Groundwater Technology

Presentation

Advanced In Situ Remediation Technologies in The Netherlands

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Introduction

Three Topics

1. **Historical Overview**
   - In Situ Remediation in The Netherlands
2. **Site Soil Management**
   - Interlinked with technology
3. **Technologies**
   - Phased & multi/technology implementation
   - Chemically enhanced degradation
   - Heat enhanced extraction

Historical Overview

<1970	1875: Nuisance Act 1928: Natural Beauty Act
1970-1980	1970: Surface Water Protection Act 1979: Lekkerkerk
1980-1990	1982: Soil Remediation Act (Interim) 1986: Soil Protection Act (calls for remediation-to-natural-background, fixed concentrations)
1990 – 2000	1993: Mandatory Assessment Industrial Sites Assessment results may lead to remediation 1997: Change of policy-implementation: pragmatic risk & cost based remediation
2000 - present	2001: Pragmatic approach implemented in guide lines Number of authorities from 16 to 50+ 2003: Soil Protection Act (revised), implementing pragmatism

Lessons learned

- Initial legislation was far too strict: clean-up levels unattainable at reasonable costs => remediation delayed. Typically, only excavation could achieve results
- Pragmatic implementation: opportunities for in situ, but closure criteria not pre-negotiable
- Pragmatic legislation: maximum ‘return on investment
- The most mobile factor in soil contamination is legislation

Site Soil Management

Site:

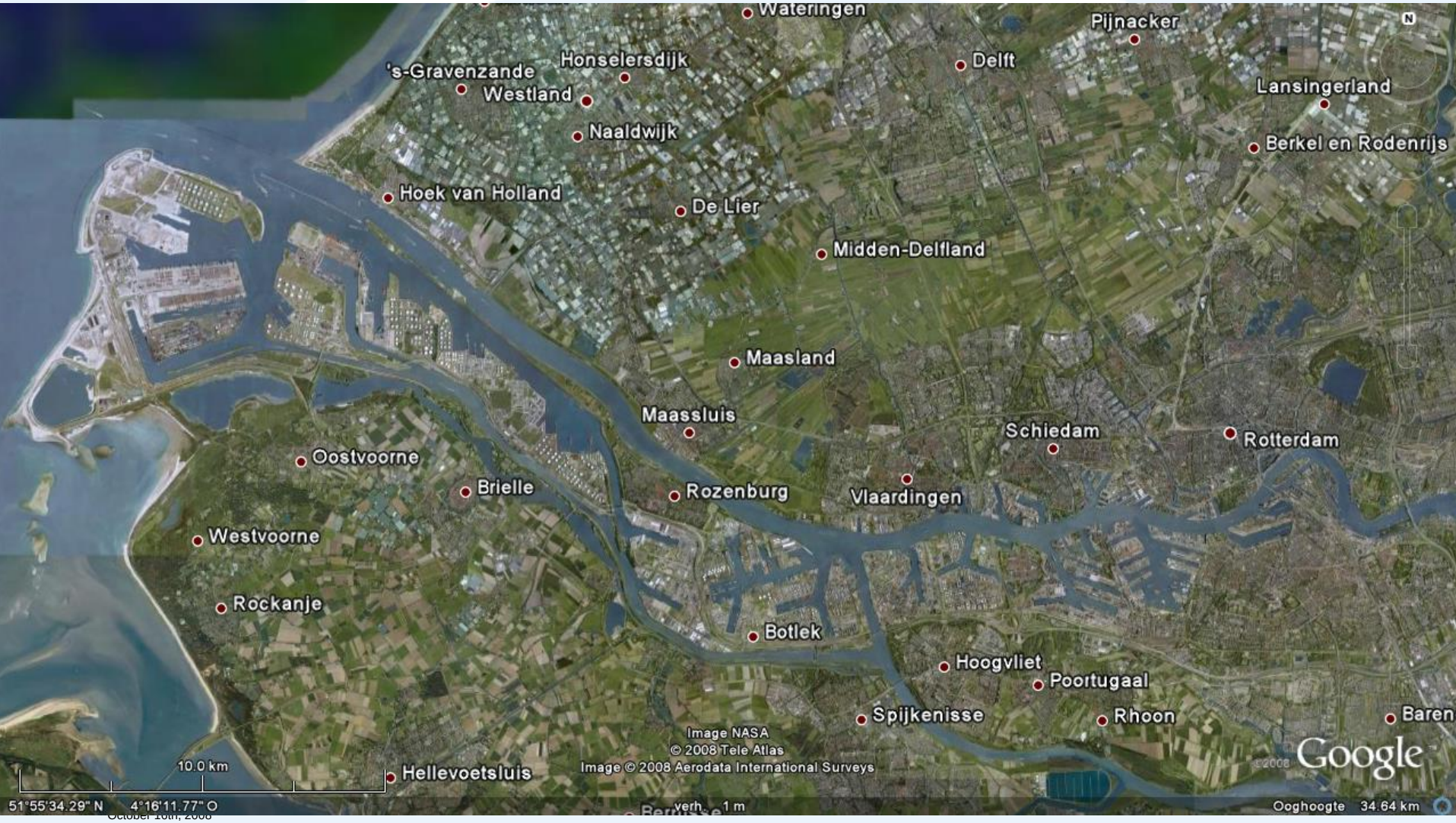
Medium size refinery, > 100 hectares

Started on pristine land

50+ years of operation

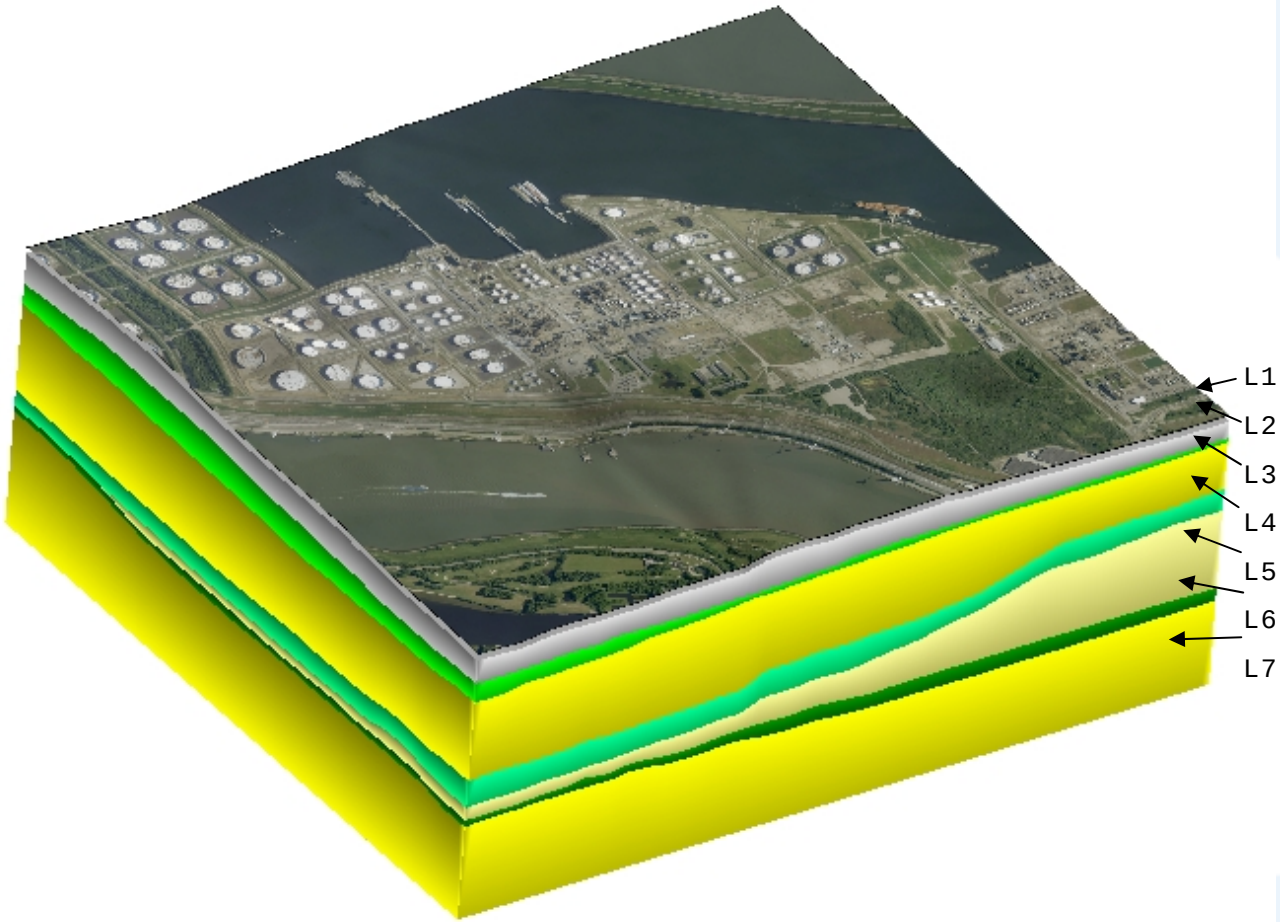
Significant ‘buried treasures’

Costs of full remediation: economically suicidal



October 16th, 2008

Geology



Layer	Top elevation	Description
L1	+5 msl	Made ground
L2	0 msl	Clay, old grade level
L3	-2 msl	Sand, silt & clay
L4	-12 msl	Silt & Clay
L5	-15 msl	Sand, silt & clay
L6	-23 msl	Peat & Clay, basis of Holocene
L7	-25 msl	First Aquifer (sand)

Site Soil Management Plan

Covers three levels:

- Agreement on Strategic approach next decades
- Live Atlas
- Implementation Plan for:
  - Shallow Soil Remediation
  - Containment deeper mobile contamination
  - Monitoring deep contamination
  - Procedures for future issues
  - Internal contaminated soil management

Implementation (1)

Implementation Plan for:

- Procedures for future issues
  - Dealing with new spills
  - Define risk-based approach to set future remediation goals
- Shallow Soil Remediation
  - Active remediation (in situ/ ex situ)
  - Co-ordinate with (future) developments
- Internal contaminated soil management
  - Dealing with health & safety issues (dig-safe procedures)
  - On site Soil treatment (Biopile)

Implementation (2)

Implementation Plan for:

- Containment deeper mobile contamination
  - Monitored Natural Attenuation where possible
  - Active In Situ remediation where necessary
- Monitoring deep contamination
  - Monitored Natural Attenuation only
- Long term possibility:
  - Development of regional deep soil management entity
  - Overlapping multi source/multi site/multi ‘owner’ issues
  - Region-wide groundwater contamination

Implementation (technology)

Technologies:

- New releases
  - Excavation where possible (within hours)
  - Active In Situ remediation
- Shallow
  - Excavate when redeveloped
  - In situ when moving off-site
- Deep:
  - Exploite nature's remediation capacity
  - MNA

Technologies (by showcases)

1. Massive benzene spill (600 m3)
2. Spill response
3. Heat Enhanced Remediation

Case
Benzene spill

Spill of 600 m3 Benzene floods tank pit in just 2 hours at 18:00 hours.

- Disaster Plan put in action
- Regular operations terminated
- Explosion & High Exposure risks

Case
Benzene spill

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Immediate Actions:

- Blanket area with triple-F foam
- Recover free standing product
- Cover Soil with sheeting
- In Situ remediation install started (operational in 2 weeks)

Case
Benzene spill

Technologies used:

- > 100 well High-vacuum multi-phase extraction (vapour, product & water)
- Biodegradation
- Vapour treatment via site vapour recovery unit.
- Enhanced Natural Attenuation (oxygen (gas), perchlorate & nutrients)

Results Benzene spill

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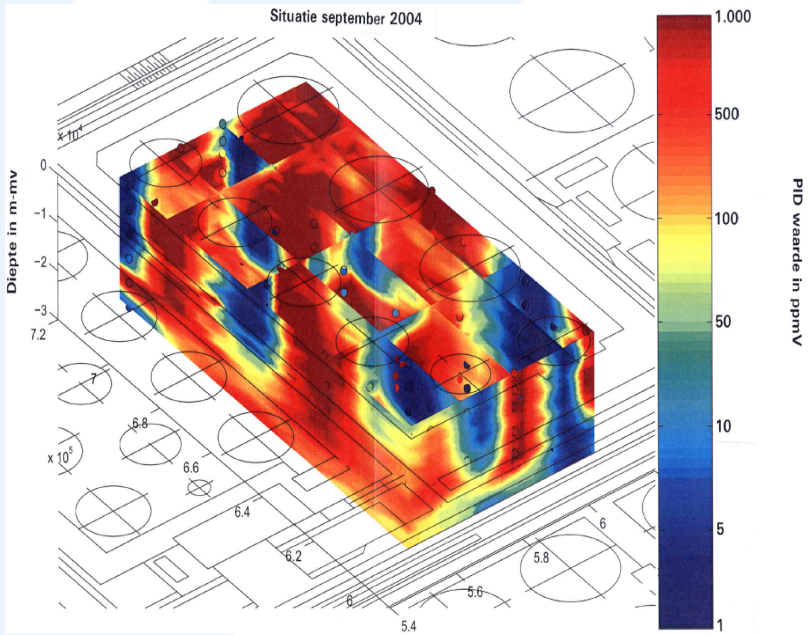
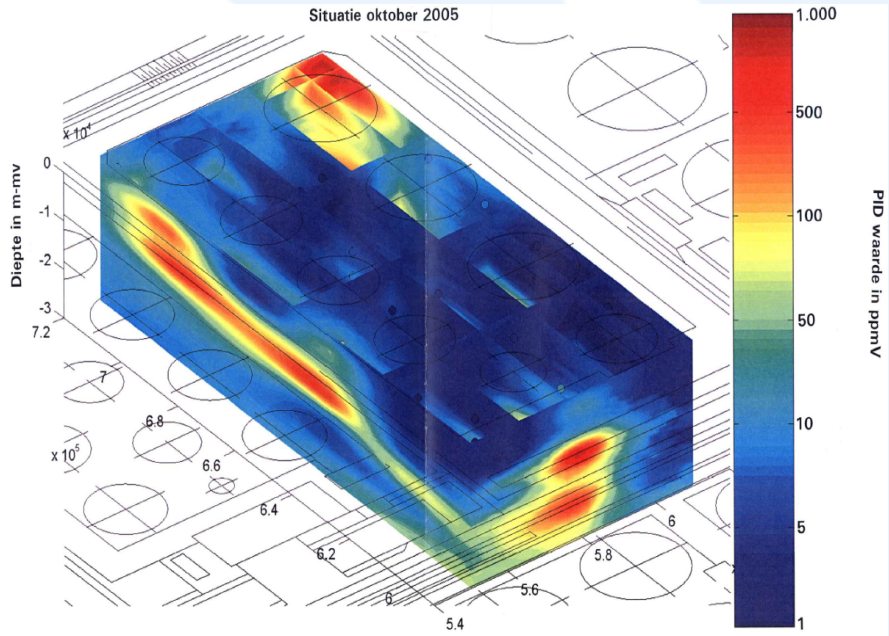
Initial



13 months



Case
Benzene spill

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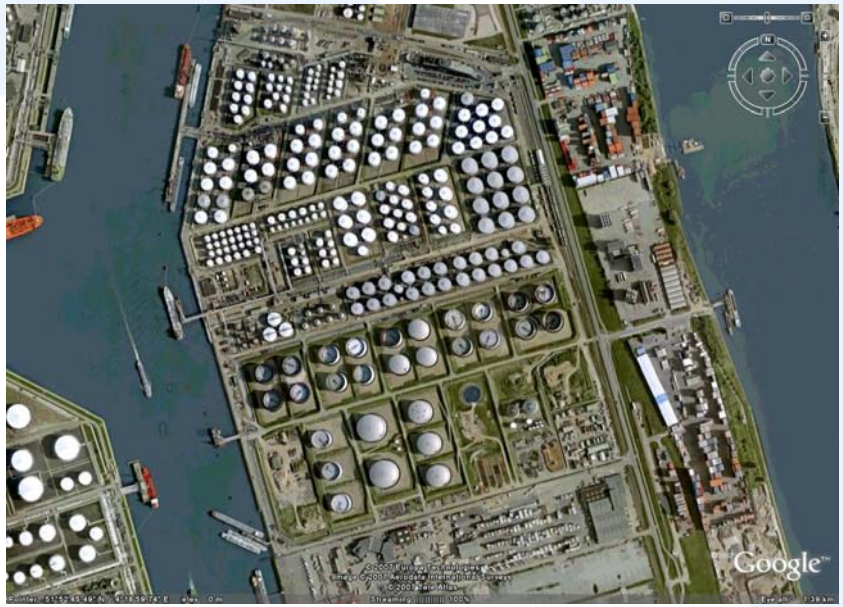
Results:

- 2 days: operations restored
- 2 weeks: remediation started
- 2 years: 99.something% of mass removed (residual mass < 500 kg)
- Enhanced Natural Attenuation (oxygen (gas), perchlorate & nutrients) to remove residual traces

Case
Leaking tank



- Tank bottom membrane failed
- Product spilled into tank mound, LNAPL on groundwater under tank
- Flamable & Toxic

Solution:

- Fix tank bottom membrane and operate tank
- Install remediation system underneath
- Operate (lump-sum-to-closure)

Case
Leaking tank

Case
Leaking tank

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Results:

- Operations without incident
- After nine months: concentrations in extraction system and in soil & groundwater next to tank below detection
- Project closure applied for 7 months ahead of schedule
- (formal closure anticipated in a few months)

Case
Leaking tank

Technologies used:

•Hi-vac, multi-phase extraction (extraction of vapours: promotes volitilization, enhancing biodegradation; extraction of liquids

•Gas/liquid separation

•No-dig installation under operating tank

•Liquid: Oil/water separation: water to site sewer system

•Catox vapour treatment

Cases Heat enhanced remediation

1. Diesel Fuel at Storage Depot
   - At start: free product
   - 4 months operation medium temperature, 2 months hot
   - After 6 months: 10.000 kg removed; residual TPG in soil < 750 mg/kg (<560 ug/l in groundwater)
2. Creosote L/DNAPL at railroad sleeper yard
   - At start: free product
   - 1 month Pump & Treat: <`0.3 kg removed
   - 1 month heat enhanced remediation : 3000 kg removed
3. Gasoil (diesel type) at storage facility
   - At start: free product (>1 m in wells)
   - 2 months heat enhanced remediation: > 2500 kg removed
   - No detectable residual contamination

System Lay-out Creosote L/DNAPL

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injection point

injection point

injection point

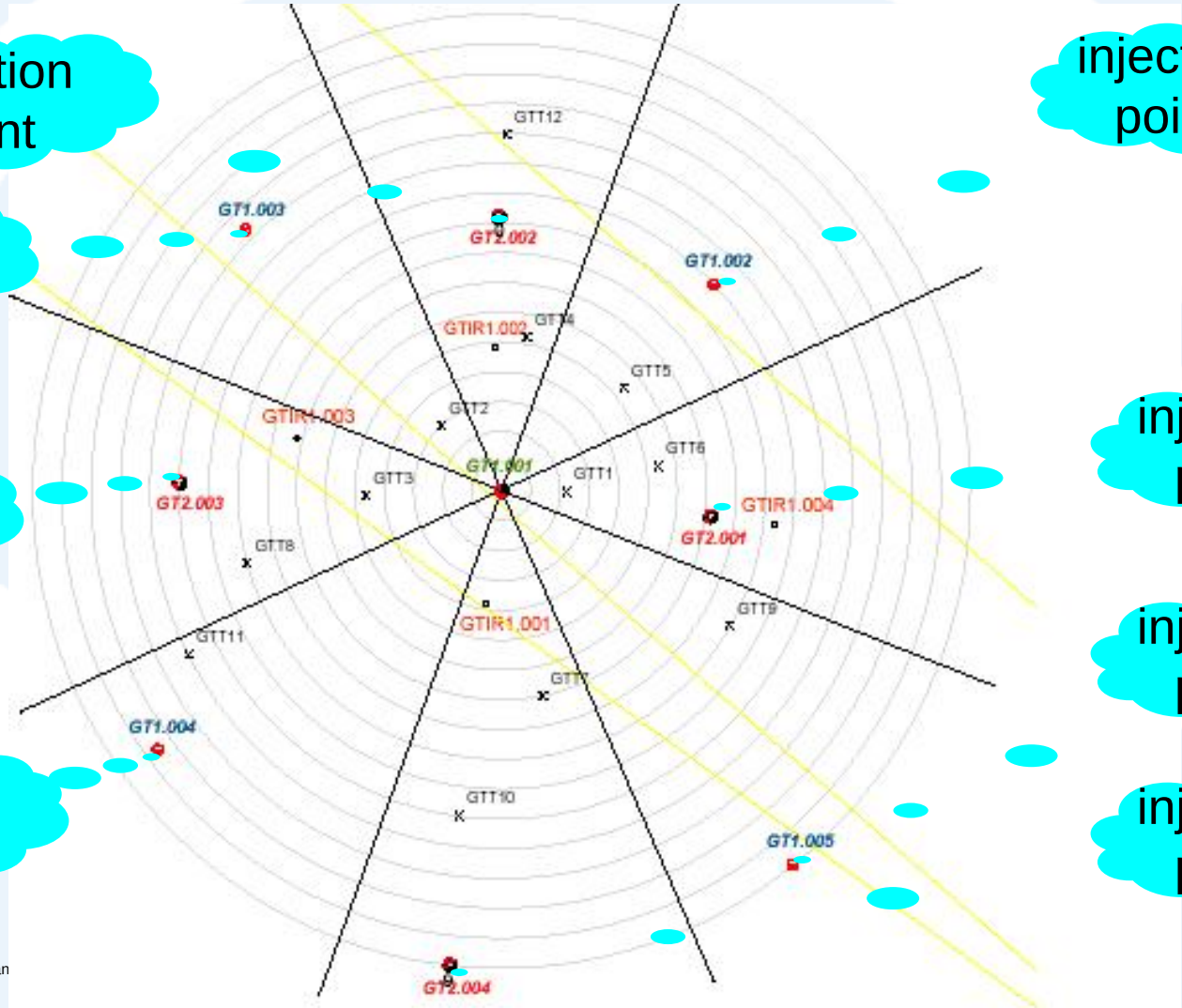
injection point

injection point

injection point

injection point

injection point

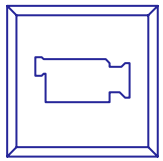


System Lay-out Creosote L/DNAPL

Results
Creosote L/DNAPL

Pilot project:

- 1 month pump & treat: 0.3 kg product removed (dissolved phase)
- 1 week steam injection: entire test area hot
- 1 month steam injection: 3000 kg removed
- Residual concentrations not determined



LATEST
'Hot and Cooking'

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Issue:

•Site (source zone 200 * 50 m, 5 m deep) contaminated with chlorinateds, non-chlorinateds, pesticides and other assorted nastinesses . . .

•Concentrations in soil: sky high, concentration of water in product < 50%

•Site in use as loading facility major chemical distributor

•Window of opportunity to install remediation scheme (three small areas accessible)

•Remediation technology unknown (but system must be capable of pump & treat, sparging, hi-vac extraction, ISCO, Enhanced anaerobic degradation, heat-enhanced extraction and must remain operational for minimum 15 years)

LATEST
'Hot and Cooking' (2)

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Our Solution:

•Horizontal wells, 5 lengths of 200 m each

•Wells & casing custom built from INOX 18/10 steel, 100 mm diameter, 0.2 mm continuous slot, in 6 m sections

•Installed in horizontal, directionally controlled borings

•Borings installed underneath fully operational facility, navigating through a maze of concrete vertical pilings

•Borings used BioBore as supporting mud. Spent Biobiore (not re-used) contained > 1.000.000 ug/l chlorinateds.

Thank You

For Your Attention

Groundwater Technology is interested to discuss opportunities for working together with one or more Canadian firms