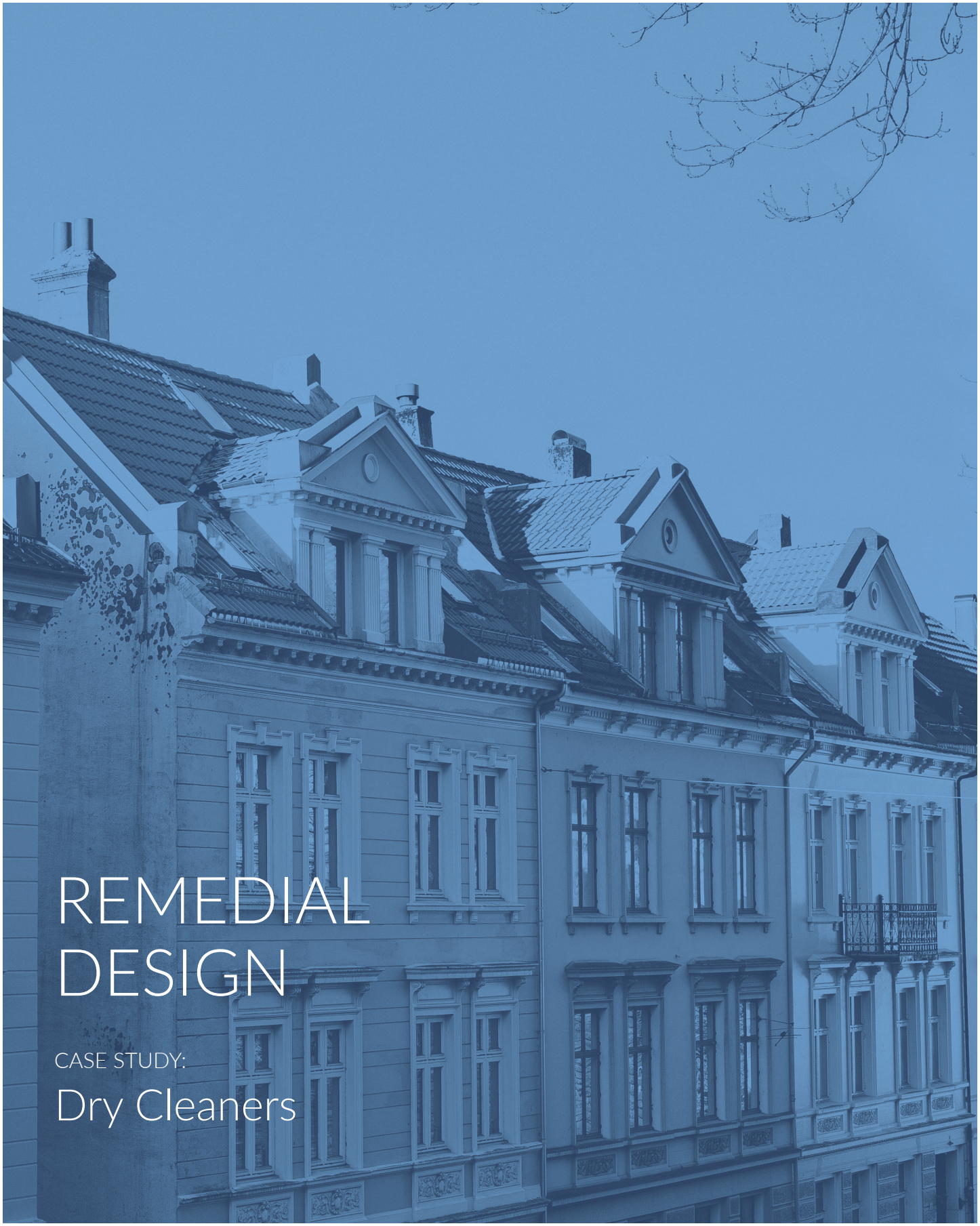
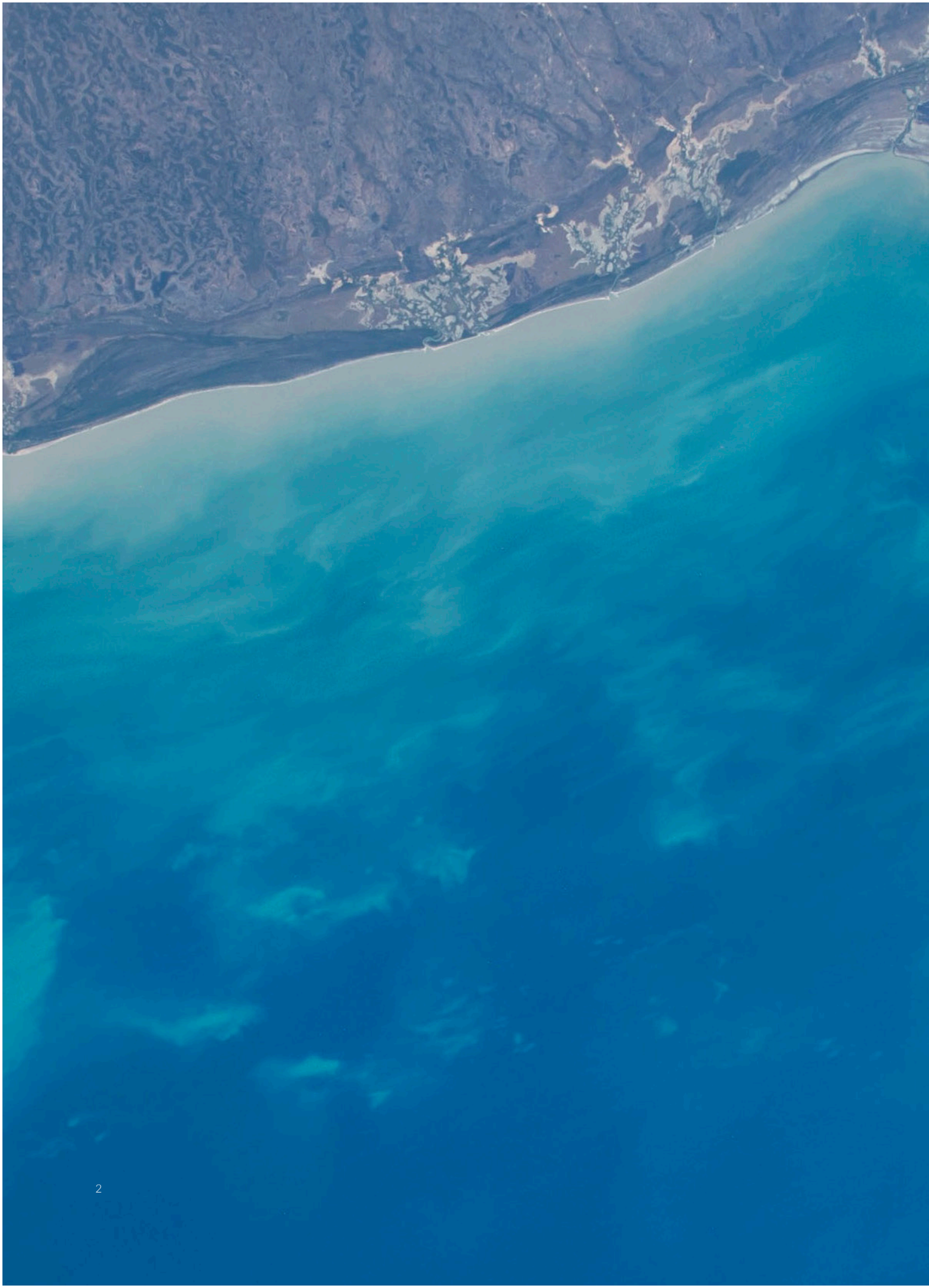
iFLUX



REMEDIAL DESIGN

CASE STUDY:

Dry Cleaners



Highlights

- HIGH RESOLUTION CONTAMINANT MIGRATION
- RISK DRIVER DETERMINATION
- REMEDIAL OPTIMIZATION

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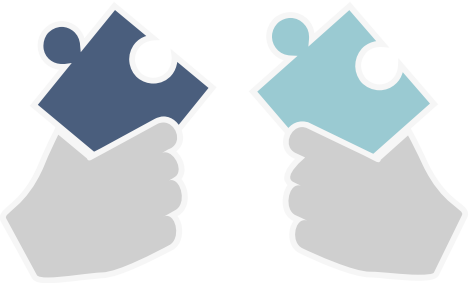
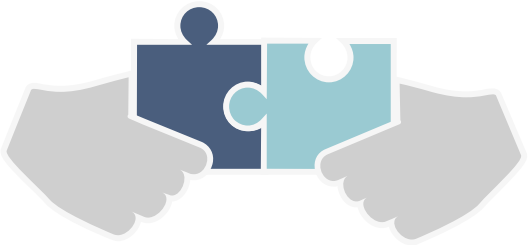
Situation

Two dry cleaners located in a residential, urban environment are located close to each other and have been identified as sources for chlorinated solvent contamination. Groundwater analyses have identified a heterogenous distribution of PCE and degradation products TCE, DCE and VC. Delineation is difficult due to the limited availability of accessible locations in the city centre. The groundwater contaminant plume is only roughly delineated. The most relevant migration source, nor the main migration path of the plume couldn't be determined.

> “ HIGH CONCENTRATION ZONES DO NOT ALWAYS MATCH WITH HIGH FLUX ZONES. FLUX MEASUREMENTS ALLOW YOU TO DEFINE THE CORRECT PLUME AXIS.

Problem versus Solution





PROBLEM

How to assess and control the groundwater migration risk:

- → Mass location?
- → Liability (source identification)?
- → Migration rate?
- → Optimal remediation?

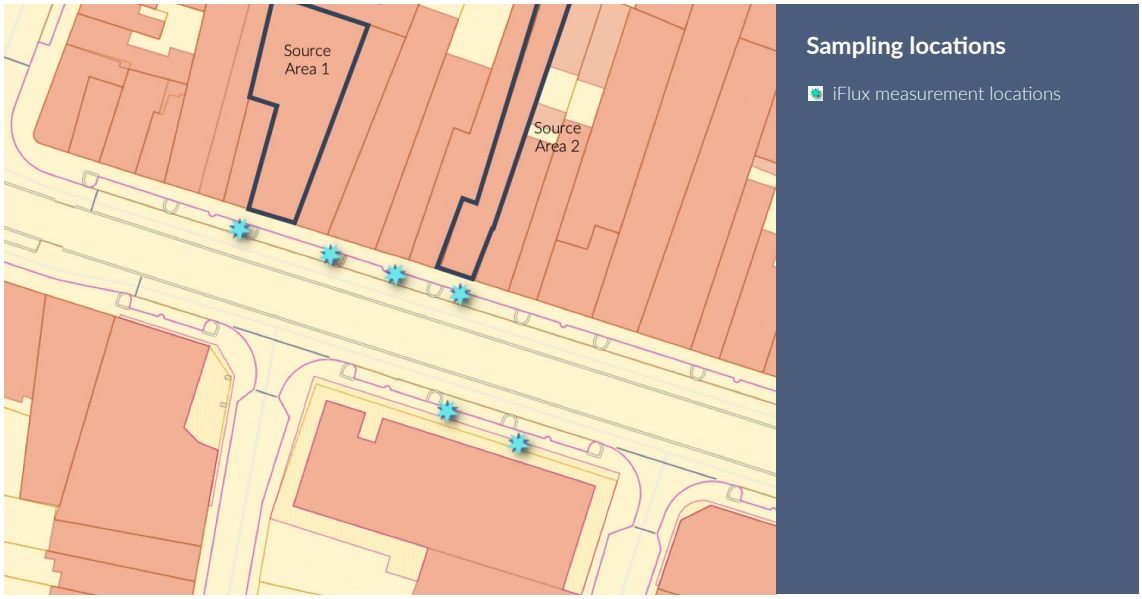
SOLUTION

iFlux provides insight in a dynamic and complex process:

- → Contaminant mass is not always indicative for the main contaminant migration path
- → The source areas can be identified by retracing the flux and VOCl fingerprint
- → In the central axis the migration rate seems to be higher than the degradation effect
- → Remedial design needs to be differentiated for mass removal (vapour exposure risk) and mass flux (migration risk)

Sampling

The iFLUX sampling consisted of groundwater and contaminant flux measurements at depths ranging between 6 to 7 m bgl and locations orthogonal to the groundwater flow. In total, 6 sampling locations were selected. Four iFLUX cartridges were installed at each location, respectively for groundwater, chlorinated solvent, nitrate and iron determination.



Available infrastructure/data:

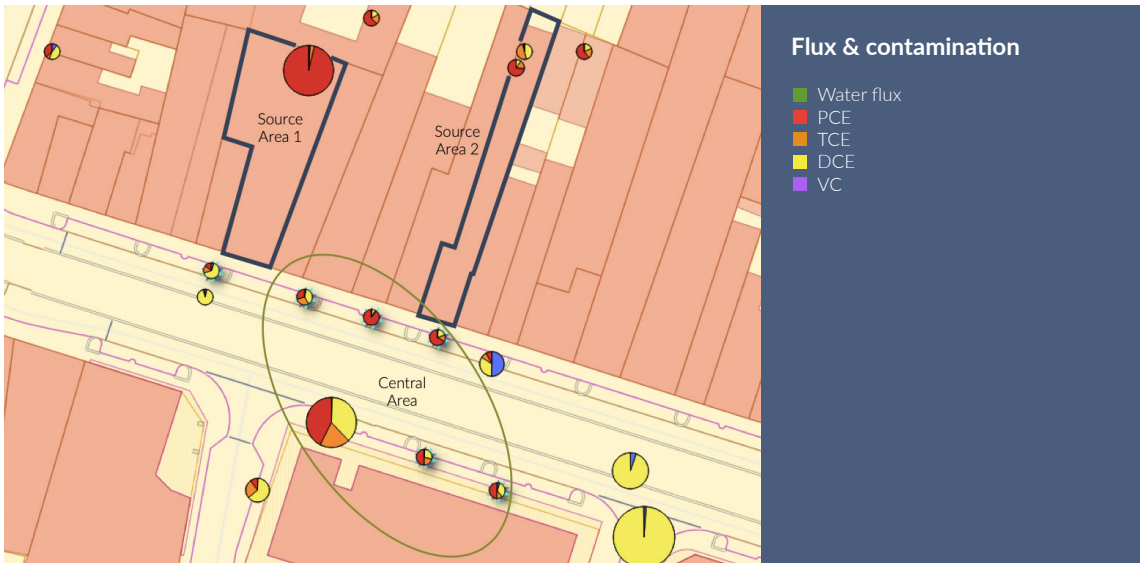
- → 6 monitoring wells with detailed borehole description downgradient from the source areas

iFlux sampling setup for each well:

- → Installation of 4 iFlux samplers:
  - → VOC flux sampler
  - → Groundwater flux sampler
  - → Sulphate and nitrate flux
  - → Iron
- → Measurement time: 31 days

Results

The flux results showed elevated contaminant fluxes of mainly PCE, also further down gradient. The highest contaminant fluxes were not measured directly downgradient for one of the two source areas. Based on a combination of the groundwater analyses and flux data it was concluded that in the central area of the plume limited degradation was occurring and the highest fluxes were measured. Degradation products were mainly present at the boundaries of the plume. The results showed that relevant contaminant fluxes in the axis of the plume are still taking place and that the most western source area is the main contributor for the elevated contaminant flux.



VOCl measured concentrations:

- → Predominantly PCE in source area 1
- → Still significant quantities of PCE and TCE downgradient from source area 1
- → PCE and TCE, with some DCE in source area 2
- → Downgradient towards the east mainly DCE and some VC

VOCl flux calculated concentrations:

- → Central area of the VOCl impact shows a similar “fingerprint”: PCE>DCE>TCE
- → The outward areas show more degraded VOCl, mainly DCE some PCE and TCE or some VC
- → High PCE concentrations in the central area are most likely due to less suitable degradation conditions compared to the outward areas

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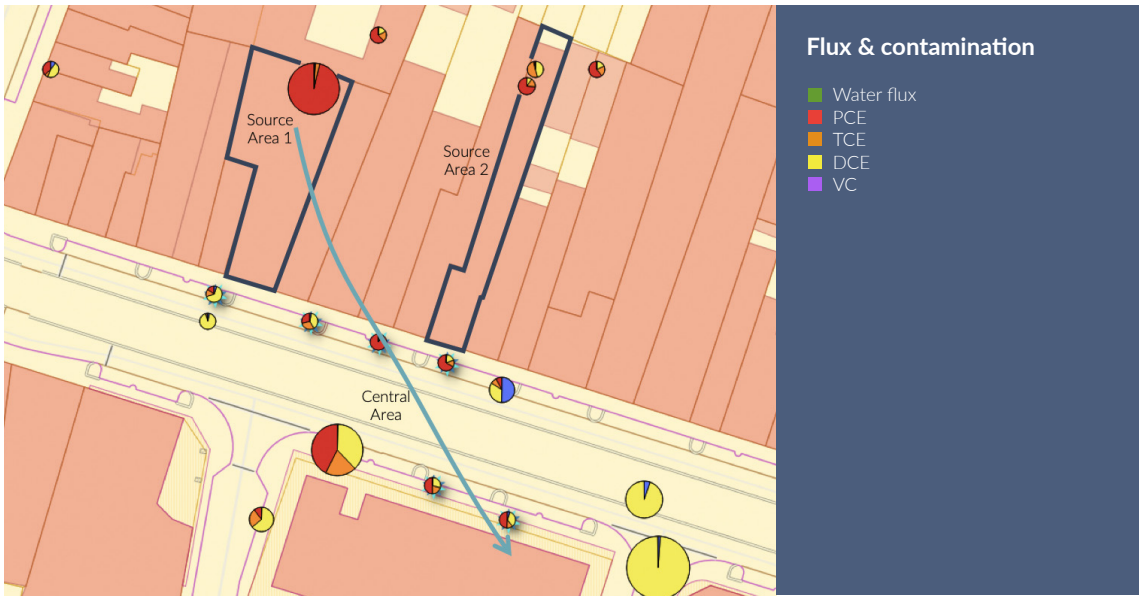
Results



CONCLUSION 1:

Largest mass is not directly located in the areas with high flux. The high mass may pose a risk as a migration source (primary or secondary).

CONCLUSION 2:

Based on all analyses combined, source area 1 seems to be the main source area. PCE is still present and is migrating the fastest (the highest flux measure!). The remedial urgency is therefore high.

CONCLUSION 3:

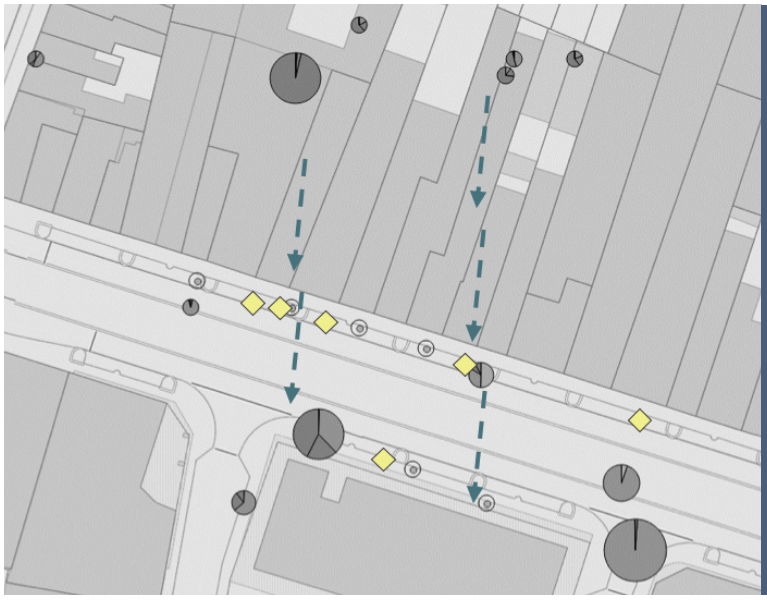
The VOCl (PCE) plume is migrating along the central axis at a flux of >100 mg/m^2/day. Measurements indicate that the plume is potentially still growing along this central axis. Degradation has some effect, as degradation product concentrations increase further downgradient.

CONCLUSION 4:

Remediation to prevent further migration can be optimized by focussing on the central axis of the plume. The highest mass is migrating along this central axis. The degradation at the outward areas of the plume is significant. Remediation to prevent vapour exposure needs to focus on the areas with high contaminant masses.

Added Value iFLUX

The iFLUX measurements identified the main driver for the migration risk. This information allowed to implement a more focussed mitigation measure, namely “soft” mass removal at the source area and a limited hydraulic barrier or reactive wall at the end of the plume. The largest contaminant mass is migrating via a narrow area along the axis of the plume. Addressing this area will reduce the migration risk significantly. A remedial approach solely looking at mass removal, for example by thermal desorption in the source area and a funnel and gate further downgradient, appears not to be the most efficient solution according to the flux measurements. Considering the potential for a more “softer” source reduction (ex. chemox) and a well-controlled measure a the end of the plume, there is a potential to half the costs and in addition reduce the environmental impact of the remediation works.



Current pilot: Soil Vapour Extraction (SVE) outside of the main migration zone

◆ SVE-well

Without flux information:

- → Current SVE-wells for the pilot are not located in the high mass or high flux areas
- → SVE will not result in relevant mass removal
- → Most likely the current SVE pilot will not be sufficient to conclude that this technique will have a relevant effect (PCE will still be migrating and potentially re-impacting the in the pilot remediated areas)

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Added Value iFLUX

Focussed remediation: SVE and migration stop via enhanced bio or hydraulic barrier

- SVE-well
- Abstraction or injection well

With flux information:

- → The main migration path for PCE has been defined
- → Remedial focus on the central axis of the plume to prevent further migration
- → Mass removal in areas with high concentrations to remove human health risk
- → Main source zone has been identified

> “ GAIN: PLUME AXIS IDENTIFIED, BETTER FOCUS FOR REMEDIATON

Theoretical case study based on measurements
and interpretations from flux projects.

iFLUX

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