CASE STUDY — ENDING A LNAPL REMEDIATION

INTERSOL 2016

OLIVIER CORRÈGE

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CASE STUDY — ENDING A LNAPL REMEDIATION

SITE CONTEXT

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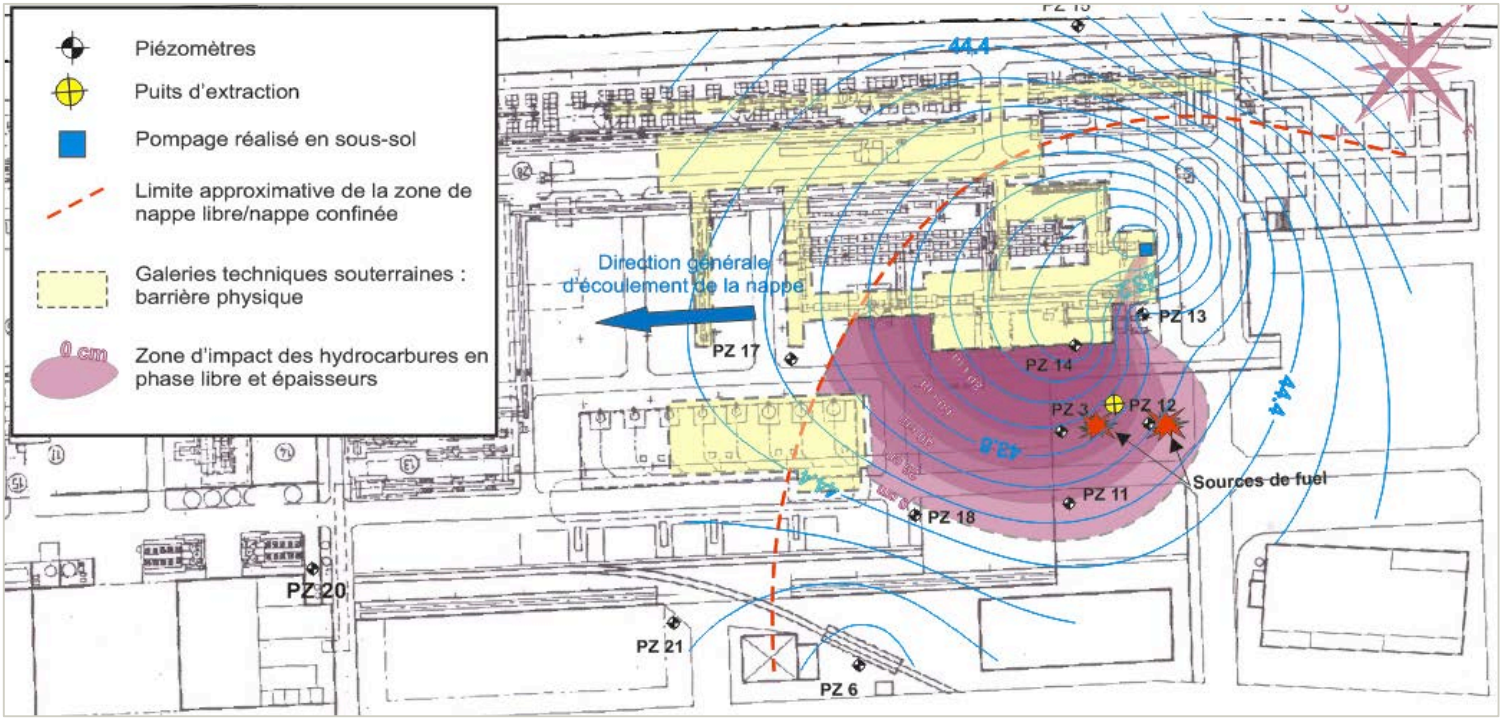
SITE CONTAMINATION



Active site in western France contaminated with free phase hydrocarbons (LNAPL) in shallow groundwater

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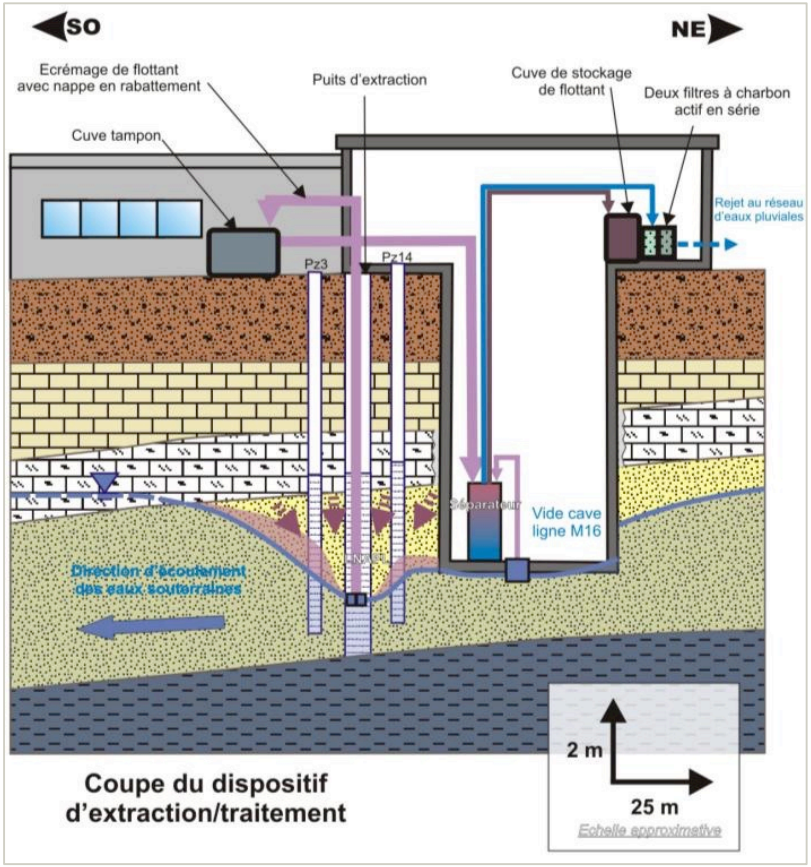
SITE CONTEXT
GEOLOGY & HYDROGEOLOGY

LNAPL lens contained beneath a production area due to:

- Basements including a dewatering well
  - physical containment and depression cone drawing LNAPL
- Confined conditions immediately downgradient the LNAPL area due to a dipping hard limestone layer
  - floating phase migration downgradient is limited



Coupe du dispositif d'extraction/traitement

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SITE CONTEXT
REMEDIATION TECHNOLOGY

- LNAPL extraction conducted by skimming under depressed groundwater conditions achieved by pumping, first at a main well located in the centre of the impacted area
- Effluents treated on a WWTP (oil-water separator and 2 serial AC filters) before release to the nearby surface water course
- Various upgrades including the installation of additional extraction points, were progressively implemented to improve efficiency/reliability (increase operating rate, optimise the extraction rate) in order to reduce the overall treatment duration and associated costs

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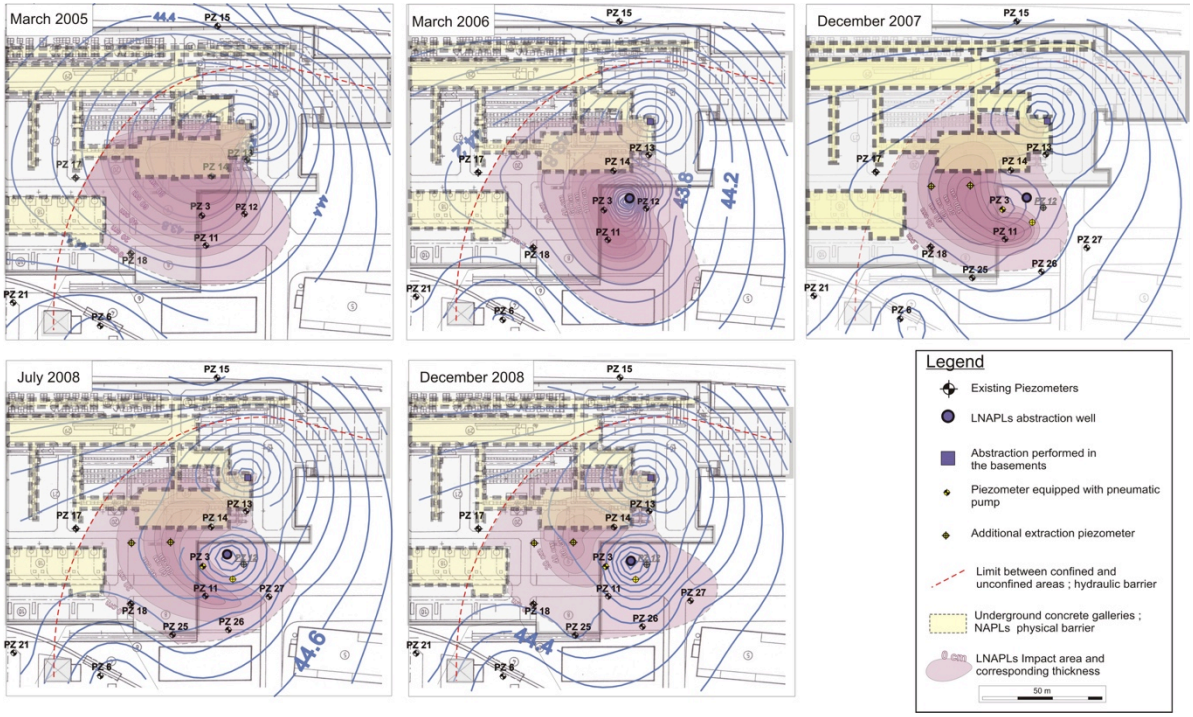
SITE CONTEXT

REMEDIATION TECHNOLOGY



Evolution of the LNAPL impact area

Good results but 15-60 cm of LNAPL remain and efficiency drastically lower despite continuous upgrades

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CHARACTERISATION OF RESIDUAL LNAPL

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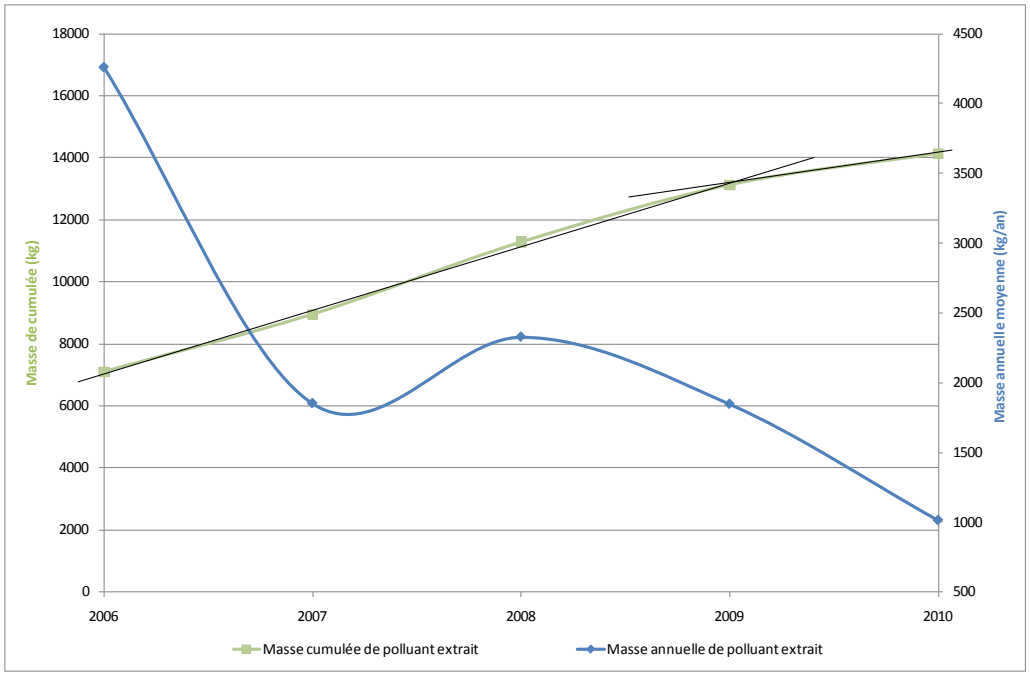
CHARACTERISATION OF RESIDUAL LNAPL

EVOLUTION OF LNAPL EXTRACTION RATE



Approximately 14 tons LNAPL extracted between 2004-2010

Despite continuous improvements of the remedial system > regular decrease of the LNAPL extraction output (approx 25% per year)

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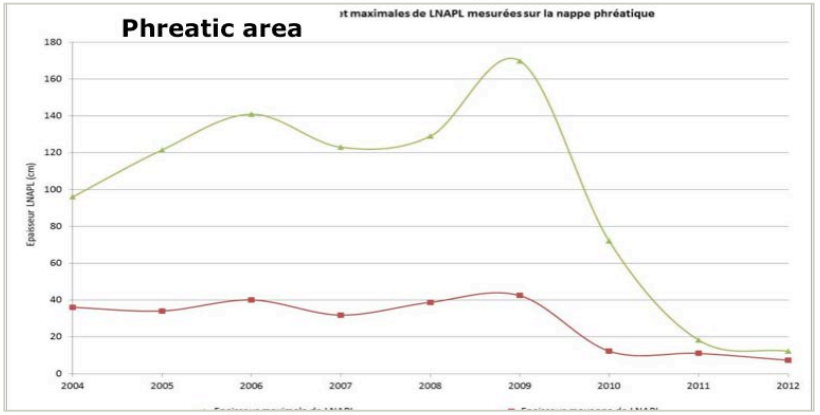
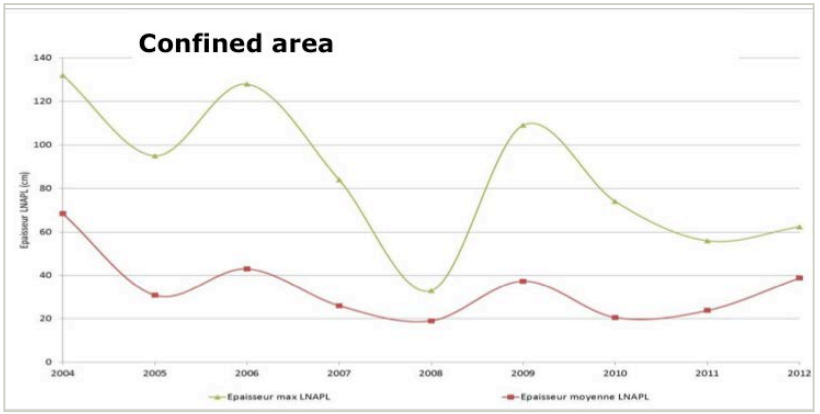
CHARACTERISATION OF RESIDUAL LNAPL

APPARENT LNAPL THICKNESS

- Average apparent LNAPL thickness significantly decreased in the phreatic area (upgradient lens area)
- Overall decreasing trend also observed at piezometers in confined conditions, but less obvious due to well effects

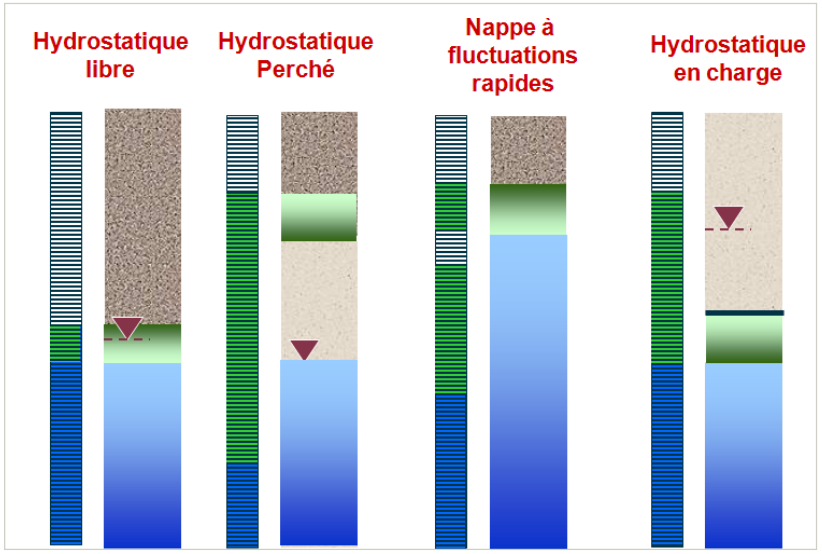




CHARACTERISATION OF RESIDUAL LNAPL

APPARENT LNAPL THICKNESS

- Baildown tests required to evaluate the actual LNAPL thickness/volume



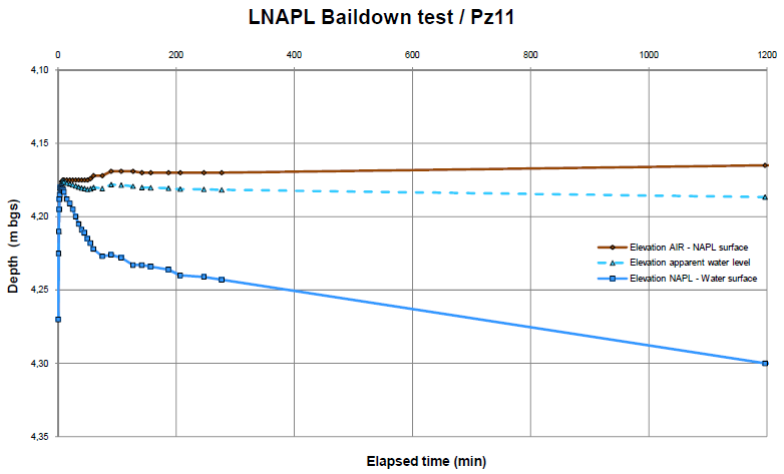
CHARACTERISATION OF RESIDUAL LNAPL

ACTUAL RESIDUAL LNAPL (BAILDOWN TESTS)

Baildown tests conducted after 6 years of extraction:

- Actual LNAPL thicknesses significantly lower than apparent and are residual (5-7 cm in the core of the lens and 2-3 cm at the edge vs 15-60 cm apparent thickness)
- Residual LNAPL mass has significantly decreased (~15 m^3) although the apparent LNAPL thickness remained fairly constant
  - supports the steadily decreasing LNAPL extraction rate despite upgrades

- Transmissivity of LNAPL (mobility) estimated between 10^{-6} and 2.10^{-8} m^2/s
  - limit conditions to use conventional extraction solutions at reasonable cost conditions*



*According to ITRC, minimal range values for LNAPL extraction via pumping or vacuum extraction at reasonable cost is of 1,1 to 8,6.10-7 m^2/s).

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RE-EVALUATION OF REMEDIAL PERSPECTIVES

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RE-EVALUATION OF REMEDIAL PERSPECTIVES

MODELLING RESULTS

Two models were completed to try and correlate site specific data with actual extraction output and re-evaluate remedial perspectives:

- Modelling of the LNAPL transfer in the aquifer (FEFLOW Model*) to simulate the influence of the current system and possible improvements
- Modeling of the extraction (API LDRM**: LNAPL distribution and recovery model)

These models aimed at re-evaluating the residual mobile LNAPL volume present in the aquifer, and its variations over time, as a basis to evaluate the efficiency of several remedial alternatives and associated costs

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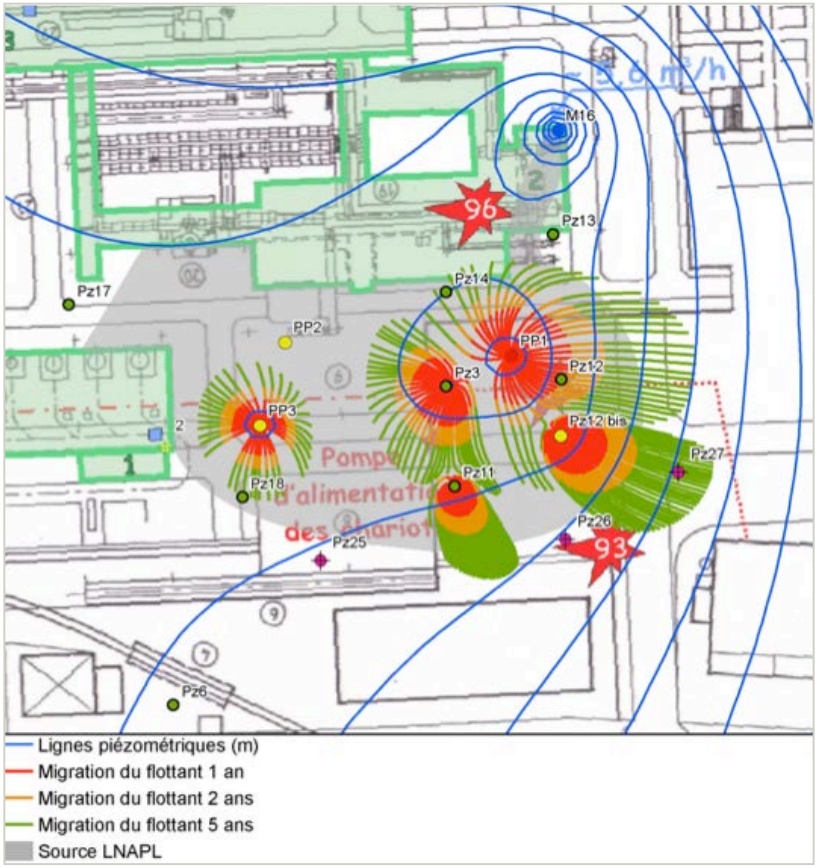
* SITA
** Ramboll Environ

RE-EVALUATION OF REMEDIAL PERSPECTIVES

HYDRODYNAMIC MODELLING

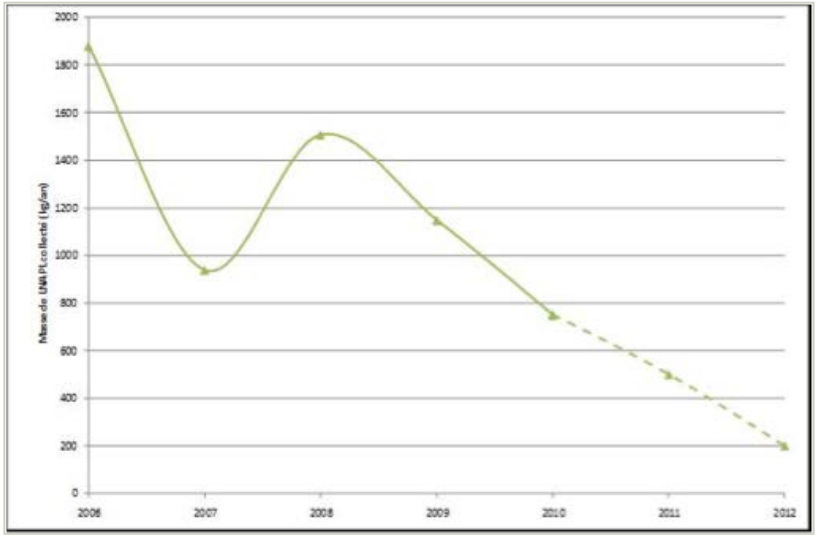
The influence of the current extraction system was modelled allowing to evaluate the radius of capture of the current wells (10m per year) after 1, 2 and 5 years.



RE-EVALUATION OF REMEDIAL PERSPECTIVES
HYDRODYNAMIC MODELLING

Based on these results, for a period of two years, the volume of LNAPL:

- Present in the ground within the radius of extraction was estimated to 4,5 then 1,4 m^3
- Recoverable with the current system was estimated using a conservative extrapolation approach: 0,7 then 0,25 m^3



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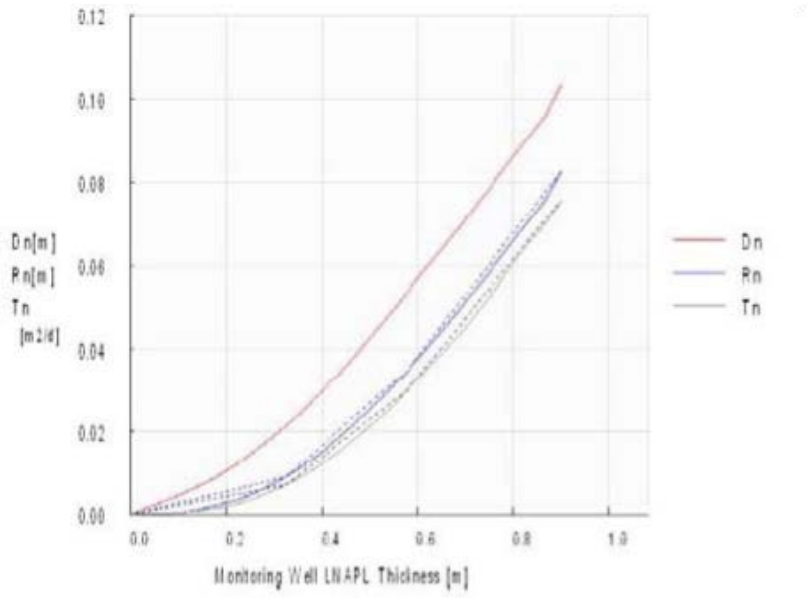
RE-EVALUATION OF REMEDIAL PERSPECTIVES

LNAPL DISTRIBUTION AND RECOVERY MODEL (LDRM)

The LDRM allows a better understanding of the residual LNAPL distribution in the ground and evaluation of its mobility

- It shows that residual LNAPL is hardly extractible due to low quantity present in the ground and its properties (viscosity and density)



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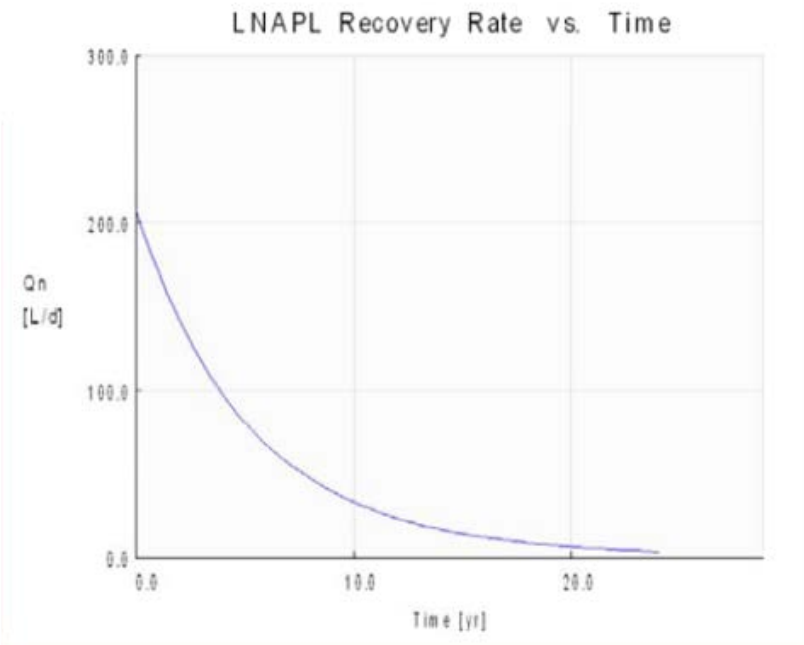
RE-EVALUATION OF REMEDIAL PERSPECTIVES

LNAPL DISTRIBUTION AND RECOVERY MODEL (LDRM)

- Total residual LNAPL volume in the ground estimated to ~12 m^3 (consistent with baildown test estimate of 15 m^3)
- Recoverable part of LNAPL estimated to ~2,5 m^3 in 4 years treatment, ie reinforcing hydrodynamics model results



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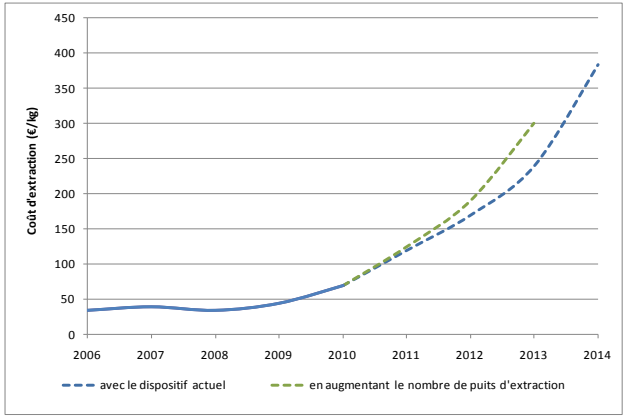
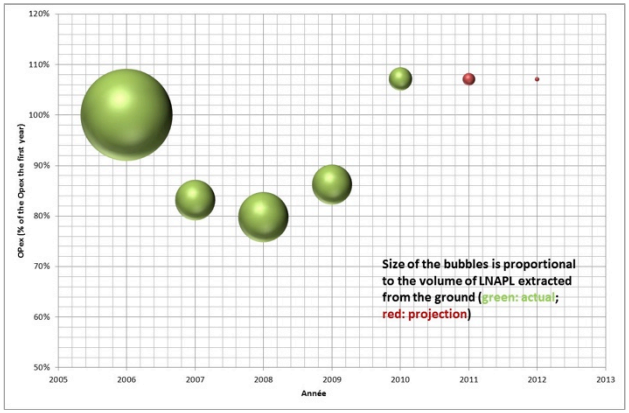
RE-EVALUATION OF REMEDIAL PERSPECTIVES

TECHNO-ECONOMIC ASSESSMENT

Evaluation of the improvement of the current system (increase the number of extraction points):

- Capex of €50k
- Opex increased by 30%
- Overall extraction cost (€/kg) significantly above average observed costs





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RE-EVALUATION OF REMEDIAL PERSPECTIVES
TECHNO-ECONOMIC ASSESSMENT

Three groups of technologies considered for the techno-economic assessment:

- Thermic solutions (coupled with extraction technologies): change of physical characteristics of LNAPL (viscosity) to increase its mobility
- Chemical solutions (coupled or not with extraction technologies): change of physical characteristics of LNAPL (density, viscosity) to increase its desorption and mobility or its destruction in situ
- Biological solutions: change of ground conditions to increase in situ bioremediation of LNAPL

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RE-EVALUATION OF REMEDIAL PERSPECTIVES
TECHNO-ECONOMIC ASSESSMENT

Alternative technologies are hardly applicable as they require:

- A dense injection/extraction network (in buildings with important activity, in a difficult geological context)
- Maintain/re-sizing of the pump & treat system to confine the dissolved contamination
- Installation of an additional system to extract and treat vapours generated before accumulation in the buildings

Alternative solutions induce:

- High capex and opex (overall >500 k€) including monitoring and significant energetic costs
- Significant constraints with respect to site activities

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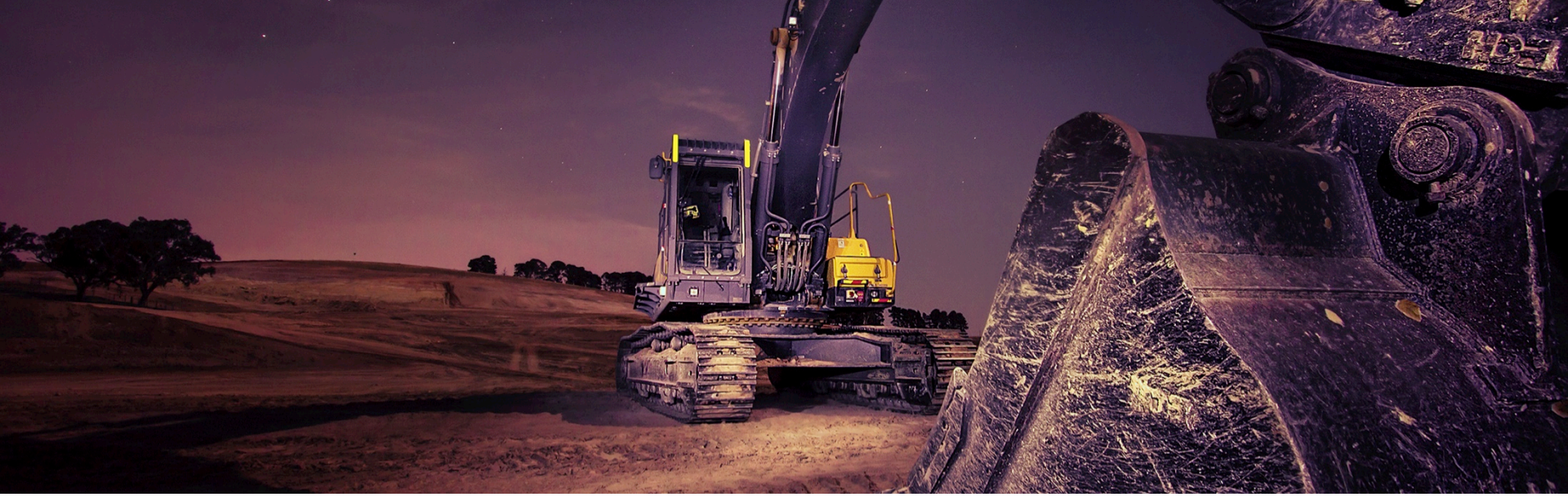

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SUMMARY AND CONCLUSION

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SUMMARY

- Baildown tests and modellings could demonstrate that the LNAPL thickness and recoverable mass are only residual (less than 5cm and 2.5 m^3)
- The techno-economic assessment showed that:
  - The current system has reached its reasonable technical and financial endpoint and cannot be reasonably improved
  - Alternative solutions represent technical-operational constraints and high capex & opex as compared to the recoverable LNAPL volume
- There is neither offsite impact (absence of LNAPL migration, dissolved concentrations low) nor unacceptable risks for site workers (indoor air concentrations below applicable standards)

The authorities considered that it was appropriate to shut off the LNAPL recovery systems and switch to a monitored natural attenuation approach

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CONCLUSION

A prospective assessment of the LNAPL remedial progress including:

- A tight monitoring of LNAPL extraction output
- Specific onsite measurements to reduce bias induced by wells and site conditions
- Modellings
- Techno-economic assessment

Allowed identiyfing rapidly the asymptotic evolution of the system and stopping it as soon as the source removal was completed, thereby saving significant costs

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THANK YOU

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