



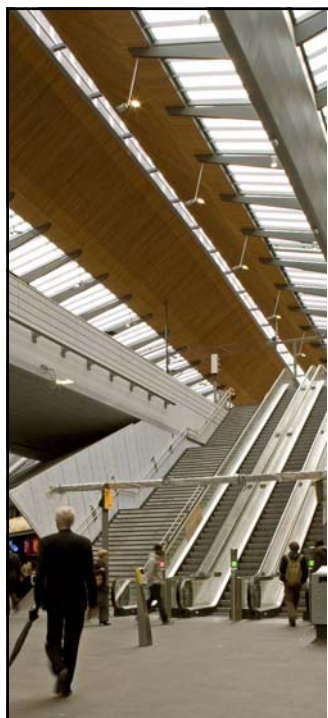
Sustainable Synergies

Combining groundwater energy with remediation,
An illustration with 2 cases

Hans Slenders
Conference GreenRemediation
Copenhagen, November 2009

Imagine the result

ARCADIS



Problem in NL

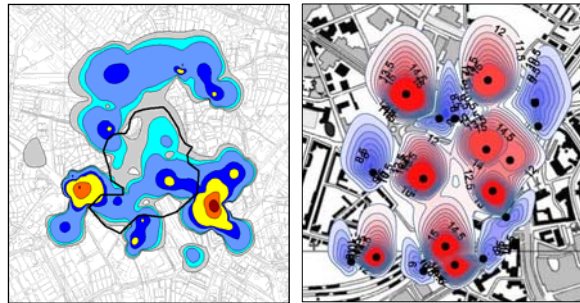
*Multiple plumes and
dynamic use of the
subsurface result in
stagnation of developments
in urban areas*

ARCADIS



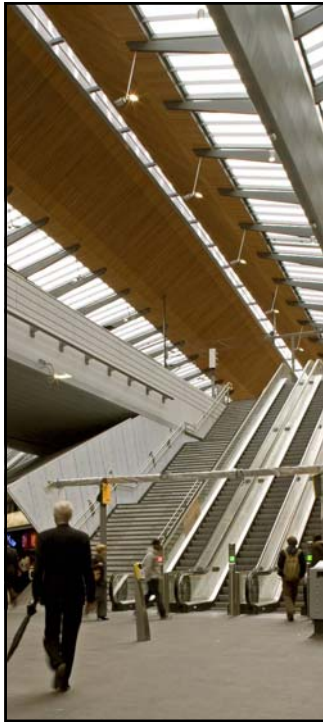
Urbanisation

1. Space is at a premium
2. Sustainable development; heat/cold storage
→ subsurface also increasingly 'crowded'
3. Historic land use resulted in many, large groundwater plumes



Urban area of Utrecht





Sustainable development; Heat/Cold Storage

- Applied more and more, in NL increase expected from 1.000 to 20.000 in 2020
- Reduction of CO2 and non-renewable sources (30-50%)
- Options to combine HCS with remediation?
- **Moves contaminated groundwater!**



Contamination in NL



130 large areas of groundwater contaminated with chlorinated solvents



Moving these contaminants as a result of subsurface activities is not allowed!

Result of this combination:



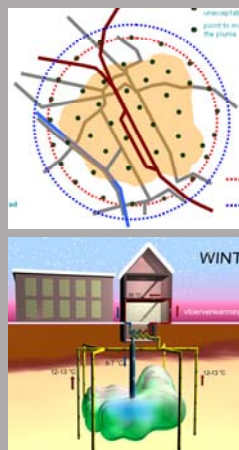
Stagnation of developments!

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How to deal with this?

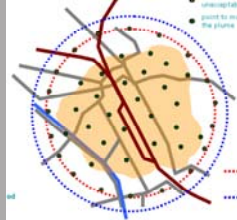


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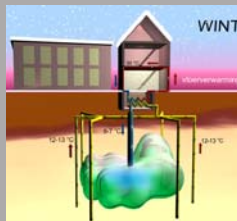
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Two case studies:



Utrecht,
Stationsgebied

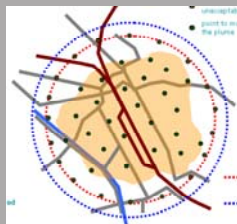


Eindhoven,
Strijp-S (Sanergy)

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Two case studies:



Utrecht,
Stationsgebied

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Case 1: Stationsgebied, Utrecht



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The plans: create a new, safe, coherent city centre



Train station (main NL hub)



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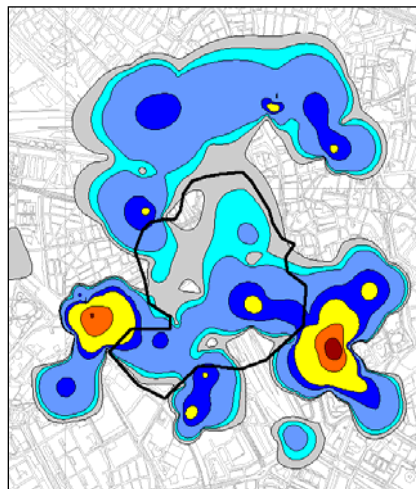


Huge interference

Projected HCS-wells 15-45 m-bgs



Vinylchloride at 15-30 m-bgs





Legal framework NL

- Since 1997: complete removal not cost efficient nor plausible
- Current goals:
 - Eliminate risks
 - Make groundwater fit for use
 - Reach environmentally acceptable situation
- Climate goals are more important than pristine groundwater in busy urban areas
- Government encourages the usefull application of the subsurface (including heat/cold storage)



Local Utrecht policy

Three pillars:

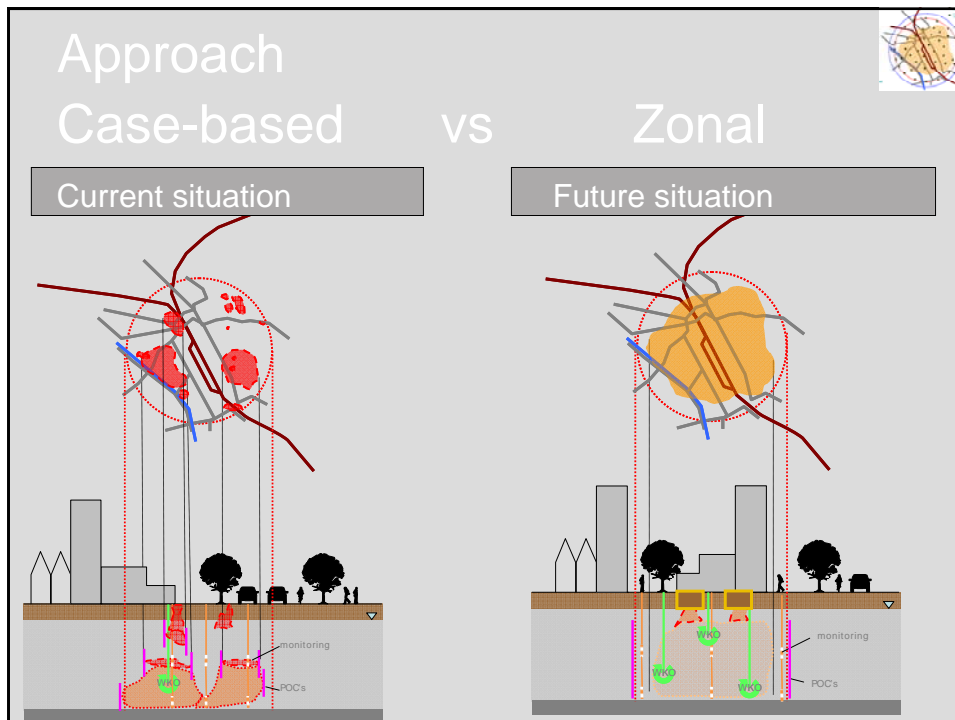
1. Protect groundwater
2. Use groundwater
3. Improve groundwater





Solution in Utrecht

- Introduce a **groundwater management zone**; to let go of individual cases of contamination and look at the bigger picture
- Enable efficient use of the subsurface (renewable energy!)
- Try to make use of activities to remediate instead of letting projects stagnate!
- Increase the contact between contaminants, nutrients and naturally occurring bacteria



Concept: Use HCS as Biowashing machine



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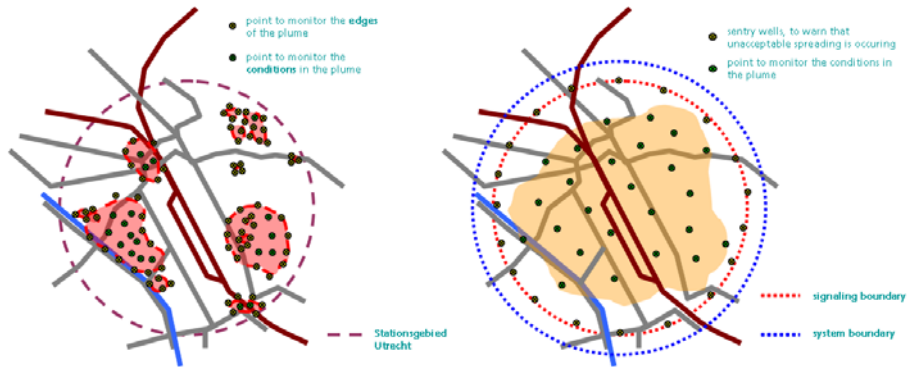


How?

- Defined system area
- Impacts are no longer viewed independently
- Spreading and mixing is allowed
- Spreading to outside of the system area is NOT allowed, a signaling boundary is defined
- Vertically, the impacts are disconnected, shallow impacts still targeted individually, risk based



Management/Monitoring strategy



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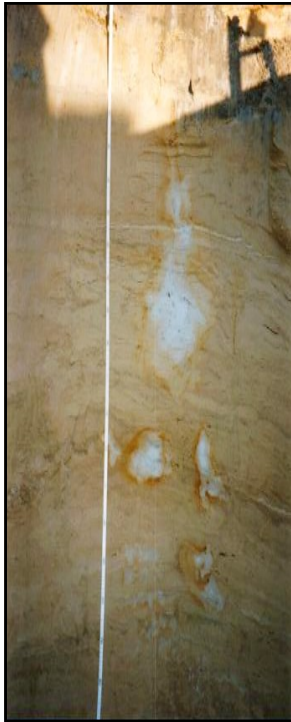
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Aspects of the project

- Monitoring network and strategy
- Feasibility study
- Phased introduction
- Disconnecting shallow sources
- Solute transport modelling to support zonal approach; very complex
- Legal implications
- First time to bring a zoned groundwater approach into reality





Does the washing machine work?? forecast needed

Complex Modflow-RT3D model was build

- 90 HCS wells
- 30 leaching source zones
- Estimation of different half life times
- Scenario modelling (what's the influence of the accuracy of halflife times)
- GIS database with alle contaminant data

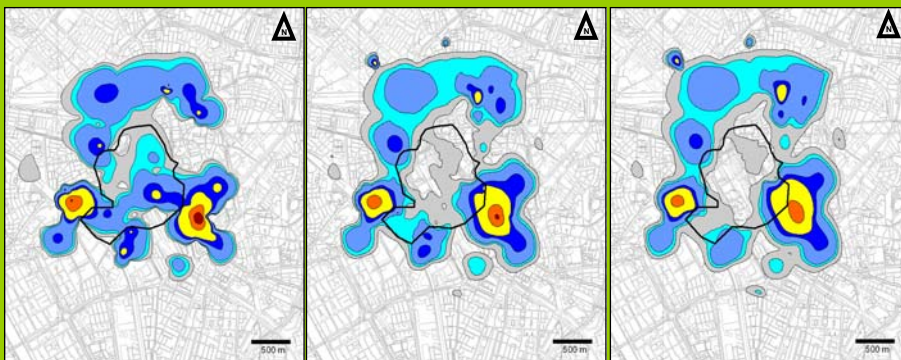


Vinylchloride concentration 15-30 m-bgs

Today (interpolation)

15 years (calculated)

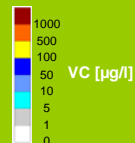
30 years (calculated)



Area of influence HCS



Groundwater concentration

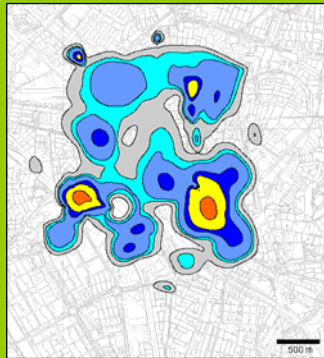


Retardation: 1,04 [-]
Halflifetime: 20 Years

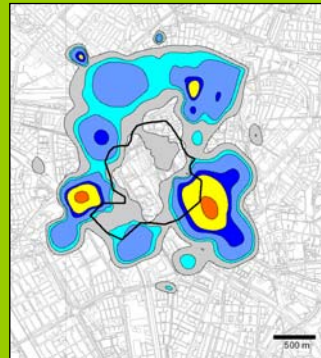
Modelling result VC concentration after 30 years



VC without HCS



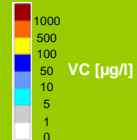
VC with HCS



Invloedsgebied
WKO systemen

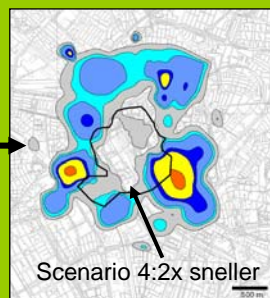
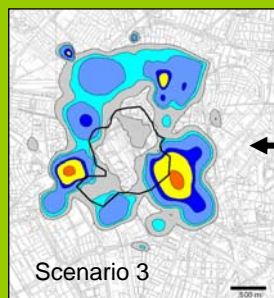
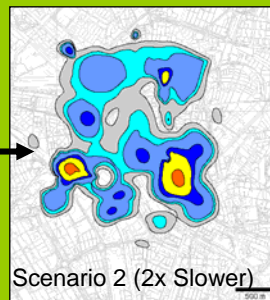
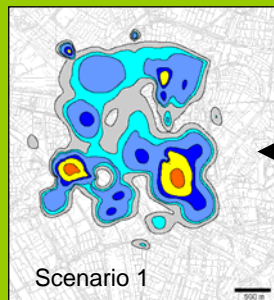


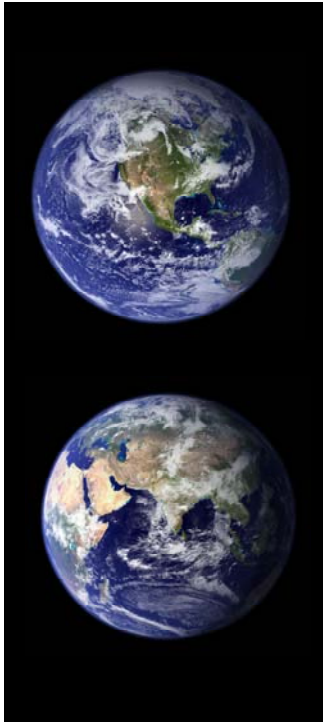
Grondwater
concentratie



Retardatie: 1,04 [-]
Halfwaardetijd: 20 Jaar

Influence of Halflife VC after 30 years FIND THE DIFFERENCES!





And what about sustainability?

- HCS's lead to 30-50% reduction of CO2 and non renewables
- Traditional remediation would cost 500 mln versus 10 for zoned approach
- In the traditional approach HCS would not be possible

It is an integral approach, a choice between options



Conclusions

From the model:

- Contaminant mass decreases from 4600 to 3600 kg, concentrations decrease
- Outer contour (1 µg/l) moves marginally
- Application of HCS has a positive effect
- 3-4 shallow source zones need attention

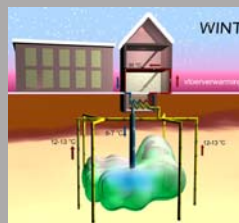
In general:

Protection, Use and Improvement of groundwater are attainable goals!

ITS NO LONGER A CONCEPT BUT A REALITY



Case study 2



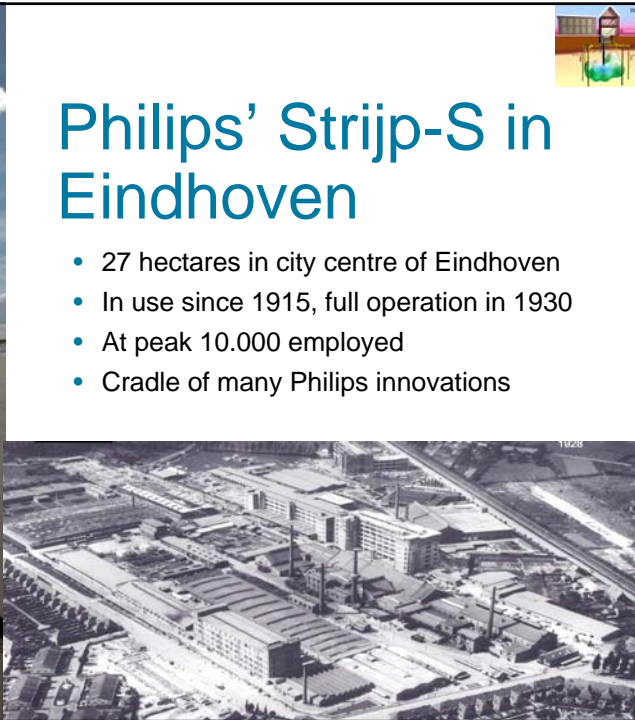
Eindhoven, Strijp-S (Sanergy)

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Philips' Strijp-S in Eindhoven

- 27 hectares in city centre of Eindhoven
- In use since 1915, full operation in 1930
- At peak 10.000 employed
- Cradle of many Philips innovations

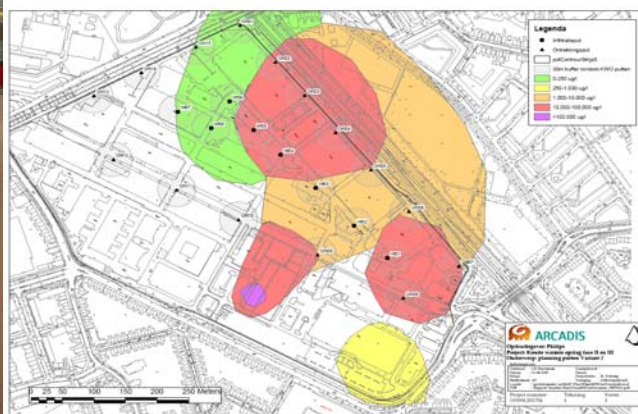




- Since 2005
- Mix of housing, business and leisure
- Maintaining historical buildings and new
- Stringent criteria for sustainability
- Philips' idea: combine remediation & energy



Groundwater contaminated with cisDCE and vinylchloride up to 60 m below surface





Challenges combining energy & remediation

- Paradox groundwater flows
 - Energy: large flows
 - Remediation: reduced flows (= cost)
- Interference of management system
 - On energy demand (seasonal)
 - Continuous containment
- Containment of contaminants:
 - Heat-cold storage?
 - Remediation and containment

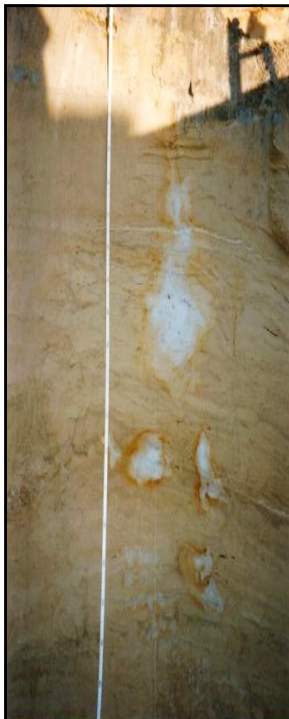
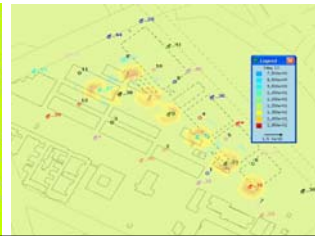
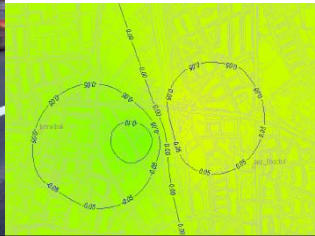


Sanergy; remediation and energy



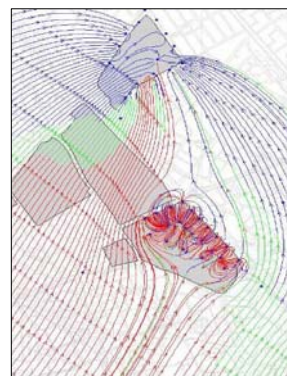
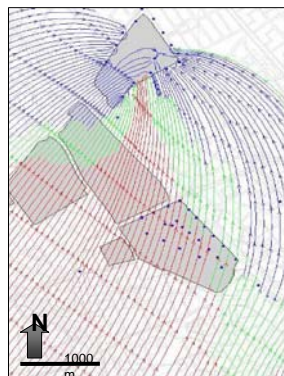
Impact assessment

- Groundwater level changes:
 - Negligible at surface
 - No soil settling;
 - No impact on flora.
- Temperature modeling:
 - No short-circuiting
 - Continuous 13 °C guaranteed in extractions



Remediation?

- Monitor the biowashing machine, how does it enhance natural attenuation;
- It is a contained system, which can be operated as a mega in situ system



What about sustainability?



	Gas (m ³)	Electricity (kWh)	CO ₂ (ktonnes)
Traditional heating and airco	2.900.000	2.400.000	6,0
Sanergy	570.000	5.300.000	3,0

- CO₂ reduction of 3,0 ktonnes for heating/cooling
- Remediation is not completely free, but made possible at very low extra cost

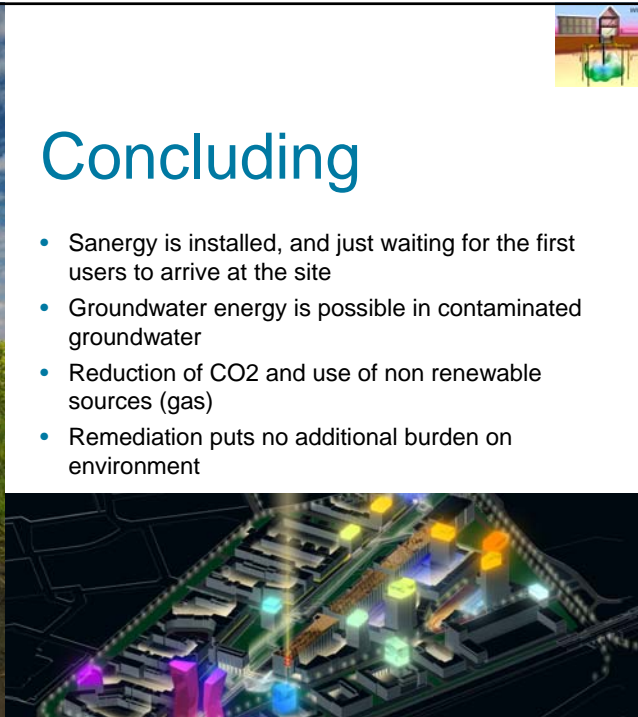
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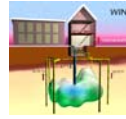
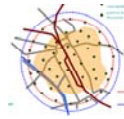
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Concluding

- Sanergy is installed, and just waiting for the first users to arrive at the site
- Groundwater energy is possible in contaminated groundwater
- Reduction of CO₂ and use of non renewable sources (gas)
- Remediation puts no additional burden on environment

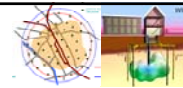




General conclusion

There is synergy in sustainable use of the subsurface and remediation!

This synergy can bridge the gap and take care of frustration and stagnation in developments. It enables sustainable remediation.



Acknowledgements:

Municipality of Utrecht, Brenda van Denter, Henk van den Berg, Frank van Gennip, Albert de Vries

Philips: Jack Schreurs, Frits Melgert

ARCADIS: Pieter Dols, Rachelle Verburg, Klaus Piroth, Philipp Joswig



Imagine the result
people – planet - profit

