envytech
Miljö & teknik

REGENESIS®

Remediation of the largest train maintenance depot in Northern Europe

CASE STUDY

Integrated remedial approach achieves >99% reduction and prevents future recontamination

INTRODUCTION

The Swedish rail authority required that an entirely *in situ* remediation strategy be implemented across the largest train maintenance depot in northern Europe, located in Hagalund, Sweden.

The contaminated area was delineated at approximately 7,500m^2, within which 30,000m^3 of contaminated soil and groundwater required treatment.

As part of the remedial works, Swedish remediation contractor **Envytech** installed a network of additional monitoring wells across the site. This was done to better delineate the plume and identify any unknown contamination prior to commencement of remediation.

These investigations identified LNAPL across much of the northern area of the site, which required a revised groundwater remediation strategy comprising:

- Dual-phase extraction (DPE) to target the LNAPL, followed by;
- *In situ* chemical oxidation (**RegenOx®**);
- Enhanced aerobic bioremediation (**ORC-Advanced®**); and
- Adsorption & biodegradation (**PetroFix®**).

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Above: Satellite view of the Hagalund rail depot near Solna, Sweden © Googlemaps (2021 CNER/Airbus) **Below:** Envytech carried out the injections using Direct Push rigs; **Cover image**: Aerial view of Hagalund depot. © Envytech

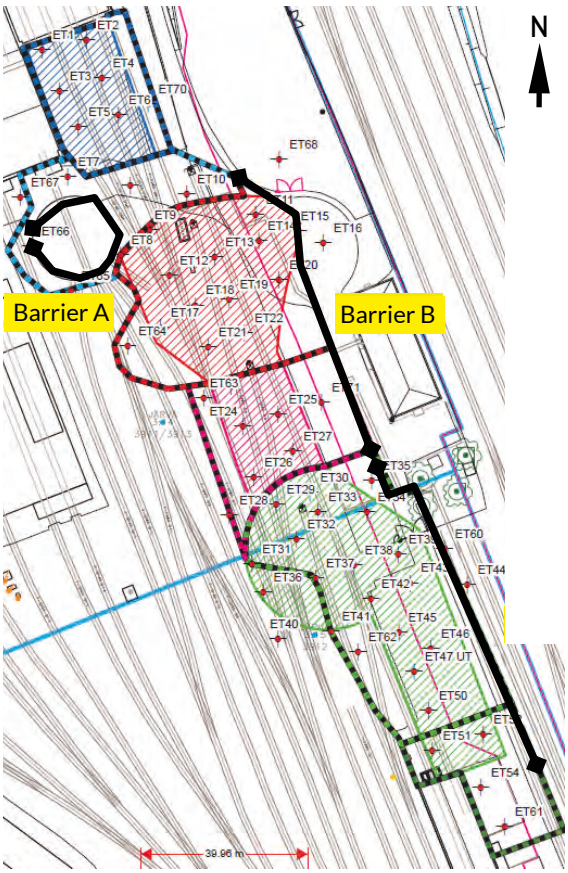
REMEDIAL DESIGN

This combined physical, chemical and biological remediation approach was required to reduce free phase concentrations of petroleum hydrocarbon contamination to concentrations below the site-specific clean up targets. The design also had to address the concern of recontamination of the remediated area due to hydrocarbons in inaccessable locations and ongoing use of the site.

Following removal of the LNAPL by DPE, RegenOx and ORC Advanced were to be used to target the residual dissolved phase mass. The applications were designed in a grid pattern, tailored to different areas of the site.

PetroFix was incorporated in the design to create both vertical and horizontal Permeable Reactive Barriers (PRBs). These would provide long-term prevention of contaminant egress or recontamination of remediated areas, through combined sorption and biological degradation.

- **Barrier A** runs along the eastern boundary to prevent on-site migration of contamination impacting the (now cleaned) groundwater beneath the site. This was deemed necessary as there was known contamination to the east, where access limitations prevented any remediation from taking place.
- **Barrier B** is located in the northwest of the site, where the presence of a railway turntable prevented access to the contamination below. A circular, vertical barrier was installed around the turntable to prevent any contamination egress through long-term sorption and biodegradation.
- **A horizontal barrier** was to be installed at the water table across the site in order to protect the remediated site from the downward migration of contamination due to:
  - Desorption from existing soil contamination in the vadose zone into infiltrating rainwater
  - Future fuel spills from locomotives continuing to operate on the site



Above: Site plan with treatment zones, barrier locations and monitoring wells.

APPLICATION

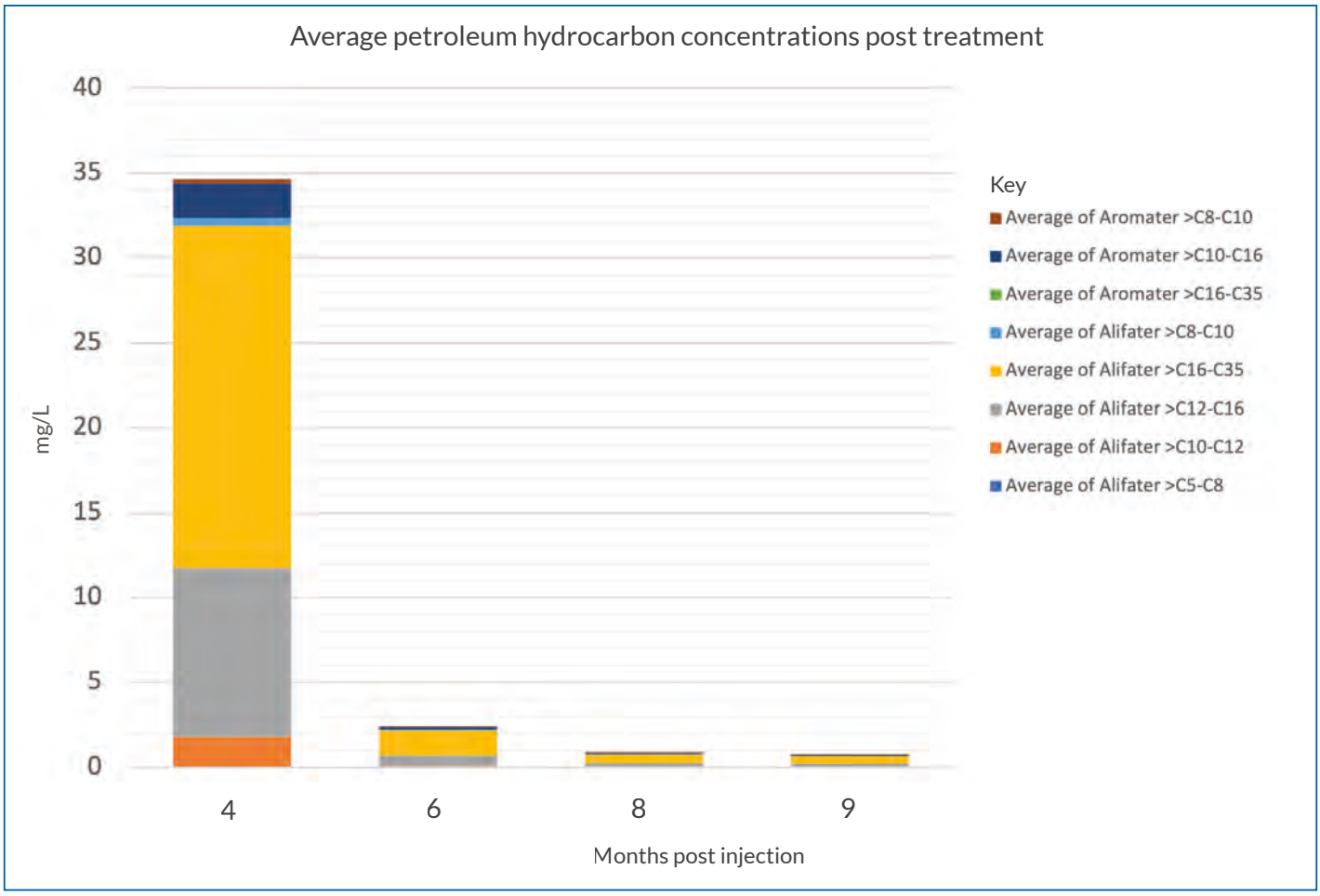
Envytech Solutions undertook the remedial works over a period of 11 months. The groundwater works comprised:

- Installation of 62 monitoring wells
- Installation of a duel phase abstraction system which recovered 40 tonnes of free phase hydrocarbons over 6 months
- 3,487 Direct Push Injections Points to apply:
    - 110,000 kg RegenOx
    - 53,000 kg ORC-Advanced
    - 56,000 kg PetroFix

Top: PetroFix, RegenOx and ORC-Advanced storage onsite. **Above:** Envytech's reagent mixing setup. **Below**: Direct Push Injection rigs in action.

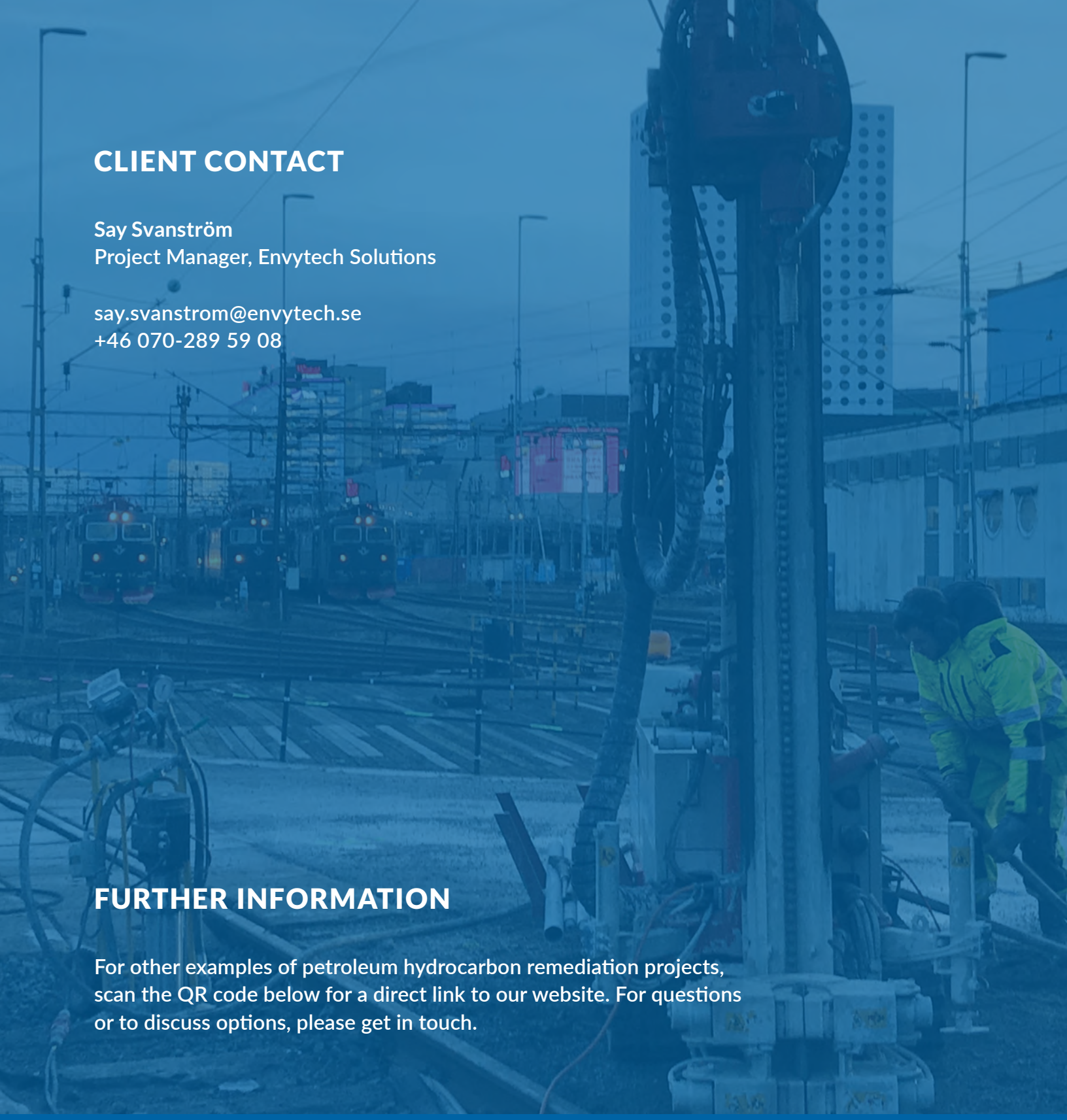
RESULTS

Validation monitoring started 4 months after the works were completed. The graph below show the average petroleum hydrocarbon concentrations post injection, from which a >99% reduction can be observed within 9 months. 3 months of further monitoring is yet to be completed.



CONCLUSIONS

- This project is an excellent example of a carefully designed integrated remediation strategy; using physical, chemical, sorptive and biological treatment.
- Innovative use of PetroFix PRBs was completed to prevent residual contaminant egress, recontamination from outside of the treatment area and protect against future spills
- Significant reductions of petroleum hydrocarbons have been achieved onsite: starting with LNAPL and reaching stringent target values - within 9 months.
- The *in situ* nature of much of this large scale remediation allowed the busy railway yard to continue working during application and as the remediation occurred.



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FURTHER INFORMATION

For other examples of petroleum hydrocarbon remediation projects, scan the QR code below for a direct link to our website. For questions or to discuss options, please get in touch.

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