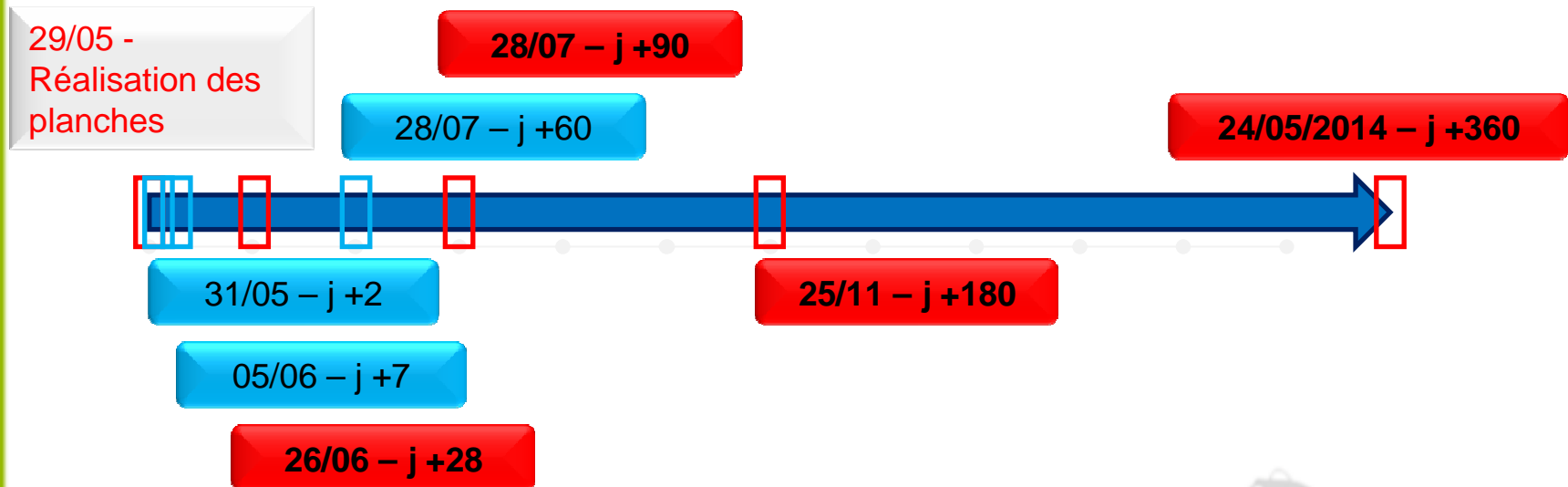


Suivi pluridisciplinaire / Multidisciplinary monitoring

| Échéance (j) | Suivi mécanique/microstructure (Eurovia, ESITC Caen-EMD-UoB-UoE) | | | | Suivi environnemental (ABTE + LASEM + sous-traitance) | | |
|-----------------|---|--------------------------------|---------------------------------------|------------------------------|--|------------------------------------|---------------------------------|
| | Essais géotech. (carottes) | Essais géotech. (éch. labo) | Essais géotech. (<i>in situ</i>) | Essais DRX-MEB (carottes) | Essais géochimiques (carottes) | Essais géochimiques (éch. labo) | Ruissellement et percolation |
| 2 | X | X | X | | | | |
| 7 | X | X | X | | | | |
| 14 | X | X | X | | | | |
| 28 | X | X | X | X | | | |
| 60 | X | X | X | | | | |
| 90 | X | X | X | X | X | X | X |
| 180 | X | X | X | X | | | |
| 360 | X | X | X | X | X | X | X |

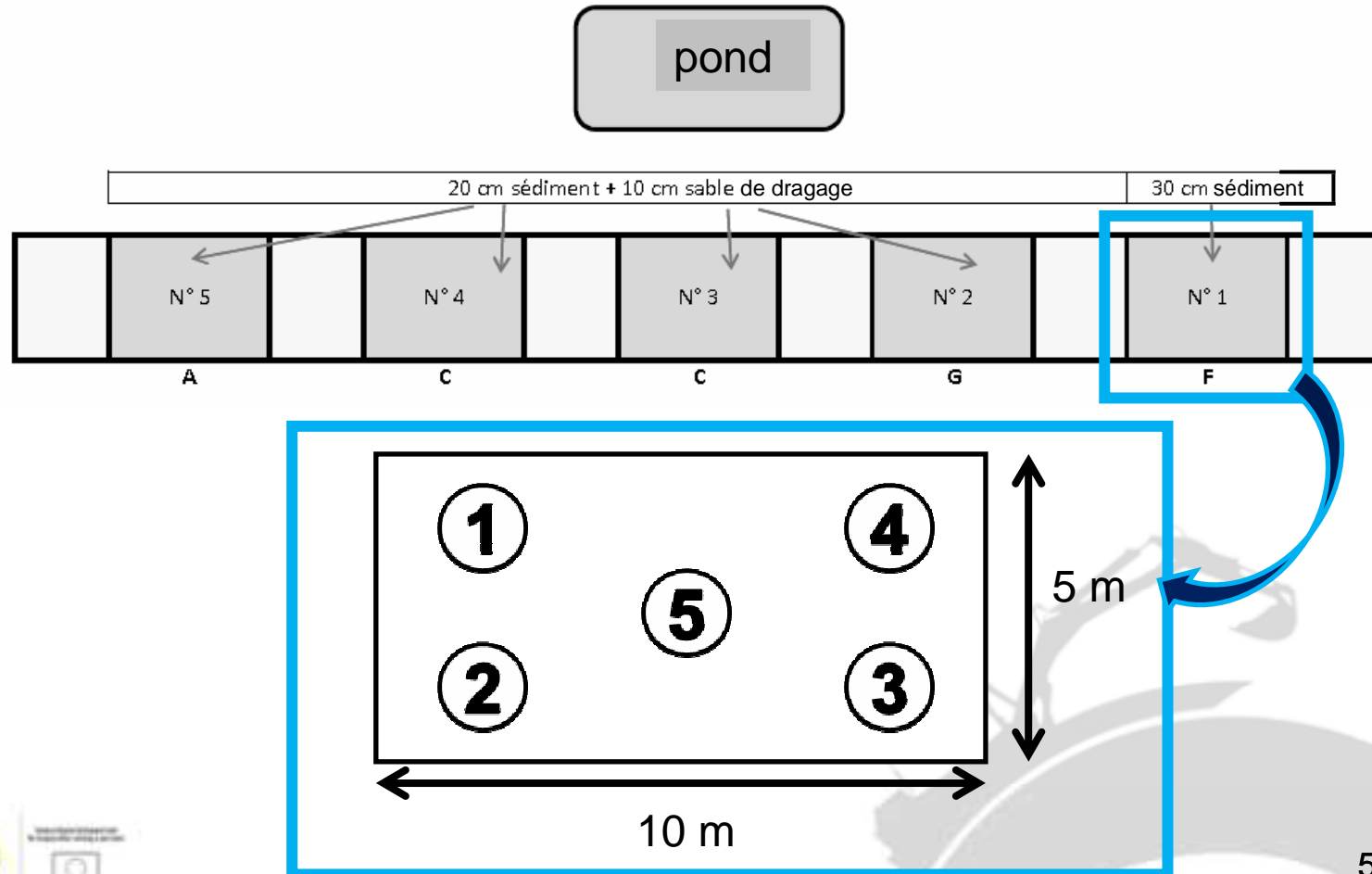
Suivi pluridisciplinaire / Multidisciplinary monitoring

Planning



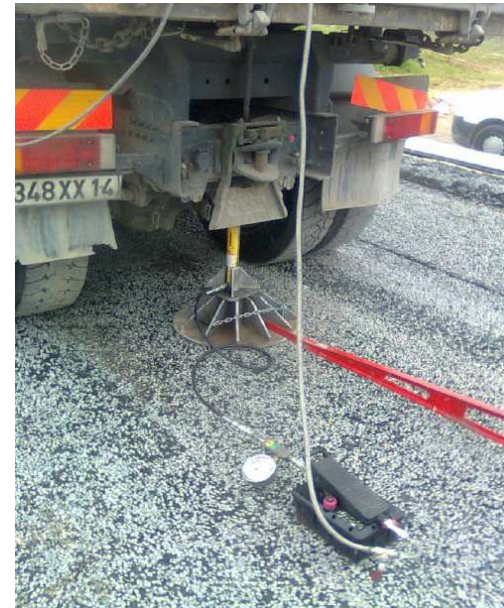
Suivi pluridisciplinaire / Multidisciplinary monitoring

Premises configuration



Suivi pluridisciplinaire / Multidisciplinary monitoring

In situ geotechnical tests : bearing capacity
Westergaard test
Eurovia





Suivi pluridisciplinaire / Multidisciplinary monitoring

Coring

Eurovia - ESITC Caen



ON THE CORES

Chemical

characterisation :
ABTE (UCBN), LASEM

Geotechnical

characterisation :
ESITC Caen, EMD

Minéralogical

characterisation :
Exeter, EMD



Suivi pluridisciplinaire / Multidisciplinary follow-up

Planches expérimentales

Essais *in situ*

Portance

*Essais parallèles
sur éprouvettes de
laboratoire*

Géotechnique

Performances
mécaniques

Carottes

Microstructure

DRX

MEB

QEMSCAN

Physico-chimie

Minéralisation
acide

Lixiviation
EUP

Concentrations élémentaires et anioniques

Eaux de percolation

WP₂ & WP₃: Characterisation and reused of the marine sediment

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1 final guideline: technical guide

With 5 interim reports :

- Report 1: Presentation of the background and the approaches
- Report 2: Presentation of the results of the analyses on the rough sediment
- Report 3: pre-treatment and handling – Choice of the samples for the field test
- Report 4: results on the handlings and analyses on the handled sediments
- Report 5: field tests results





Merci pour votre attention

Thank you for your attention



Contact :
DUMAYNathalie@cg22.fr