LEGACY
The London 2012 Olympics represents one of the largest regeneration projects of its kind in recent years. Located in the east of London, the site was home to numerous contaminative uses including chemical works, fertilizer works, engineering works, landfills and depots leaving a legacy of soil and groundwater contamination.

SPECIALIST REMEDIATION DESIGN
The remediation of the Olympic Park was subdivided into a number of construction zones with remediation delivered through a partnership of lead designer (Atkins), advisors to the Olympic Delivery Authority (CLM), Tier 1 Remediation Contractors (BAM Nuttall and Morrison’s) and a range of Tier 2 specialist contractors.

WSP working in conjunction with Erith are a Tier 2 remediation design and implementation specialist focussing on the characterisation of numerous contaminant plumes within both shallow and deep aquifers and the design and implementation of various remediation solutions.

MAIN STADIUM BACKGROUND
The site has a significant industrial heritage having been heavily industrialised during the late 19th century. The site history included, a dye works, an ‘oil’ refinery, furniture makers, various chemical works and a scrap metal reclamation facility.

The main contaminants of concern were predominantly chlorinated solvents, and dissolved phase hydrocarbons present at concentrations in excess of solubility within a highly permeable aquifer (River Terrace Deposits) in the location of the former ‘oil refinery’ and chemical works located immediately to the south of the main Olympic stadium.

The range and concentrations of contaminants present within the RTD were considered to present a significant risk to the nearby sensitive environmental receptors (the surrounding surface water bodies) and the remediation of groundwater would be required to address those risks. This work had to be undertaken whilst the main Olympic Stadium and all the associated structures were being built.

A strategy was developed to contain the contamination in the first instance followed by more aggressive works to reduce the source zone contamination when the building schedule allowed. This was achieved through:

- The installation of a hydraulic containment system to reverse the hydraulic gradient (and contaminant migration: and,
- An aggressive programme of chemical oxidation via the injection of Fenton’s Reagent, followed by the injection of potassium permanganate to chemically destroy the contaminants.

GROUND CONDITIONS
The ground conditions comprised:

- Made Ground: 0.5m to 3.1m thick, comprising brown sandy gravelly clay with some fine to coarse gravel of flint, concrete and brick.
- Alluvium: Comprising soft to firm brown alluvial clay averaging 1.26m in thickness.
- River Terrace Deposits (RTD): Comprising fine to coarse sand and fine to coarse sub-angular to rounded gravel of flint and quartzite averaging 2.54m in thickness.
- Lambeth Group: Comprising firm to stiff grey clay and forming the aquitard/base of the aquifer.
CONTAMINATION

Contaminant delineation works identified a distinct area of heavily impacted groundwater in the southern corner of the main stadium site. The main contaminants of concern comprised chlorinated solvents (trichloroethene, 1,1,1-trichloroethane and associated breakdown products), free and dissolved phase hydrocarbons, polycyclic aromatic hydrocarbons (PAH) and arsenic. Concentrations of many contaminants often exceeded solubility. Studies had found a large contaminant plume migrating south and from this source.

A hydraulic model was developed using hydraulic parameters gathered on site by WSP to develop the abstraction rates required, number of abstraction points, injection points and zones of capture to allow for complete hydraulic control of groundwater within the RTD.

The purpose of the hydraulic containment system design was to abstract sufficient groundwater at a fixed hydraulic head, at specific points around the perimeter of CZ3a, to reduce hydraulic heads and reverse the hydraulic gradient across the site and prevent the off-site migration of contaminants of concern.

The groundwater model indicated that as a result of the relatively high permeability of the RTD (k value of c.28m/day) and the relatively flat hydraulic gradient measured at 0.001 across the site, only a limited drawdown between 9 and 16cm would be required at the point of abstraction to create the necessary cone of depression to reverse groundwater flow within the RTD and achieve hydraulic capture across the site. The model also had to take into account variable hydraulic heads as a result of tidal variations in the nearby surface water courses.

A hydraulic containment system was subsequently designed and installed by WSP comprising of the following elements;

- A network of hydraulic containment wells with variable speed driven pumps and level controllers connected by Ethernet to a central control point;
- Associated pipework, duct and electrical cabling to power and control pumps and deliver abstracted water to a central treatment point; and
- Treatment plant to remove contaminants from water and allow for re-injection and/or disposal to a combination of foul sewer and/or surface water.

Verification of the plant performance confirmed complete capture and successful treatment of abstracted groundwater.

SOURCE TREATMENT – FORMER CHEMICAL WORKS AREA

Source treatment in the former chemical works area was undertaken following release of the area by the Stadium construction team.

The viability of chemical oxidation was confirmed by WSP through bench scale tests and field trials. Tests were undertaken to determine the Soil Oxidant Demand (the single most limiting factor in the use of Chemox) and the oxidant most suited for the destruction the range of contaminants present.
The trials demonstrated potassium permanganate performed well in the destruction of PAHs and chlorinated ethenes (i.e. trichloroethene, cis-1,2-dichloroethene, etc.) whilst Fenton’s reagent was highly efficient in the destruction of aliphatic hydrocarbons and chlorinated ethanes (such as 1,1,1-trichloroethane).

A remedial plan was developed using a combination of Fenton’s reagent in the areas where aliphatic hydrocarbons and chlorinated ethanes persisted, followed by an injection of potassium permanganate across the whole area once the Fenton’s Reagent had completely auto-decomposed.

A network of 110 permanently buried injection points, each with a dedicated injection line to allow for complete control of oxidant dosing were installed across a 1,100m² treatment area. The wells were connected to oxidant mixing, injection and dosing plant that allowed total control over delivery of oxidants to each well.

Heat exchangers were attached to the site generators to optimise energy efficiency and allow the warming of dosing waters to 25°C to increase permanganate solubility.

**SUMMARY**

Two injection rounds were undertaken in June and December 2010 with a total of 705m³ of Fenton’s Reagent, and 288 tonnes of potassium permanganate being injected over both rounds.

Verification works are on-going but show very high rates of contaminant destruction for most of the chemicals of concern, with only a handful of minor exceedences remaining.

**FURTHER INFORMATION**

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