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AQUIFER REMEDIATION

Capability Statement

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Date: September 2003

Issued to	Date of Issue	Initials

WJ GROUNDWATER LIMITED

Aquifer Remediation Capability Statement

1. Background

WJ Groundwater Limited was first established in 1981 as a specialised dewatering contractor to service the needs of the construction industry. The company has since expanded to offer the design, installation and operation of groundwater and soil remediation systems. A team of experienced staff, and a long track record, enables WJ to offer cost-effective solutions to a wide range of groundwater and soil remediation problems encountered by the construction industry.

WJ are able to provide design, construction, installation, operation and maintenance of in situ and ex situ remediation and treatment systems for impacted soil and groundwater. WJ have experience of removing a wide range of contaminants including metals, petroleum hydrocarbons, chlorinated solvents, pesticides and radioactive solutions. WJ have access to a comprehensive set of remediation techniques for both soils and groundwater. With this capability WJ are able to provide the most appropriate technology to suit site specific criteria and conditions.

WJ's client list ranges from multi-national contractors to local engineering companies, consulting engineers, landfill operators and landowners. WJ is able to tailor its services to its clients' needs in order to provide the best-value solutions, consistent with delivering a reliable professional service throughout the tender, design and implementation phases of a project.

It is WJ's aim to develop long lasting business partnership relationships with existing and future clients, subcontractors and suppliers, respectively promoting effort and commitment to innovation and high quality cost effective solutions.

WJ's technical expertise was endorsed when it was invited by the Construction Industry Research and Information Association (CIRIA) to prepare the new industry standard guide *Groundwater Control: Design and Practice*. This expertise is available directly to clients at all times on all projects.

2. Summary of capabilities

2.1 Groundwater and soil remediation

WJ carry out groundwater and soil remediation on contaminated sites under a variety of contract situations matched to our clients' requirements. Detailed method statements, risk assessments, site records and drawings are produced for all contracts. Sub-contract packages include engineers, technicians and site staff with back-up facilities on nation-wide 24-hour call basis. All systems are available with automatic alarm systems and remote monitoring equipment, which can be accessed through the Internet on a real time basis. Resident site operators can give 24-hour emergency cover when required.

The plant selected for a particular project depends primarily on the nature of the contamination and the anticipated ground conditions. WJ is able to supply a complete range of soil and groundwater remediation plant including key components, wells, treatment plant, and the services network to complete the package.

2.2 Installation and development

WJ has the specialist equipment to drill in a variety of soil conditions at diameters from 150 to 450 mm using cable percussion, rotary and auger methods. WJ's considerable experience in well design, installation and development allow them to tailor designs for each site by the use of specific drilling methods, screen details, installation methods and filter packs. WJ have a wide variety of equipment that can be used to flush out and develop wells to ensure that each operates at optimum performance. Well capacities vary from 0.5 to 25 l/s per well. WJ provide appropriate pipework, valves and associated equipment, together with electrical controls, alarms and all the necessary safety equipment and protection.

Multi-purpose wells may be screened to effect selective extraction or recharge at different soil horizons. The screening system is flexible and may be changed during the course of the project. The wells are also designed to accommodate sampling and data collection equipment.

2.3 Pilot trials and pumping tests

Pilot scale trials are the most desirable way in which to ensure that large scale remediation projects are conducted efficiently and effectively to meet the clients' needs, budgets and time frames. Within the trials the effectiveness of the techniques can be monitored and specific information can be collected which can then be incorporated into the design of the full-scale system. During pumping tests groundwater is abstracted from a well in a controlled manner and is monitored for quality, while flow rates and reduction in piezometric heads are recorded. This can be a useful way of investigating pollution problems at a site and can allow remediation

strategies to be developed. Tests can involve single or multi-well pumping with datalogging equipment used to continuously record key parameters. WJ is able to design and carry out such pilot scale studies and can analyse the resulting data to define the conditions at a site.

2.4 Monitoring systems

Electronic datalogging systems can be used to collect data on piezometric levels, pumped flow rate and mechanical system performance. WJ develop, install and operate datalogging equipment for contaminated sites. Data loggers can be stand-alone units for individual isolated monitoring wells or can be multi-sensor units for large and complex sites. Hardware and software can be configured to transfer data off-site via telephone (land-line or cellular) links. WJ have a variety of standard dataloggers for hire and also develop site specific systems tailored to the data acquisition, handling and interpretation needs of each site or client. In this way WJ can supply real time information to our clients via the Internet through a suitably protected system.

3. Techniques - Free product recovery

When organic compounds such as petroleum or solvents are released into the sub-surface they travel down through the vadose zone and then tend to pool or become trapped either at the water table or at restricting layers within the aquifer. The ultimate location depends primarily on the density of the organic compound. Compounds that are less dense than water are referred to as Light Non Aqueous Phase Liquids or LNAPLs. These tend to accumulate as a floating layer on the surface of the water table. Many chlorinated organic solvents (such as tetrachloroethene, trichloroethene and trichloroethane) are more dense than water and are referred to as Dense Non Aqueous Phase Liquids or DNAPLs. These tend to accumulate as a separate layer on the bottom of the aquifer or on impervious strata (eg silt lenses) within the aquifer.

Recovery of the separate non aqueous phase liquid (either LNAPL or DNAPL) is often the first and most important element of site remediation. Otherwise, the LNAPL or DNAPL will serve as a source of continuing dissolved-phase contamination. For LNAPL residues floating on the water table, the recovery options include skimming pumps, bioslurping and soil vapour extraction (SVE). For DNAPL residues pooled on the bottom of an aquifer, the recovery options include a low flow pumping and in-situ oxidation, but the more challenging aspect is first to find the location of the trapped DNAPL. Any recovery of free product should also include recovery of residues trapped in the vadose zone because a significant fraction of the free product will remain trapped within the pore spaces in the soils above the water table.

Product recovery of petroleum using skimming pumps can be completed in either wells or trenches depending on the depth to groundwater. These recovery systems may also include a separate water extraction pump to lower the water table and create a cone of depression to enhance the product recovery rate. Bioslurping is a comparatively new recovery method which uses a vacuum at the well head to create an 'effective' cone of lower pressure which also causes the free product to migrate towards the recovery point. The product is recovered through a 'slurping' tube which, is adjusted to recover a maximum of product and minimise the amount of water recovered. Bioslurping has been shown to be highly effective in lower permeability soils where recovery with skimming pumps has limited effectiveness. Bioslurping can also be implemented within a recirculating well so that the same below ground installation (the recirculating well construction) is able to complete both the product recovery phase and the dissolved plume phase of groundwater restoration.

4. Techniques – Groundwater remediation

The traditional approach to remediation of contaminated groundwater relies on installation of extraction wells to withdraw affected waters for treatment above ground and subsequent discharge. This configuration may work in simple flow systems, but suffers mass transfer limitations when implemented in heterogeneous environments. Because water will flow through the path of least resistance, pump and treat systems restore the high permeability zones rapidly, but require excessive time periods for restoration of zones containing fine silts and clays. A number of new technologies have been developed to accelerate clean up in both simple and challenging matrices.

4.1 Permeable treatment barriers

A permeable treatment barrier is constructed from the water table down to an impermeable layer beneath the contaminant plume. Barriers are passive, in-situ treatment systems that are well suited for plume management applications. Barriers consist of material that will capture (eg absorb) or destroy the contaminant on contact. They may be permeable along their entire length or may comprise of funnels (impermeable sections) and gates (permeable sections filled with an active agent). As groundwater flows through the permeable sections of the wall, contaminants are absorbed, immobilised or broken down. For chlorinated solvents and hexavalent chromium, zero-valent iron has proven effective as the active media and WJ personnel were involved in the first European installation of such a scheme in 1995. These systems are particularly effective in shallow soil with slow moving groundwater and have proven attractive to the environment agencies in that their operation can take place long after a company may have left the site.

4.2 In situ air sparging

In-situ air sparging is a remediation technique suitable for the removal of volatile organic compounds (VOC) dissolved in groundwater, sorbed to the saturated soils or trapped in the pore spaces within the soils. The system involves the injection of compressed air at controlled pressures and volumes into the water saturated soils. The contaminant removal is achieved by a number of mechanisms notably air stripping of dissolved VOC's; volatilisation of trapped and adsorbed phases below the water table and within the capillary fringe; and aerobic biodegradation of both dissolved and adsorbed phase contaminants.

4.3 Recirculating wells (in well stripping)

For thicker and deeper plumes, recirculating wells can be applied to strip volatile contaminants in the well. Each well has two screened sections, one at the bottom of the plume and one above the plume. Air is injected in the well to create an airlift pumping action. The air is channelled through an inner casing so that water is drawn into the bottom screen and allowed to discharge through the upper screen. As the air-water mixture rises in the well, VOC's are volatilised from the water. The top of the well is kept under vacuum so that injected air and all VOC's are withdrawn for treatment. The groundwater is oxygenated in the process to promote aerobic biodegradation of any residues. Because the water is returned to the aquifer above the withdrawal point, vertical circulation patterns are established which are more efficient at flushing heterogeneous strata than traditional extraction wells.

4.4 Fracture enhancement

When contamination lies within a low permeability matrix, hydraulic or pneumatic fracturing can be applied to increase the permeability and thereby increase the effectiveness of the remediation system. High pressure injection of liquid or air in a grid across the contaminated zone induces radial fracture patterns that become preferred flow paths for both air and groundwater. Depending on the site requirements, the high pressure injection to induce fractures may be undertaken using a proppant containing sand, which effectively creates zones of increased permeability within the fracture zones (Frac Rite™). Pump and treat or recirculating well systems are then operated within the newly fractured zone.

4.5 Wetland technology

The development of wetland technologies incorporating reed beds can often provide a cost effective, low maintenance solution to water treatment. These systems can be developed to be incorporated into the overall site rehabilitation schemes to provide a long term contaminate management option while adding to the general site ambience and providing a wildlife habitat.

The system involves a complex mechanism of bacterial oxidation, filtration, adsorption, sedimentation, and chemical precipitation.

5. Techniques - Soil remediation

The traditional approach to restoration of contaminated soil has relied on excavation and off-site disposal or treatment. While this approach is clearly an effective method, there are potential problems concerning the long term sustainability of this option. In addition on operational sites and in areas of infrastructure the disturbance caused by this method of remediation is not always the most desirable. In many cases this treatment option may not be technically feasible because of access restrictions or the depth where contamination is located. As a result, several in-situ methods have been developed for restoration of contaminated soil.

5.1 Soil vapour extraction

Soil vapour extraction (SVE) is the most widely implemented in-situ soil remediation technology for volatile and semi volatile compounds such as chlorinated solvents or gasoline present in the soil. The process uses a vacuum pump or blower to move air as a carrier medium through contaminated soil. The SVE process takes advantage of the volatility of the contaminants to allow the mass transfer from the adsorbed, dissolved and free phases in the soil to the vapour phase, where it is moved under vacuum and treated with an appropriate off-gas treatment system (typically adsorption on activated carbon or destruction using an oxidation system).

The process can be applied either in-situ or in above ground piles (biopiles). Important site factors which affect the design and implementation of this technology include contaminant volatility, soil moisture content, soil air permeability, the presence of ground surface cover and depth to groundwater. It is possible to estimate the yield of a soil venting well (based on the soil air permeability and thickness of contaminated soil). This can then be used to design a system layout based on site conditions and project objectives.

Technology enhancements to SVE that have been implemented at complex sites include thermal enhancement and pneumatic and hydraulic fracturing. Thermal enhancement is used for semi-volatile compounds and heavier petroleum fractions such as diesel and heating oils. Pneumatic fracturing can be used to increase the air flow permeability of certain types of dense soils.

5.2 Bioventing

Bioventing is an in-situ remediation technology applicable to soils contaminated with compounds, which are aerobically biodegradable (typically residues from petroleum spills). The fluid handling element of bioventing is very similar to a SVE application except that the objective is to draw oxygen to the contaminated soil zone in order to enhance in-situ biodegradation processes. Other process considerations may also include control of soil moisture and adding trace nutrients as necessary. In comparison to soil vapour extraction, bioventing is applicable to heavier less volatile petroleum fractions such as diesel and may also be more effective in lower permeability soils.

5.3 Vacuum enhanced recovery

Vacuum Enhanced Recovery (VER) utilises the application of a high vacuum or negative pressure on a recovery well which increases the net effective drawdown on the well, thus enhancing the liquid recovery from the well. VER also increases the mass removal of the volatile and semi-volatile compounds by facilitating the volatilisation from previously saturated soils. In addition the increase in the subsurface oxygen levels enhances mass removal due to aerobic biodegradation of the contaminants.

6. Examples of projects carried out by WJ Groundwater Limited

Groundwater remediation, Northern England

Working for the landowner, WJ carried out an investigation to establish the source, extent and significance of sulphate contamination beneath an existing manufacturing facility. The investigation traced the source to a leaking foul drain system; piled foundations were exposed and showed evidence of sulphate attack. Subsequently WJ designed, installed and operated a groundwater remediation scheme that removed the major part of the contamination.

Groundwater quality control for the river Medway submerged tube tunnel - Kent

WJ were responsible for the groundwater control work to enable the safe construction of the submerged tube tunnel units in a 300m by 300m by 15m deep casting basin. Deep wells were utilised to provide adequate drawdown whilst at the same time minimising saline intrusion of the north Kent water supply aquifer. WJ designed and monitored dewatering operations to achieve these objectives. The work involved extensive analytical studies to support the proposed dewatering strategies, which were subject to the approval of the EA.

Removal of waste from a closed landfill site – Buckinghamshire

Building development was proposed for a closed landfill site in which the planning consent required the removal of the waste and replacement with inert wastes. Working for the consultant, WJ advised on the groundwater and leachate pumping measures that would be required to excavate the waste in a controlled manner. The pumping regime proposed by WJ had an important input into the development process.

Well pumping trials – Pride Park, Derby

WJ designed and constructed a series of pumped and observation wells on a former industrial site and carried out well pumping trials including background monitoring, step-drawdown tests, constant discharge tests and recovery tests. Automatic data logging equipment was used to monitor flow rates and groundwater levels.

Perimeter well point scheme – Cardiff Bay barrage

An 800m long sand/rock bund was used to retain the sea allowing excavation to –10mOD for the barrage lock structure covering some 26,000m². The bund included a thin grout cut-off. WJ designed installed and operated a perimeter well point scheme and sump system to drain the excavation and control of residual seepage through the bund and cut-off. The total discharge from the system was approximately 150l/s.

Vapour enhanced recovery – Industrial site - Derby

A VER system was installed on a site where diesel contamination had resulted from a leaking fuel line. The system was designed to remove a film of groundwater contamination and soil vapours while enhancing the biodegradation within the vadose zone through the introduction of air.

Pump and treat system – Industrial site – East Scotland

A pump and treat system was design for a site underlain by pesticide contaminated groundwater. The groundwater was abstracted and treated prior to discharge under the approval of SEPA.

Soil Vapour Extraction - Residential development – Scotland

A site where a fuel oil spill had migrated beneath a residential building. A vapour extraction system was installed beneath the building floors to remove vapours.

Treatment of Recharge Water – Power Station Development, South Wales

As part of the site dewatering scheme, the abstracted groundwater required recharge to the aquifer beneath this site. Complex reactions within the groundwater body that was contaminated with chlorinated hydrocarbons resulted in fouling of the recharge wells. A treatment system was designed and installed by WJ, which removed the excessive costs being incurred as a result of well redevelopment.

Groundwater Management – Barrow Street Gasworks, Dublin

As part of the remediation strategy for the development of an extensive gasworks in the dockland area of Dublin WJ Groundwater were responsible for the abstraction and treatment of groundwater within the excavation areas. The groundwater treatment was capable of removing petroleum hydrocarbons, phenols and other gasworks contamination

Groundwater Treatment – Secondsight Gasworks

As part of Secondsight Properties plc (formerly Lattice plc) remediation programme WJ has been commissioned by the main earthworks contractor to provide groundwater treatment to remove phenols, poly aromatic hydrocarbons, tars and cyanide products from perched water bodies as part of the site remediation strategy.

Pump and Treat – former garage Cockfosters, London

During the development of a former garage a pump and treat remediation scheme was installed to remove contaminated groundwater from beneath one portion of the site. The groundwater was treated on-site prior to discharge under consent from the local utility company.

Pump and Treat – Budenburg Gauge building, Altrincham

Groundwater management and treatment for extensive development of former industrial site including treatment for chlorinated solvents, petroleum hydrocarbons and mercury.

Pump Tests to obtain data for Remediation Design – Various locations in the UK and Ireland

To obtain aquifer characteristics a number of pump tests have been undertaken both in shallow and deep aquifers. Groundwater contamination with petroleum hydrocarbons, metals and chlorinated solvents has been treated on-site as part of the discharge criteria within the pump test. Both absorption and volatile stripping techniques have been employed to ensure discharge limits are adhered to during the test.

7. Client list

WJ have carried out groundwater control contracts for many clients, including:

Alfred McAlpine Civil Engineering Limited	Johnston Construction Limited
AMEC Civil Engineering Limited	Keller Ground Engineering
AMEC Tunnelling	Kier Construction Limited
Amey Construction Limited	Kilroe Civil Engineering Limited
AOKI Corporation	Kvaerner Construction Limited
Bachy Limited	Laing Civil Engineering
Balfour Beatty Construction Limited	Lancashire Waste Services Limited
Ballast Wiltshier PLC	Mabey Construction Limited
Barhale PLC	McNicholas Construction Co. Limited
Bechtel Limited	McPhillips (Wellington) Limited
Birse Construction Limited	Miller Civil Engineering Limited
Biwater Europe Limited	M J Gleeson PLC
Bovis Construction Management	Morrison Construction Limited
Cementation Projects Limited	Mott MacDonald Group
Charles L Warren Limited	Mowlem Civil Engineering Limited
Christiani and Neilsen Limited	Nishimatsu Corporation
Clugston Construction Limited	North West Water
Costain Civil Engineering	Norwest Holst Construction Limited
Crowngap Construction Limited	P C Harrington Contractors Limited
Currall Lewis and Martin Limited	Pierse Contracting Limited
DCT Civil Engineering Limited	P J Walls (Civil) Limited
Dean & Dyball Construction Limited	Railtrack PLC
Edmund Nuttall Limited	R O'Rourke & Son Limited
Ernest Ireland Construction	Schal International Limited
Eve Construction Limited	Scott Wilson CDM
Fox Contracting (Owmbly) Limited	Seymour (Civil Engineering Contractors) Ltd
Galliford Construction	Shimizu (UK) Limited
Geoffrey Osbourne Civil Engineering Ltd	SIAC Construction (UK) Limited
Geotechnical Engineering (Northern) Limited	Sir Robert McAlpine & Sons Limited
Geotechnics Limited	Soil Mechanics Limited
George Leslie Limited	Bachy Soletanche Limited
Greenham Construction Materials Limited	Tarmac Construction Limited
Harbour and General Works Limited	Taylor Woodrow Construction Limited
Heyrod Construction Limited	Trollope and Colls Limited
Hochtief (UK) Construction Limited	Vianni Lavori SPa
J Murphy & Sons Limited	Wallis Limited
J N Bentley Limited	Wimpey Construction Limited

8. Key personnel

WJ's management and technical staff have extensive experience and expertise in civil engineering, groundwater control and land remediation. They are backed up by administrative staff at offices in Bushey and Chester. Brief biographical details of key members of staff are given below:

Dr Toby Roberts BSc PhD CEng FICE CGeol FGS MCIWEM FRGS - Managing Director

A leading expert in groundwater systems and with considerable experience in the UK and overseas, Toby has overall responsibility for all technical and contractual matters at WJ. Toby has been responsible for the implementation of more than 600 groundwater control projects in the UK and overseas ranging from minor street works to major infrastructure projects. He is author/co-author of 19 publications on groundwater control systems including the CIRIA publication C515 'Groundwater control: design and practice' 2000. Toby has acted as expert witness in several commercial arbitration cases involving groundwater control works.

Professor Jim White MA DPhil CEng FICE- Chairman

A specialist in the computer modelling of water resources, groundwater control systems and the chemistry and biology of the degradation of solid waste and gas generation in landfills. As well as overseeing WJ's overall strategy Jim is responsible for several research and consultancy projects in his area of expertise. He is currently Chairman of the Steering Group for the Engineering and Physical Sciences Research Council Platform Grant Research Project on Landfill Gas Generation and Transport, University of Southampton. Jim also supervises the computer modelling design work necessary for major dewatering schemes.

Professor William Powrie MA MSc PhD CEng FICE - Consultant

Professor Powrie acts as consultant for WJ, specialising in groundwater problems and other geotechnical and soil mechanics matters. Particular expertise includes groundwater flow and characterization of soil permeability, studies of consolidation and other dewatering induced settlements, diaphragm and sheet-pile walls including installation effects and temporary prop loads, stability and remediation of cutting and embankment slopes, and waste mechanics and landfill engineering including the potential for groundwater pollution.

Mr Michael Roper MSc DIC CEng MIMM FGS- Remediation Manager

An expert in environmental geotechnics with more than 15 years experience in the design and implementation of innovative remediation schemes for both soil and groundwater. Michael is responsible for WJ's remediation sector, including contaminated groundwater and soil clean-up as well as landfill engineering projects. Completed projects include, dual phase abstraction, pesticide treatment, reedbed/wetland treatment systems, in-situ reactive barriers, soil vapour extraction, landfill leachate recirculation and landfill gas systems.

Mr Richard Fielden – Contracts Director

Richard is responsible for the day to day management and programming of all WJ's dewatering projects. He has previous experience with a specialist geotechnical sub-contractor and a major civil engineering contractor.

Mr Steve Earl BSc – Site Engineer

Steve is involved in all aspects of WJ's instrumentation and monitoring systems, in which he has many years experience. Steve has been responsible for the design and installation of the monitoring systems on many major projects such as the Channel Tunnel Rail Link. He has also implemented datalogging systems in countries such as Italy, Ireland and Dubai.

Mr Sebastian Fisher – Design Manager

Sebastian is responsible for the design of many of the projects undertaken by WJ. He has a wealth of knowledge of groundwater control in a wide range of ground conditions, which is backed up by more than ten years site experience. He has overseen the installation and operation of dewatering systems in Hong Kong, the Philippines and Singapore as well in the UK.