

London 2012 Olympic Park

Enabling Works (Stage 1) Consolidated Validation Report – Planning Delivery Zone 3

July 2012

Notice

This document and its contents have been prepared and are intended solely for the Olympic Delivery Authority (ODA)'s information and use in relation to summarising remediation and validation works within Planning Delivery Zone 3 on the Olympic Park site.

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- Figure 2: Thanet Sand NAPL boreholes and Infrastructure Plan
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PART 1

1. Introduction

1.1 Objectives

The aim of this Enabling Works Consolidated Validation Report (CVR) is to provide a high level commentary on the approved remediation related documentation pertaining to Planning Delivery Zone 3 (PDZ3). These remediation works were completed as part of the Olympic Delivery Authority (ODA) redevelopment of the London 2012 Olympic Park in Stratford, London. On the basis that the individual remediation reports have previously been approved by the Local Planning Authority (Olympic Delivery Authority Planning Decisions Team (PDT)) this Enabling Works CVR will neither reproduce nor re-evaluate any of the detailed testing, results, or assessments that have been previously reported and are contained therein.

This Enabling Works CVR has been prepared to gain PDT partial discharge for the remediation carried out by Enabling Works under Condition 35 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Site Preparation Planning Application⁽¹⁾. However, it is acknowledged that a further 12 month groundwater monitoring period is required across the CZ3a Banner site in the River Terrace Deposits, Thanet Sand and Chalk aquifers. This groundwater monitoring period will commence as soon as reasonably practicable post Games in order to establish long terms in contaminant chemical concentrations. As a result this groundwater monitoring and any associated remedial actions represent a residual remediation item, which until its completion to satisfy the regulator/PDT requirements, Condition 35 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Site Preparation Planning Application⁽¹⁾ can only be partially discharged.

1.2 Report Objectives

The focus of this report is to discharge the ODA's responsibilities under the relevant Planning Conditions in the following principal Planning Applications. The CVRs prepared by the ODA shall be issued to the PDT for approval in two stages to provide clarity and ensure progressive regulatory approval is achieved. This two stage process, which covers the ODA's work, is set out as follows, but it should be noted that additional reporting stages may be required should third parties, such as LOCOG, be required to validate their work:

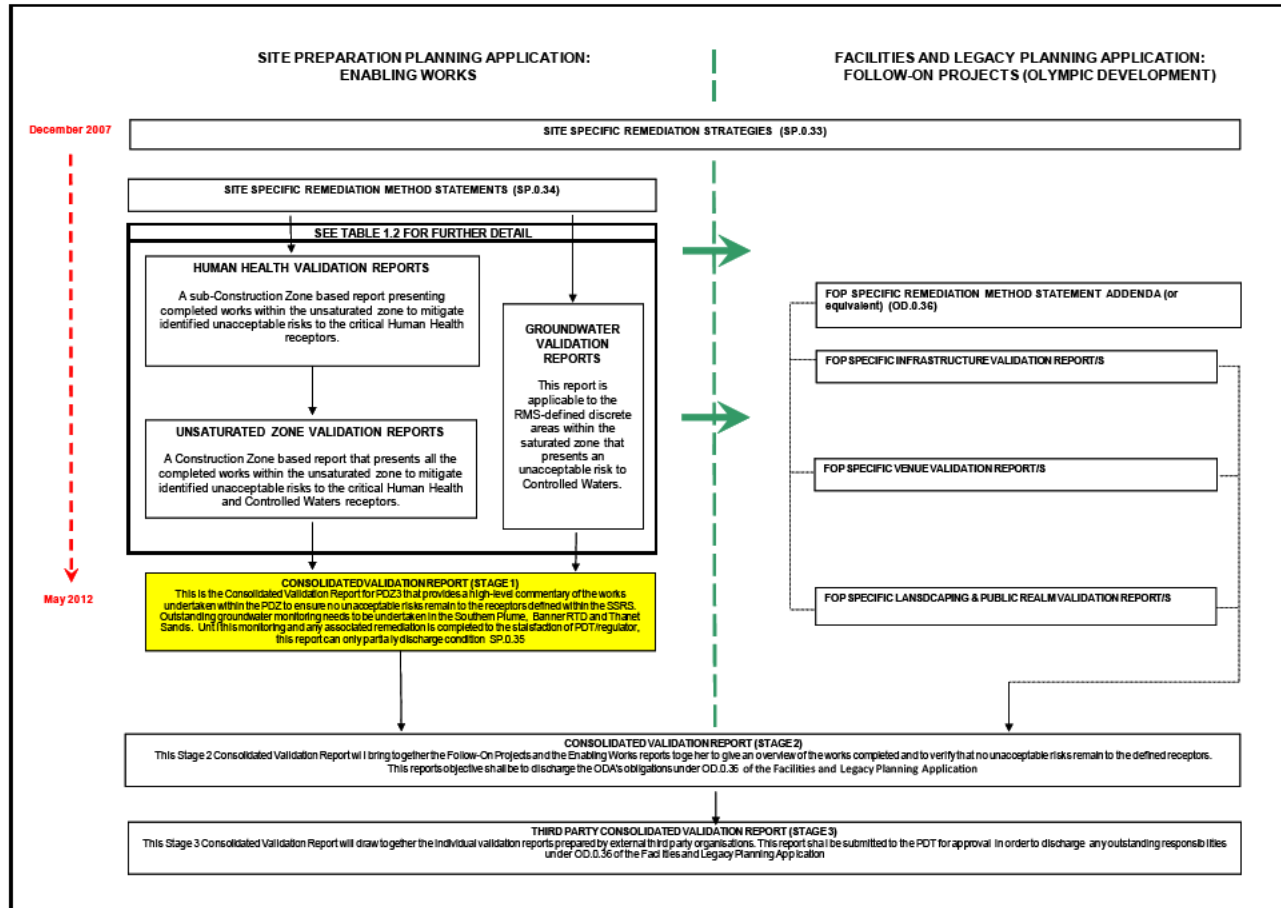
- **Stage 1** will comprise Part I (Background) and Part II (Implementation of Design – Site Preparation (Enabling Works)). Part I sets out the remediation works within the context of the preceding remedial design. Part II shall concisely discuss the implementation and validation works completed by the Enabling Works Team. The objective of this CVR (Stage 1) is to obtain a partial discharge from PDT for the remediation works carried out under Condition 35 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Site Preparation Planning Application⁽¹⁾. However, it is acknowledged that a further 12 month groundwater monitoring period is required across the CZ3a Banner site in the River Terrace Deposit, Thanet Sand and Chalk aquifers. Until this monitoring and any associated remedial action is completed to the satisfaction of the Regulator/PDT then full discharge of Condition 35 cannot be achieved.

- **Stage 2** will comprise only Part III (Implementation of Design – Olympic Development (Follow-on Projects)). Part III presents the completed construction and remediation works as required to facilitate the development aspects of the works i.e. infrastructure, venues and landscaping. The same CVR issued with completed Part III will be submitted to discharge the ODA's obligation under Condition 36 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Facilities and Their Legacy Transformation Planning Application⁽²⁾ and subsequent applicable Slot-In Planning Conditions relating to construction variations.
- **Stage 3** may be required in instances where the Human Health Separation Layer and other overlay / completion works will be carried out by external third party organisations, most notably the London Organising Committee of the Olympic and Paralympic Games (LOCOG). In such circumstances, it will be the responsibility of these third parties to prepare, submit and obtain PDT approval of their works by way of separate Validation Reports. As a consequence of these separate validation reports, it is currently envisaged that another CVR (Stage 3) will require submittal under Condition 36 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Facilities and Legacy Transformation Planning Application⁽²⁾. If such a Stage 3 CVR is required this will be prepared and submitted by a third party organisation.

Liaison will be undertaken with LOCOG to understand not only the areas of their work which require the production of a Stage 3 CVR, but also the timing of this report production. The findings from these discussions will be conveyed in the Stage 2 CVR.

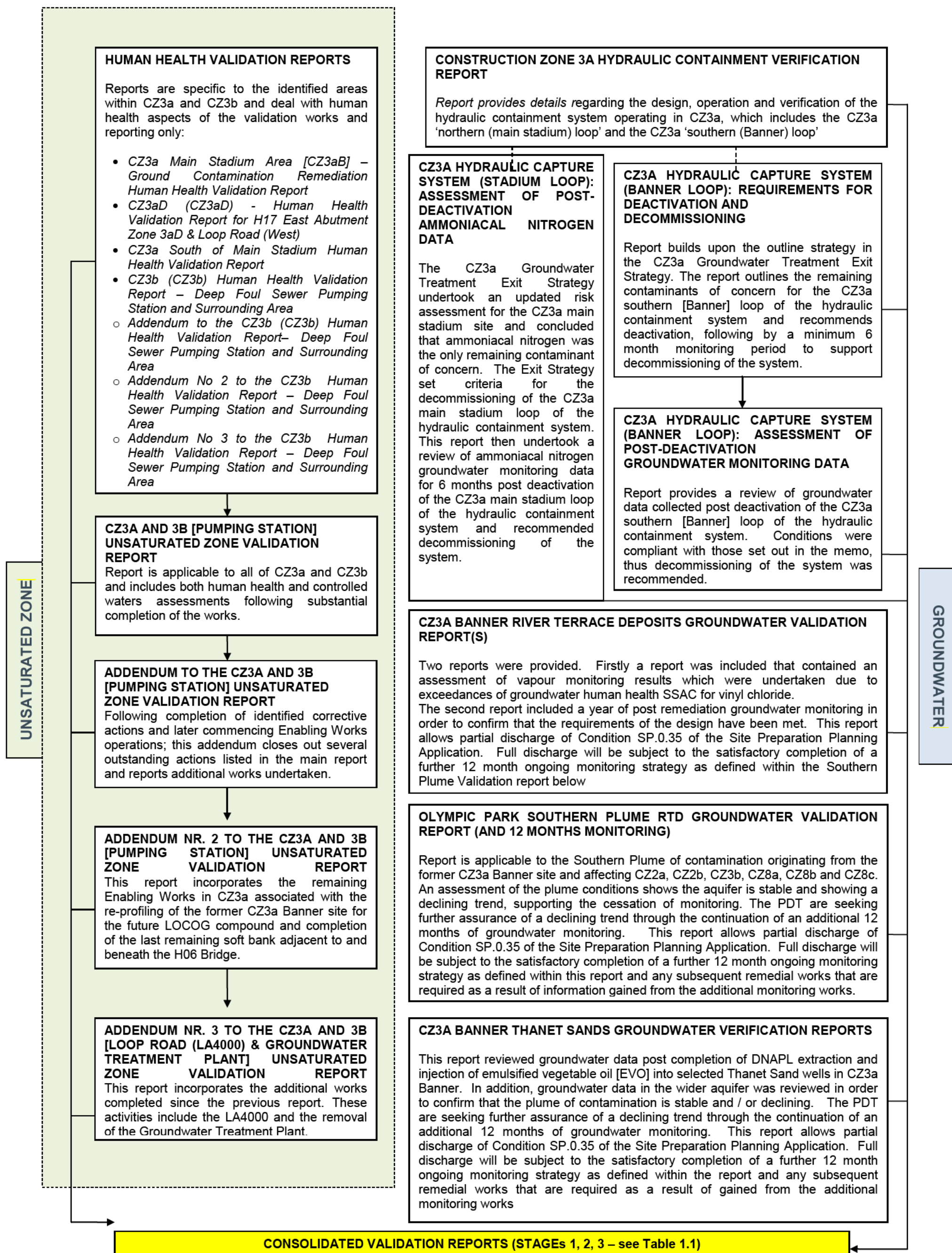
The PDZ3 validation reporting sequence, presenting these three stages of Consolidated Validation Reporting, is illustrated in Table 1.1 below. Given the complexity of the PDZ3 reporting, Table 1.2 presents a more detailed summary of the reporting structure,

Table 1.1: PDZ3 Validation Reporting Structure



* Please refer to Appendix B and Table 1.2 for a summary of each report and the development of the remedial design, implementation and validation

Table 1.2: Detailed Enabling Works Validation Reporting Structure



1.3 Relevant Planning Conditions

The reporting boundary for this CVR is presented on Figure 1. The document is submitted to the PDT for approval to facilitate discharge of the Planning Conditions listed in Table 1.3 below.

Table 1.3 - Validation Related Planning Conditions to be discharged by this Report

<u>Site Preparation Planning Application (No. 07/90011/FUMODA)</u>		
<i>SP.0.35</i>	<i>Remediation Validation</i>	Stage 1 submitted for Discharge
SP.0.35	<p>Remediation validation</p> <p>Validation of the Remediation Works for the purposes of human health protection must be provided within one month of completion of the Enabling Works Protection Layer within any Planning Delivery Sub-Zone. When all Remediation Works necessary for the protection of human health are completed within any particular Planning Delivery Zone, a consolidated Validation Report drawing together the Planning Delivery Sub-Zone validations shall be submitted to the Local Planning Authority. This shall include detailed topographic mapping of the as-built ground levels. Validation of the Remediation Works for the protection of controlled waters shall be undertaken on completion of the relevant Remediation Works relating to controlled waters and a Validation Report shall be submitted to the Local Planning Authority for the whole of each Planning Delivery Zone.</p> <p>Reason: To ensure that all Remediation is properly validated and recorded.</p>	

1.4 Outstanding Works

This CVR has been prepared on the basis of the works completed to date and the associated approved documents.

As part of the outstanding works in the CZ3a Banner site, it is acknowledges that a further 12 month groundwater monitoring period will commence as soon as reasonably practicable post Games in order to establish long term trends in contaminant chemical concentrations. This monitoring will specifically target the presence of the main contaminants of concern in the area, which includes vinyl chloride, chlorinated ethenes, dissolved ethanes, methane, arsenic, and total organic content determinants such as iron and chloride for the River Terrace Deposits. This monitoring will be undertaken in eleven boreholes, the locations of which are defined in Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0382, which have previously been agreed with the PDT/Regulator. These boreholes will be sampled on a monthly basis for six months and then following a review of the data and further discussion with the regulator/PDT the monitoring may reduce to a quarterly frequency for the remaining six months.

Whilst for the Thanet Sand and Chalk aquifers a combination of the following monitoring streams will be undertaken across ten boreholes (six Thanet Sands and four chalk boreholes as defined in Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0831), which have been previously agreed with the PDT/Regulator. In-situ monitoring in the form of water level, electrical conductivity, temperature, pH, dissolved oxygen, oxidation reduction potential will be undertaken. In addition

chemical sampling and testing for arsenic (total and dissolved), ammoniacal nitrogen, polycyclic aromatic hydrocarbons, volatile organic carbons, total organic carbon, dissolved methane and ethene will also be undertaken. In all cases the presence or absence of non-aqueous phase liquids (NAPL) will also be recorded. This monitoring will be undertaken on a monthly basis for six months and then following a review of the data and further discussion with the regulator/PDT the monitoring may reduce to quarterly for the remaining six months.

On the basis of these monitoring works for both the CZ3a Banner River Terrace Deposits and the Thanet Sands the need for any further remedial works in this area as required by the Regulator/PDT to fully discharge Condition 35 will be defined. As a result this 12 month monitoring and any associated remediation work represents a residual remediation item and until its completion, to the satisfaction of the Regulator/PDT, the Condition 35 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Site Preparation Planning Application⁽¹⁾ can only be partially discharged.

1.5 Limitations/Exclusions

This CVR is based on third party information made available to the ODA from the sources listed as key supporting data and references and the information is assumed to be accurate and complete.

This CVR does not re-evaluate any of the data previously assessed within the approved documents summarised herein.

This CVR should be read in light of the legislation, statutory requirements and/or industry good practice applicable at the time of the works being undertaken. Any subsequent changes in this legislation, guidance or design may necessitate the findings to be reassessed in the light of these circumstances.

2. Basis of Remedial Design

The Enabling Works Project primarily comprised site clearance, demolition, earthworks and remediation works to deliver a platform upon which the infrastructure and venues for the London 2012 Olympic Park could be constructed. These works were implemented by the Enabling Works Tier 1 Contractors BAM Nuttall (BNL). The core objective of the Enabling Works was to ensure the site was remediated to a standard protective of both human health and controlled waters receptors as defined by the Olympic and Legacy Masterplans (see section 2.2).

The Global Remediation Strategy (GRS) was prepared by Capita Symonds for the project as a high level roadmap that was further developed by the construction zone specific Site Specific Remediation Strategies (SSRS). In addition, the SSRS were informed by the investigation works completed in accordance with the Intrusive Investigation Method Statement (IIMS) that presents a framework and provides a generic specification for undertaking contamination intrusive investigations across the London 2012 Olympic Park.

For the purposes of risk assessment and remediation, PDZ3 was divided into Construction Zone 3a (CZ3a) and the Pumping Station part of Construction Zone 3b (CZ3b). The remainder of PDZ3b was outside the scope of the Enabling Works activities. CZ3a and CZ3b are physically separated by the Greenway and were further sub-divided according to Legacy land use and remediation areas defined by the Designers and phasing of the works due to handover dates.

2.1 Site Location

The Site is located approximately 1.1 km west of Stratford, London and comprises CZ3a Main Site, CZ3a Banner and the Pumping Station part of CZ3b, known collectively as PDZ3. The location of these three areas is illustrated in Figure 1. CZ3a is a triangular parcel of land covering approximately 20ha bounded by surface watercourses and the Greenway to the south. The Pumping Station portion of CZ3b is a rough triangular parcel of land that is approximately 0.5ha. This site is bounded by the Greenway to the north and east, railway line to the south and Marshgate Lane and the remainder of CZ3b.

The remaining portion of CZ3b was neither investigated nor remediation as part of the Enabling Works project as the land was never in the ownership of the London Development Agency (LDA) or its successors the Olympic Park Legacy Company (OPLC) or the London Legacy Development Corporation (LLDC). Subsequent Follow-On project works were undertaken in this area in order to construction the temporary warm-up track, and other infrastructure works and these will be covered within the Stage 2 CVR.

2.2 Olympic and Legacy End Use

The Olympic and Legacy end use as defined by the Designers⁽³⁾ is as follows:

Olympic Mode (Figure 2): The Olympic Stadium forms approximately 60% of the total site area for CZ3a. The remaining site use will be hardcover with a relatively small proportion of soft landscaping bordering the surface watercourses. The Pumping Station part of CZ3b will be used for a pumping station and deep sewer shaft.

Legacy Mode (Figure 3): The Main Olympic Stadium will remain in Legacy. The surrounding areas is proposed for residential and educational mixed use, a permanent road, deep foul sewer, soft river bank and soft landscaping. The Pumping Station part of CZ3b is currently earmarked for residential use.

There has been design changes to the topographic levels which were reviewed and assessed (where appropriate) in SSRS and RMS addenda. Whilst the Stadium was slightly moved northwards, there have been no significant venue movements. In addition, the Masterplan figures should be read in conjunction with Drawing SKE-ATK-XX-ZZZ-OLP-XXX-O-0003 (Sub Zone Remediation Areas (including areas anticipated as no remediation)).

2.3 Site History

The London 2012 Olympic Park has had an extensive industrial legacy of potentially contaminative land uses ranging from, but not limited to, petrol stations, glue factories, match works, uncontrolled landfills, garages and fish processing. PDZ3 was identified to have had an extensive industrial heritage from the late 1900's with heavy industrial activity continuing up until the Enabling Works gained possession of the site in 2006 onwards. A detailed site history is outlined in the original SSRSs⁽³⁾, which is summarised below in Table 2.1.

Table 2.1: Historic Land Use for PDZ3

Timescale	Industrial Use
From 1869	Corn Mill present on the west side of CZ3a. Area of CZ3b is occupied by marshland.
From 1882	Corn Mill still present. Tar & Turpentine Distillery present in east area of CZ3a.
From 1896 to 1916	Corn Mill now Knobshill Cottage. Bone Works towards southern end of CZ3a with Colour Works (was a forerunner to the DROF works and dying has been ongoing at this site for some considerable period of time), Hence this area in the central western portion of CZ3a has become known as the DROF site. Oil Works and Marshgate Works located southeast of the Bone Works in place of Tar & Turpentine Distillery The area of CZ3b now contains ditches and pathways.
From 1916 - 1936	Bone Works has disappeared with Old Ford Pumping Station located in the south-western area of the Site. The Colour Works remains in the same location. CZ3b unchanged.
From 1936 - 1951	Bone Works once again shown at previous location. Colour Works remains, but Knobshill Cottage disappears. Landfill (land raise) occupies the whole site north of Pudding Mill River and the Bone Works (except where the cottage was located). CZ3b unchanged.
From 1954 - 1970	Fertiliser Works situated north of the Bone Works. Unknown 'Works' building located near to mouth of Pudding Mill River. Queen Mary Engineering College located south of Pudding Mill River. CZ3b unchanged.
From 1975 - 2003	New large Warehouse north of the Fertilizer Works. Parts of the Pudding Mill River have been infilled in area south of Marshgate Works and in area of CZ3b. Banner Chemicals also had a processing and chemical distribution centre in the south western portion of the CZ3a, which has subsequently been known as the Banner Chemicals site.

Reference should also be made to Drawing 2DD-ENL-VL-ZZZ-OLP-SP1-E-0047 entitled a Plan Showing Potential Locations of Pathogens in CZ3 and CZ4, which illustrates locations of former bone works, soap works and fertiliser works. The drawing also shows the location of colour works and Lamp Black, which represents the location of the DROF site.

2.4 Site Investigation

As part of the site investigation scoping exercise a review of the historical (and current) site usage via walkover surveys, review of trade directories, aerial photographs and pertinent environmental data sources was used to design a technically robust and pragmatic site investigation. This has resulted in several stages of site investigation and associated ground gas and groundwater monitoring/sampling being undertaken both prior to and as part of ODA redevelopment of the site. The exploratory holes carried out during the Site Investigation phase are presented on Figure 4 and summarised below in Table 2.2 (in

terms of the stratum the exploratory hole was terminated), noting this excludes exploratory holes carried out during the remediation phase.

Table 2.2: Summary of exploratory holes in PDZ3 (during the Site Investigation Phase only)

Number & Stratum	Made Ground	Alluvium	River Terrace Deposits	Lambeth Group	Thanet Sands	Chalk
Exploratory Holes	256	62	7	101	41	20

2.5 Geology

In summary, the ground conditions encountered during site investigations carried out prior to and during the Enabling Works comprised Made Ground overlying Alluvium, which in turn overlay the River Terrace Deposits (RTD). The solid strata comprised the Lambeth Group overlying the Thanet Sand Formation, with the White Chalk present at depth. A more detailed description of each geological stratum is presented in Table 2.3 below.

Table 2.3: Summary of Site Geology (from Site Investigation)

Stratum	Generalised Description	Approximate Average Thickness (m)	Aquifer Classification
Made Ground	Dark brown, slightly clayey gravelly fine to coarse sand with ash, concrete, brick, flint and clinker. Fragments of wood, ceramic, glass, plastic, metal, slate and organic material	5.5m	Not Classified
Alluvium	Grey/green, slightly silty clay with frequent organic material and peat	2.0m (minimum 0.2m)	Non-Productive
River Terrace Deposits	Grey brown, slightly clayey/silty, sand & gravel of flint and quartz	3.0m	Secondary (Minor)
Lambeth Group	Variable lithologies comprising laminated clays, silts and sands and loosely cemented black flint gravel in grey, clayey sand matrix	20.5	Secondary (Minor)
Thanet Sand	Very dense, slightly silty sand	14.0	Secondary (Minor)
Upper Chalk	Micritic limestone with flint nodules and interbedded calcareous mudstone in lower part of the Upper Chalk	(base not proven)	Principal (Major)

2.6 Hydrogeology

The SSRS⁽³⁾ classifies the ground directly underlying the site (understood to relate to the RTD) as a Secondary (Minor) Aquifer. The Thanet Sands are generally in continuity with the Chalk and are classed as a Secondary (Minor) aquifer, with the Upper Chalk classified as a Principal (Major) aquifer (Table 2.3 above).

Water encountered within the Made Ground is referred to as perched water, although where encountered in PDZ3 this was found to be discontinuous in nature. Groundwater within the RTD is referred to as shallow groundwater and groundwater within the Thanet Sand and the Upper Chalk is referred to as deeper groundwater.

The Lambeth Group is generally considered to act as an aquitard across the Olympic Park, limiting downward migration to the Thanet Sands and Upper Chalk, due to the presence of clays and silts of relatively low permeability interbedded with sand lenses of greater permeability. However, it is considered likely that in discrete areas within the Banner part of CZ3a, the Lambeth Group has been compromised (possibly through a preferential pathway) to allow the downward migration of contaminants. Figure 2 entitled "Thanet Sand NAPL boreholes and Infrastructure Plan" within the Drawings section illustrates locations where Dense Non Aqueous Phase Liquids (DNAPL) have been located. It is surmised from this figure that as a minimum the Lambeth Group will have been comprised in the vicinity of these two DNAPL sources.

Much of the western part of the Site lies within a groundwater Source Protection Zone (SPZ) as a result of a Thames Water Abstraction Well (Old Ford Well) which can potentially be used as a potable supply, which is located in the southwest corner of CZ3a. The well draws its water from the Chalk aquifer (approximately 60mbgl). Old Ford has three recorded adits that extend approximately 850m radially away from the main well beneath CZ3a and CZ4. Whilst this well has not been in continuous use since 1953, Thames Water have currently undertaken further works, including pumping trials, with a view to re-commissioning this abstraction well in the near future^(3c). Additional longer term pumping trials have been undertaken by Thames Water in the spring of 2012, but full details of the rate and duration of groundwater abstraction are not known. It will be Thames Water and the Drinking Water Inspectorate will be responsible for ensuring that no contaminated water associated with this groundwater pumping exercise reaches the public drinking water supply.

The Thanet Sand and Chalk Aquifer flow direction is also impacted by the nearby continuous pumping from Stratford Box* located to the northeast.

2.7 Hydrology

The Old River Lea flows along the western boundary of PDZ3 with the River Lea Navigation being present at the southwestern corner of the site. The City Mill River flows southwards along the eastern boundary of PDZ3a, whilst the Waterworks River is located 200m from the eastern boundary of CZ3a. No surface watercourses border the Pumping Station part of CZ3b.

It was initially considered that the River Lea and the City Mill River were the most critical controlled water receptors via lateral migration through the RTD aquifer, along with vertical migration down into the underlying Principal Chalk Aquifer. Following further investigations and impoundment the horizontal compliance point was shifted to a notional compliance point 100m beyond the southeastern boundary of the Olympic Park.

2.7.1 Impoundment

The Impoundment Scheme is a British Waterways London led project involving the construction of additional locks to improve the navigation of the River Lea and its tributaries. The details and potential effects of the impoundment works on the River Lea, its tributaries and groundwater levels discussed in the British Waterways^(4a) and Capita Symonds reports^(4b). Principally, the study addressed two main areas:

- potential changes in contaminant migration pathways in the aquifers; and
- increased risk of groundwater related flooding.

It concluded that due to the impoundment there is a theoretical 'change point' in surface water levels approximately 2.4 km upstream of the Prescott Channel impoundment structure (adjacent to CZ6d). Downstream (south) of this change point, surface water levels are predicted to increase above the current mid tide river levels.

As the RTD groundwater elevation variations at PDZ3 are only marginally tidal, a significant effect was not recorded on the groundwater elevations once impoundment has taken place. The overall contaminant loading to the river was considered to remain the same post-impoundment.

* 'Stratford Box' refers to the construction of a below ground structure to house the Stratford International Station which is associated with the Channel Tunnel Rail Link. This, in turn, has resulted in the underlying Thanet Sand/Chalk aquifer being locally permanently dewatered.

3. Development of Remediation Design

The development of the remedial design for these individual construction zones commenced progressively from 2006 culminating in a series of Site Specific Remediation Strategies for the three constituent parts of the PDZ3: CZ3a Main Site^(3a), CZ3a Banner Area^(3b) and the Pumping Station part of CZ3b^(3c). A series of addenda have also been issued to capture subsequent design changes or additional ground data which allowed the CSM to be refined. The objective of these SSRSs was to design a reflective remediation strategy to practicably minimise the risks to the identified human health and controlled waters receptors.

The area to the west of the PDZ3b Pumping Station will be temporarily used by the ODA as a Warm-Up Track during Games Mode, following which it is currently envisaged that it will be returned to its (private) landowner. It is because of the ODA's temporary occupation of this parcel of land that a Position Paper was prepared which outlined why no specific remediation is considered necessary^(3d). It is on this basis that the Warm-Up Track activities will not be discussed within this Stage 1 CVR, but will be captured within the Stage 2 CVR.

Given the risk assessment and remediation for PDZ3 was sub-divided down due to land availability constraints associated with vacant possession, construction programme purposes and transfer of work scope, the Conceptual Site Model (CSM) were covered by the individual SSRSs. A CSM was prepared for each of the three constituent parts and the SSRSs present the potential sources of contamination, sensitive human health and controlled waters receptors, and pathways representing pollutant linkages between the sources and receptors. These are schematically presented on the following drawings:

- 2DD-ATK-CM-03a-OLP-XXX-E-0045: Schematic Conceptual Site Model for Human Health Assessment for CZ3a Main Site (reproduced from the CZ3a Main Site SSRS);
- 2DD-ATK-CM-03a-OLP-XXX-E-0046: Schematic Conceptual Site Model for Controlled Waters Assessment for CZ3a Main Site);
- 2DD-ATK-CM-03a-OLP-XXX-E-0044: Zonation of Site for Human Health Assessment (reproduced from the CZ3a Main Site SSRS);
- 2DD-ATK-CM-03a-OLP-XXX-E-0048: Controlled Waters Risk Assessment Zoning of the Site (reproduced from the CZ3a Main Site SSRS);
- 2DD-ATK-CM-03a-OLP-XXX-E-0049: Schematic Controlled Waters QRA Conceptual Site Model (reproduced from the CZ3a Banner SSRS Addendum);

- Figure 2: Revised Conceptual Site Model for CZ3a Banner (reproduced from the CZ3a Banner SSRS Addendum No.3);
- 2DD-ATK-CM-03b-OLP-XXX-E-0029: PDZ3b Pumping Station Schematic Conceptual Site Model for Human Health Assessment (reproduced from the PDZ3b Pumping Station SSRS); and
- 2DD-ATK-CM-03b-OLP-XXX-E-0033: PDZ3b Pumping Station Schematic Conceptual Site Model for Controlled Waters Assessment (reproduced from the PDZ3b Pumping Station SSRS)

The SSRS documents used a two tiered approach to risk assessment, incorporating Generic Quantitative Risk Assessment (GQRA) and Detailed Quantitative Risk Assessment (DQRA). GQRA was undertaken using screening values outlined in the Global Remediation Strategy (GRS), unless otherwise indicated. If elevated chemical concentrations within the ground conditions were found to exceed GQRA screening values, further assessment and DQRA was undertaken and Site Specific Assessment Criteria (SSAC) and Site Specific Remediation Targets (SSRT) were derived. SSAC illustrate the individual contaminant concentrations protective of either controlled waters or human health and SSRT are the chemical criteria above which remedial corrective action is likely to be required. Representative concentrations for soil and groundwater data were derived through statistical analysis and/or where the representative concentration exceeded the respective SSAC remedial action or further delineation was outlined⁽³⁾.

In the case of PDZ3, the risk assessment process identified unacceptable risks from both organic and inorganic contaminants to both human health legacy and controlled waters receptors that required further investigation, delineation and removal.

The remedial design was developed in tandem with remedial works in PDZ3 as more data from further site investigation became available. In accordance with good practice and to ensure a robust CSM was maintained, the design documentation was further refined to ensure the remedial works were reflective of the encountered ground conditions. A summary of the nine principal changes to the CSM design are presented within Appendix B. These changes primarily related to the change in topographic levels and refinement of the CSM following the collection of additional ground investigation data, which identified the requirement for groundwater treatment in the RTD and Thanet Sands. The nine main changes are listed as follows:

1. CZ3a Banner Area SSRS Addendum No.1: This report addendum was prepared to present the revised controlled waters DQRA on the basis of predictive groundwater flow modeling for the assumed surface water impoundment conditions. The changes to the controlled waters DQRA amended the receptor to the Waterworks River 270m to the east thereby increasing the pathway length. The addendum also modified the methodology for assessing the potential risks to the Thanet Sand / Chalk Major Aquifer by introduction of dilution in the receiving aquifer underlying the site. The report also removed the unsaturated pathway from the CSM and produced a revised list of SSAC for the protection of controlled waters.

2. CZ3a Main Site SSRS Addendum No.1: This report was also prepared to reflect the revised controlled waters DQRA for the CZ3a Main Site on the basis of predictive groundwater flow modeling results for the assumed surface water impoundment conditions. Again the results of the modeling show the Waterworks River approximately 300m to the east of the site to be the controlled waters receptor. In addition the Main Stadium site is modeled as one source zone rather than the previous seven zones and a revised list of SSACs was produced.
3. CZ3a Banner Area SSRS Addendum No.2: This report was prepared as a result of additional information collected during a further round of ground investigation, which provided further evidence of contamination within the Thanet Sand. It also indicated the discontinuous presence of putty chalk on top of the Upper Chalk, which suggests that the Thanet Sand and Chalk are considered to be in hydraulic continuity. This led to further amendment in the SSAC criteria.
4. CZ3a Hydraulic Containment System (Northern Stadium Loop): An exit strategy for deactivation / decommissioning of the hydraulic containment system was developed that defined the Remedial Action Objectives (RAO) taking into account background concentrations of ammoniacal nitrogen in up-hydraulic gradient monitoring locations. The criterion for deactivation of the system is now set at 26.0mg/l (as NH₄) and permanent decommissioning of the system at 18.9 mg/l (as NH₄). A review of the first six months of post deactivation, which based on the observed trends, complies with the agreed criteria for completion and decommissioning of the CZ3a Stadium ('northern loop') component of the hydraulic containment system. On this basis the northern Stadium loop was decommissioned.
5. Southern Plume Position Paper: This report presents a detailed technical review of the distribution of contaminants in RTD groundwater in the Southern Plume. The following contaminants of concern (COC) are considered relevant to the Southern Plume - tetrachloroethene (PCE); trichloroethene (TCE); cis-1,2-dichloroethene (cDCE); vinyl chloride (VC); and arsenic. This report also sets out the requirements for monitoring of the COC concentrations in the Southern Plume. Quarterly monitoring for chlorinated ethenes, ethene and arsenic will be carried out and the monitoring results will be evaluated to demonstrate the validation criteria is being met.
6. CZ3a Hydraulic Containment System (Banner Loop) Requirements for Deactivation and Decommissioning, The aim of this document is to update the strategy for deactivation and decommissioning of the CZ3a Banner southern loop of the hydraulic containment system, following completion of Atkins' Southern Plume position paper. Specific aims of this document are to confirm the list of contaminants of concern and associated target values; and outline the monitoring requirements and data assessment methodology.
7. CZ3a Banner Area SSRS Addendum No. 3 – Revision of Vertical Pathway SSAC. This report relates to the CZ3a Banner SSRS and considers the achievability of the SSAC considering downward migration of contamination from the RTD groundwater into the Thanet Sand aquifer. This report acknowledges that the Thanet Sand and Chalk aquifer at the site have already been impacted and it is not practical to achieve SSAC derived on the basis of Drinking Water Standards (DWS). Therefore, the vertical pathway SSAC for the RTD groundwater has been revised, taking into account new recent chemical quality

data, to provide more realistic, achievable criteria which will prevent any further deterioration of the quality of the Thanet Sand and Chalk groundwater.

8. PDZ3 Unsaturated Zone Validation Report Addendum: This report confirms the completion of the corrective actions noted in the preceding reports as well as completion of the remaining remediation scope for areas not previously validated (there were no SSRS/RMS defined hotspots located in these areas). However the main issue detailed in this report is that following further assessment of the volatile exceedances in the CZ3a Banner area, it was agreed that the landowner will incorporate vapour mitigation measures for the Legacy land use only.
9. Remediation Change Note for CZ3a, This report presents a summary of the issues and consequences of finding Very Low-Level and some Low Level Radioactive waste at CZ3a. The purpose of this report is to specify how the remediation process will be amended to take into account the unexpected contamination, which is in the form of contaminated wastes discovered in discrete patches across CZ3a.

Following on from the initial design phase, the Enabling Works Tier 1 Contractor – BNL developed a series of Remediation Method Statements (RMS). These RMS's detail how the design will be implemented with the intention of:

- supporting ground contamination management, including the basis upon which validation would be achieved;
- summarising additional ground investigation data completed after approval of the SSRS (and SSRS Addenda) and assessing whether the additional information supports the CSM;
- defining the extent of the remediation required by the current design;
- providing an outline of the remedial measures proposed;
- outlining the environmental monitoring procedures in place to protect against impacts from the works; and
- discharging the relevant planning conditions relating to ground contamination.

For validation reporting purposes the project developed a structured receptor-based approach to demonstrating compliance with the SSRS within the Human Health, Unsaturated Zone and Groundwater Validation Reports. This approach is schematically presented in the flow charts in Table 1.1 and 1.2 and shown on Figures 11a and 11b.

3.1 Human Health Design

The design allows for placement of a Human Health Separation Layer (HHSL) or hard standing in the proposed Olympic and Legacy end-uses within PDZ3 that will reduce the Human Health pathways such as dermal contact, ingestion and dust inhalation to acceptable levels⁽³⁾. The general remedial profile adopted across the Park is presented in Appendix A.

The placement of a minimum of 600mm HHSL (or less should hardstanding be used) is designed to result in the underlying General Fill materials having to comply with less stringent Human Health remedial targets. The HHSL (the base of which is typically demarcated by a brightly coloured Marker Layer – see Figure 8) and General Fill are required to be validated to demonstrate compliance with the Human Health and Controlled Waters Site Specific Assessment Criteria (SSACs).

The CSM included within the respective CSM differed based on the defined Olympic and Legacy end uses. It is on this basis that the PDZ3a CSM was split into two Human Health zones based on the Legacy end use of the site:

Zone I to the north is the Main Stadium is based on Games use of the main Olympic Stadium with associated hard and soft landscaping during games Mode, with Human Health receptors will include spectators, athletes and officials associated with the London 2012 Games. In Legacy this portion of the site is proposed to include the Main Stadium, which is assumed to contain commercial premises including offices, with areas of green space to the north, The critical receptors in Zone I were determined to be a both a child and female adult; the child receptor is considered for the outdoor air pathway (in a residential scenario) and the female commercial receptor working within the Stadium for is considered for the indoor air pathway.

Zone II (including the Banner Area) in Games mode is considered to be an operations area during games time, which was assumed to comprise offices, associated buildings and services, as well as hard standing and general vehicular and pedestrian access. In Legacy the area is to be used for Educational use with any play areas being assumed to be formed of hard standing. In addition, there is also a residential end use associated and the critical receptor is a child who spends the majority of their time at home with inhalation considered to be the most sensitive pathway given the presence of the separation layer. .

For the CZ3b pumping station area, the Olympic use was unclear at the time the SSRS was produced and so a conservative assumption was made that there may be residential properties on the site and therefore to be protective of all receptors a child was considered to be the critical human health receptor. In Legacy the site was to comprise a pumping station, although for the purposes of the design it was assumed that the land surrounding the pumping station may have residential development without individual gardens. As per the other residential scenarios the critical receptor was again a child.

3.1.1 CZ3a Main Site

The human health quantitative risk assessment findings were to remove the Made Ground to a depth of 0.6m below final finished levels (bFFL) and deliver the site to the Enabling Works Formation Levels. The Designers in the SSRs^{(3a(i)-(ii))} concluded that the majority of soils from below 0.6m would not represent a risk to Legacy end-users and as such would not require management. However, the SSRS did identify a number of hotspots representing a risk to human health via the inhalation pathway and recommended its excavation and replacement with chemically and geotechnically acceptable materials to reduce these risks to acceptable levels.

3.1.2 CZ3a Banner Area

This area primarily falls within the previously designated Zone II, although a small area in the north lies within Zone I. For the purposes of the CSM, this small area was included within Zone II. The Human Health SSACs for sub-grade and backfill materials have only been derived for human health risks from soil and water for the vapour inhalation pathway^{(3b(iv)-(vii))} only given the placement of a minimum of 600mm of human health separation layer material, which will intercept the direct dermal contact, ingestion and dust inhalation pathways. In addition extensive hardcover will be present across the site during Games Mode and as noted above it has been assumed that any educational uses will also have hard standing play areas.

A number of organic contaminant exceedances were identified in the unsaturated zone and perched water as representing a risk to Human Health and Controlled Waters (see section 3.2). In addition, there were six discrete locations within the underlying shallow RTD groundwater, which were recorded as having concentrations of inorganic and organic (including chlorinated hydrocarbons) contaminants in excess of the Human Health and Controlled Waters SSAC.

The distribution of these contaminants across the site indicated that the contamination was widespread and sufficiently elevated when compared to the prevailing SSACs; therefore it was considered unlikely that further modelling would derive SSAC above the representative mean necessitating remediation. In addition, there were also a number of exploratory locations to the north and northwest of the CZ3a Banner Area displaying visual and olfactory evidence indicators of elevated concentrations of organic contaminants.

Based on this information, the Designers recommended that the soils to the base of the unsaturated zone (including removal of any encountered perched water) would be an appropriate remedial technique to address the risks from the unsaturated zone given the timelines for delivery^{(3b(iv)-(vii))}. In addition it was recommended that an appropriate remediation technique be utilised to address the vapour risks to human health from the RTD groundwater (see Section 3.2).

3.1.3 Pumping Station part of CZ3b

The risk assessment for human health was based on the intended Legacy Use (residential without gardens) as it represented the most conservative land use. The majority of the site will contain the sewage pumping station which will remain into Legacy. A limited number of organic and inorganic contaminants in the unsaturated zone were recorded in excess of the Human Health SSAC^(3c). These exceedances will be removed via excavation and replaced with chemically and geotechnically acceptable materials. These exceedances represented a risk to human health for future site occupants during the Legacy phase.

3.2 Controlled Waters Design

PDZ3 was considered as three separate controlled waters remediation areas as a result of differing CSMs. These three areas are: CZ3a Main Site; CZ3a Banner Area; and the Pumping Station part of the CZ3b. Consequently, the collected chemical results from these remediation areas were assessed separately given the differing SSACs (due to their different CSM).

It should be noted that perched waters within the Made Ground are not considered to be 'Controlled Waters' under the legislation at the time of the Design, in addition it should also be noted that the perched water was discontinuous in nature. Additionally the shallow RTD groundwater was considered by the EA and the PDT to represent a source and/or pathway for contaminants but not a receptor⁽³⁾.

3.2.1 CZ3a Main Site

The controlled waters CSM initially identified the City Mills River and River Lea, located directly adjacent to CZ3a, as the main controlled waters receptors within the first SSRS issued for the site^{(3a(i))}. Following the collection of additional data, it was possible to update the DQRA^{(3a(ii))} following discussions with the EA and utilising the results of predictive groundwater flow modelling work carried out by Capita Symonds^(4b) under the assumed surface water impoundment conditions. The groundwater modelling associated with impoundment further developed the original report by British Waterways^(4a). The results showed that RTD groundwater flow was towards the Waterworks River, located approximately 200m to the east with only limited hydraulic continuity occurring between the groundwater, City Mill River and the Old River Lea.

It should be noted that the remedial design did not require the remediation of unsaturated soils for the protection of controlled waters during the Enabling Works beyond the extensive excavations required for the main stadium earthworks design. The Enabling Works Formation Level (EWFL) and proposed backfill materials were compared to the DQRA derived controlled waters SSACs

A range of organic and inorganic contaminants were locally observed in excess of the SSAC within the RTD groundwater. The primary contaminants were chlorinated solvents, BTEX and arsenic. Ammoniacal nitrogen was recorded as being elevated across the site.

A hydraulic containment system was identified as being the most effective remedial technique^{(5a(iii))} to remove the groundwater pathway between the contaminated RTD groundwater and the controlled waters receptor - Waterworks River. At the time of its original implementation the RTD hydraulic containment system was design to the stop water flowing towards the Old River Lea, CZ3b and the City Mill River. However, later this just became the Waterworks River. This system comprised two loops, the 'northern loop' encapsulated the Main Stadium and the 'southern loop' contained the Banner Area (see Section 3.2.2). This system was linked to an above ground treatment plant located in the Pumping Station part of CZ3b with treated water then being discharged under license to foul sewer.

In tandem with the above activities a detailed groundwater and surface monitoring regime was also proposed on this zone. The results were then used to update the assessment via Atkins CZ3a Exit Strategy⁽⁷⁾ which informed and revised remediation strategy/lines of evidence required in order for validation to be achieved.

3.2.2 CZ3a Banner Area

The unsaturated zone soils in CZ3a Banner have been impacted by both inorganic and organic contaminants, which were considered to be the primary source of contamination. Vertical migration from these primary source contaminants of concern had resulted in the underlying shallow RTD groundwater being impacted with LNAPL, DNAPL and dissolved phase organic contamination; thereby creating a secondary source of contaminated shallow groundwater.

The Banner CSM was refined on several occasions^{(3b(v)-(vii))} subsequent to the main SSRS^{(3b(iv))} as a result of assessing additional ground data. The surface water controlled waters receptor was changed from the Old River Lea and City Mill River to the Waterworks River (located 270m from the site boundary) as discussed in Section 3.2.1

Visual and olfactory indicators of potential contamination were identified in the Thanet Sands during the site investigation phase from NBHCZ3a-155 suggesting groundwater within the Thanet Sand was impacted by organic contamination. This was, at the time, thought to infer the presence of a vertical preferential pathway, which existed from the RTDs, through the relatively impermeable Lambeth Group, to the Thanet Sands and the underlying Principal Chalk Aquifer (see Section 2.6). The Chalk groundwater quality also appeared to be impacted by organic contaminants including TPH, PAH and phenol in a discrete area within this site.

The primary sensitive controlled water receptors are considered to be the Waterworks River and the Chalk Principal Aquifer. As such the water quality standards were based upon the lowest of the Environmental Quality Standards (EQS) as well as Drinking Water Standards (DWS)^(3b and 5b). This is one of the principal reasons that the controlled waters criterion within the CZ3a Banner Area is more stringent than elsewhere in PDZ3. The primary objectives of the groundwater treatment remediation works were to:

- Achieve a significant reduction in the contaminant mass and concentrations of the contaminants of concern within the RTD and Thanet Sand groundwater by active removal of LNAPL (RTD only), DNAPL and gross hydrocarbon contamination sources and reducing contaminant mass in groundwater.
- Betterment of groundwater quality within the RTD and Thanet Sand through the direct application of substrates to assist natural attenuation of the aquifers in the medium to long term using chemical oxidation and Emulsified Vegetable Oil respectively.

In addition to the active removal of contamination from the RTD and Thanet Sands in the Banner Area, the 'southern loop' of the hydraulic containment system^{(5a(viii))} contained the RTD groundwater in Banner. The purpose of which is the same as that noted in Main Stadium area discussed in Section 3.2.1.

3.2.3 CZ3b Pumping Station

For the CZ3b Pumping Station site the City Mill River was considered to be the most sensitive controlled waters receptor with respect to CZ3b. This is based on the assessment of the groundwater flow direction within the shallow RTD aquifer^(3c).

A selective number of inorganic contaminants (namely ammoniacal nitrogen and copper) were encountered in the unsaturated soils that were considered to pose to controlled waters at shallow depths (up to 1.5 mbgl), which will be removed as part of the physical earthworks^(3c & 5c).

3.2.4 Southern Plume

Upon completion of the majority of the SSRS programme in the south of the Olympic Park, it became apparent that an area of contaminated groundwater was present within the RTD across several southern PDZs. This affected area was subsequently referred to as the 'Southern Plume'. It is currently considered that the 'Southern Plume' originated from the historical heavy industry located on the CZ3a Banner Area which resulted in a primary source of a southward migrating diffuse plume consisting mainly of cis 1,2-dichloroethene, vinyl chloride, and arsenic^(6a&b).

Assessment of data collected from the Southern Plume considered that natural attenuation is occurring and is likely to continue to occur. Removal and treatment of unsaturated soils in several locations in the southern Olympic Park has resulted in the removal of the majority of the identified sources and therefore it is anticipated that the residual groundwater contamination will decline over time. Following the completion of a twelve month period of groundwater monitoring will be required to confirm that both the natural degradation and subsequent reduction in contaminant trends are continuing. As a result a further 12 month period of groundwater monitoring will commence as soon as practicable after Games. The results of this monitoring and any associated remedial action will be confirmed with the Regulator/PDT, but until these works are completed to the satisfaction of the PDT/regulator they will remain as a residual remediation items

PART II

4. Implementation of Design – Site Preparation (Enabling Works)

4.1 Summary of Works Undertaken

Remediation works within PDZ3 began in October 2007 on the basis of the Atkins SSRs and the remedial design developed as the remediation works progressed (as discussed above). The majority of the physical Enabling Works scope was completed in 2009 with groundwater treatment being completed in 2010 and the majority of the first period of on-going groundwater monitoring continuing up to January 2012. Groundwater validation monitoring continues following the treatment of the organic contamination in the RTD and Thanet Sands beneath the Banner Area, as such, this Stage 1 CVR will be updated with the results of these monitoring strands. A summary of all changes to the remedial design is presented in Appendix B.

4.1.1 Significant Land Use Changes

There has been design changes to the topographic levels which were reviewed and assessed (where appropriate) in SSRs and RMS addenda. Whilst the Stadium was slightly moved northwards, there have been no significant venue movements. In addition, the Masterplan figures should be read in conjunction with Drawing SKE-ATK-XX-ZZZ-OLP-XXX-O-0003 (Sub Zone Remediation Areas (including areas anticipated as no remediation)).

4.1.2 Hotspots

Table 4.1: Number of Unsaturated Zone Defined Hotspots (presented in the SSRS & RMS) in PDZ3

Document	No. of hotspots		Comments
Site Specific Remediation Strategies (including subsequent addenda)	PDZ3a Main Stadium	4 (HH) 24 (CW)	Note one hotspot represents a risk to both Human Health and Controlled Waters.
	PDZ3a Banner	8 (HH) 9 (CW)	
	Pumping Station part of PDZ3b	2 (HH)	
2 (CW)			
Remediation Method Statement (including subsequent addenda)	PDZ3a Main Stadium	4 (HH) 24 (CW)	Unsaturated zone hotspots presenting a risk to Controlled Waters will be mitigated via groundwater remediation as detailed in the CZ3a RMS Groundwater Addendum ^{(5)(b)(vi)} .
	PDZ3a Banner	8 (HH) 9 (CW)	The unsaturated zone was removed during the earthworks, thus removing all of these hotspots.
	Pumping Station part of PDZ3b	2 (HH)	
2 (CW)			
Validation Reports (including subsequent addenda)	PDZ3a Main Stadium	4 (HH) - (CW)	2 (of 24) Controlled Waters hotspots in the unsaturated zone were physically removed prior to confirmation that these will be mitigated via groundwater remediation.
	PDZ3a Banner	8 (HH) 9 (CW)	The unsaturated zone was removed during the earthworks, thus removing all of these hotspots.
	Pumping Station part of PDZ3b	2 (HH)	
2 (CW)			

NB: Hotspot numbers are not cumulative

According to the unsaturated zone validation reports all hotspots identified to represent a risk to human health and controlled waters were excavated, validated and replaced with fill materials compliant with the prevailing SSACs.

4.2 Unsaturated Zone

In addition to these SSRS/RMS defined hotspots, there were a number of outliers recorded as part of the chemical validation testing of backfill materials to demonstrate compliance. These outliers were then subsequently delineated, removed, validated and backfilled with compliant materials. In the limited number of cases where this was not the case, due to agreements with the Follow On Projects, these are recorded in Table 5.1 and Figure 10.

In total, approximately 600,000m³ of unsaturated soil was removed during Enabling Works, and replaced with approximately 200,000m³ of chemically compliant general fill (below the marker layer materials) and approximately 60,000m³ of chemically compliant HHSL. These backfill materials were used to fill hotspots and to raise levels to the Enabling Works Formation Level. The HHSL was placed over a brightly coloured Marker Layer comprising orange Terram geotextile. The Marker Layer serves as a visual indication of the boundary between underlying general fill and / or in situ soils and 'cleaner' overlying HHSL materials. The Enabling Works subgrade, sub-formation and formation level (EWFL) are presented on Figures 5, 6 and 7 respectively. The extent of Marker Layer and thickness of HHSL is illustrated on Figure 8⁽⁶⁾.

As a part of the earthworks and remediation design there was a requirement for a minimum of 600mm separation layer (human health protective material) to be placed unless specifically agreed with PDT that an alternative such as hard standing could be utilised. In certain instances the FoPs were better placed to either install the Human Health Separation Layer or undertake general remediation works in which case this requirement will have been passed to the FoP to complete.

It was agreed in certain circumstances that the thickness of/or presence of the HHSL/marker layer can be varied to suit the incoming Follow-on Projects scope of works. These agreements were made to facilitate earlier workings and for the benefit of the Programme. Such circumstances were discussed and formally agreed with the incoming Project Team, which are detailed in the specified Validation Reports and presented in Figure 8.

Table 4.2: PDZ 3 Unsaturated Zone Fill Volumes, Sampling Frequency and Corrective Actions

Fill type	Zone	Material Description	Origin	Volume (m ³)	Number of Samples	Sampling Frequency	Exceedances
General Fill	CZ3a Main Site	Processed Made Ground	Olympic Park	199,172	483	1 per 412m ³	Outliers were present but given they were all present beneath either proposed bridge abutment locations or the Main Stadium and the fact that the overall representative mean passes the compliance criteria the material was left in place.
	Cz3a Banner	Processed Made Ground					Exceedances and statistical outliers were encountered for 1,2-dichloroethane, vinyl chloride, naphthalene and petroleum hydrocarbons. Vapour monitoring subsequently proved that none of these exceedances represented an unacceptable risk.
	CZ3b	Processed Made Ground					Two exceedances of the SSAC for 1,2-Dichloroethane were identified, which were shown not to represent an unacceptable risk by subsequent vapour monitoring

Fill type	Zone	Material Description	Origin	Volume (m ³)	Number of Samples	Sampling Frequency	Exceedances
Separation Layer	CZ3a Main Site	Crushed brick	Olympic Park	48,636	383	1 per 126m ³	No representative mean failures were noted.
		Crushed concrete and crushed brick	Imported from recycling yards				
		Subsoil material	Imported from Bournemouth Quarry in Kent				
		Pipe bedding and crushed limestone aggregate	Imported from Yeoman Aggregates				
	Cz3a Banner	Crushed concrete and crushed brick	Olympic Park derived material and import from McFen				Two exceedances for benzo-a-pyrene were noted and these were subsequently removed by excavation and replaced with compliant materials.
		Lime stabilized PLUG	Olympic Park				
		Crushed limestone and concrete	Imported from Torr Works and Yeoman Aggregate				
		Pipe bedding	Imported from Tarmac Limited				
	CZ3b	Lime stabilized PLUG	Olympic Park				Nine detected exceedances of the residential SSAC for Aliphatics >C12-C16. Outliers exceeded the residential SSAC for arsenic and benzo(a)pyrene associated with four samples, which were identified as requiring corrective action. An exceedance of the acceptance criteria for asbestos was also noted. A combination of exceedance excavation and remodelling resolved these outstanding issues.
		Crushed concrete and crushed brick	Imported from Recycling Yards				
		Crushed limestone aggregate	Imported from Yeoman Aggregates				

4.2.1 CZ3a Main Site

Exceedances of the relevant controlled waters SSAC were locally recorded in the subgrade for selective inorganic contaminants. Following further assessment^{(8a(iv)-(vii))}, it was considered that the sub-grade exceedances do not represent unacceptable risks to controlled waters when the following 'lines of evidence' are taken into account:

- The removal of approximately 600,000m³ of predominantly Made Ground material has significantly reduced the overall contaminant mass across the site and potential risk to controlled waters. These works are expected to result in the long-term improvement of groundwater conditions.
- The UCL (or representative mean where applicable) concentrations for all determinants were below their respective SSAC indicating the overall contaminant mass does not present an unacceptable risk to the sensitive controlled water receptor.
- The CZ3a Groundwater Treatment Exit Strategy⁽⁷⁾ states that ammoniacal nitrogen is the only remaining soil and groundwater contaminant of concern at the CZ3a Main Site. Other contaminants (such as arsenic, chromium and zinc, i.e. non-volatile determinants) were discounted as posing a risk to controlled waters largely based on the predicted travel times to the receptor.
- The majority of the site will be capped by hardcover and structures (e.g. stadium and its surrounding area and the loop road), which will significantly reduce infiltration and subsequent contaminant mobilisation in the unsaturated zone.
- Surface water receptors across the southern Olympic Park have been compliant with the relevant assessment criteria. Up-stream and down-stream concentrations have been comparable, both of which indicate that the unsaturated soils across the site are not significantly impacting the surrounding surface water quality.

4.2.2 CZ3a Banner Area

Based on the assessments presented in the unsaturated zone report^{(8a(iv)-(vii))} and the unsaturated zone report addenda the sub-grade is not considered to present an unacceptable risk to controlled waters when the following 'lines of evidence' are taken into account:

- The unsaturated soils were completely removed across the majority of the site down to the furthest practicable extent. This has significantly reduced the overall contaminant mass and potential risk to controlled waters. These works are expected to result in the long-term improvement of groundwater conditions in addition to the works completed below.
- Recorded concentrations in the Waterworks river has generally been compliant with the relevant assessment criteria and shows no evidence of detrimental impact from these contaminants.

The remaining contaminant mass is considered to be present mainly as contaminants sorbed to the saturated RTD soils and as residual, unrecoverable DNAPL. The removal of the saturated RTD soils would be technically challenging and not cost effective. In addition, any such action could result in the (re-)mobilisation of contaminants that are currently immobile^{(8a(iv)-(vii))}.

Vapour Risk

Following a review of the collected soil and groundwater validation data and subsequent vapour monitoring data, it was identified that the unsaturated zone no longer exceeds the human health Legacy SSACs via the indoor air pathway (volatilisation). However, this compliance does not apply to recorded groundwater concentrations. This is discussed further. This is further discussed in Section 4.3.2.1^{((5b(xiii), 8a(v) & 8b(xii))}.

4.2.3 Pumping Station part of CZ3b

The hotspots identified in the SSRS were removed and replaced with appropriate backfill before marker layer and human health separation layers were placed utilising acceptable material^{(8c(xvi))}.

4.3 Saturated Zone

4.3.1 CZ3a Main Stadium

4.3.1.1 River Terrace Deposits

The aim of the remediation was to reduce the contamination present in the underlying groundwater to acceptable concentrations. The primary mechanism used was one of hydraulic containment and the secondary mechanism was to accelerate the degradation of ammoniacal nitrogen. These works were completed are outlined below.

Hydraulic Containment

As noted in Section 3.2.1, the hydraulic containment system was formed of two loops, the 'northern loop' which refers to the Main Site, and the 'southern loop' which refers to the Banner Area (see Section 4.3.2). This hydraulic containment system was designed, installed and operated by Tier 2 specialist remediation contractor, Erith/WSP Remediation on behalf of the Tier 1 Enabling Works Contractor BNL to prevent the off-site migration of dissolved phase ammoniacal nitrogen^{(5a(iii))}.

The system consisted of 12 abstraction wells around the circumference of PDZ3a and two injection wells in the north and west of the site. The system had the aim of containing and preventing hydraulic flow in the RTD from leaving the CZ3a Main Site^{(8a(viii))}. The abstracted water was pumped to the Groundwater Treatment Plant located in the Pumping Station part of PDZ3b for treatment prior to disposal to foul sewer (in line with the Thames Water discharge consent) or re-injection back into the aquifer (see below).

The 'northern loop' was activated in early December 2008 and deactivated for assessment on 27 November 2009 in line with the CZ3a Groundwater Treatment Exit Strategy⁽⁷⁾, which defines the process for the deactivation and decommissioning of the hydraulic containment system. Following deactivation, a six-month programme of groundwater validation monitoring was undertaken. These results demonstrated that the aquifer was stable and groundwater concentrations of ammoniacal nitrogen met the SSACs set out in the Exit Strategy. It was on this basis that the northern loop of CZ3a hydraulic containment system was decommissioned^{(3a(iii), 5a(iii) & 8a(viii))}.

Treatment of Ammoniacal Nitrogen

The Archaea groundwater treatment element of the hydraulic containment system was installed in April 2009 as a secondary treatment train that aimed to reduce the loading of ammoniacal nitrogen in the RTD over the long term and reduce foul sewer disposal costs by re-injecting a proportion of the treated abstracted groundwater back into the RTD^{(5a(iv))}.

Archaea are a domain of single celled micro-organisms that generally resemble bacteria. The purpose of the Archaea treatment system was to enhance and increase the indigenous aerobic Archaea population whilst protecting indigenous anaerobic Archaea via the use of Arkea™ in the RTD. The aim is to increase the oxidation rate and aerobic/anaerobic nitrate reduction therefore reducing ammoniacal nitrogen concentrations and preventing a build up of nitrate.

The groundwater was abstracted (via the northern loop) and passed through two bioreactors containing Arkea™ configured in sequence. Treated groundwater exiting the last bioreactor in the treatment train was sampled and re-injected into the RTD.

Groundwater assessed after it had been processed at the treatment plant showed that the ammoniacal nitrogen concentrations reduced significantly, by 95% in some cases, which is below the SSAC for CZ3a RTD groundwater and background site concentrations. These trials were then up-scaled to directly inject the Arkea™ into the aquifer; however, the results for direct application did not mirror the positive results recorded in the bioreactors. The bioreactors were removed from Site at the same time as the deactivation of the 'northern loop'.

4.3.2 CZ3a Banner Area

4.3.2.1 River Terrace Deposits

Hydraulic Containment

As noted above, the 'southern loop' of the hydraulic containment system was installed in the Banner Area and linked to the Groundwater Treatment Plant located in the Pumping Station part of CZ3b. The 'southern loop' captured groundwater impacted by organic contaminants (TPH, VOC, and PAH) as well as arsenic associated with the former Banner Area^{(5a(iii))}. The plant treated the abstracted water by vapour-stripping and granular activated carbon (GAC) to reduce the concentrations of organic contaminants to acceptable levels suitable for discharge to foul sewer^{((3b(viii), 5a(iii), 5c(xv) & 8b(x))}. Whilst the plant was not specifically set up for the treatment of inorganic contamination, the water treatment process did reduce arsenic concentrations to acceptable levels suitable for discharge to foul sewer.

The 'southern loop' system was activated in December 2008 and deactivated in October 2010 in line with the Atkins Memo entitled 'Requirements for Deactivation and Decommissioning'^{(3b(viii))} and the CZ3a Groundwater Treatment Exit Strategy⁽⁷⁾. Following deactivation, a six-month programme of groundwater validation monitoring was undertaken, which demonstrated a stable aquifer and groundwater concentrations of ammoniacal nitrogen met the SSACs^{(8b(x))}. It was on this basis that the 'southern loop' of CZ3a hydraulic containment system was decommissioned^{((3a(iii), 5a(iii) & 8a(viii))}.

NAPL Recovery

Prior to the treatment of the dissolved phase using ISCO, both secondary sources (LNAPL and DNAPL) were removed from the RTD using skimmers. The subsequent groundwater monitoring regime confirmed that NAPL removal had been successful^{(8b(xii))}.

In-situ chemical oxidation (ISCO)

In tandem with the NAPL removal, design work on selecting the most-suitable remedial technique also commenced to address dissolved phase groundwater contamination within the across the wider Banner source area. The first phase of treatment commenced in July 2008, which comprised the application of ISCO (using sodium persulphate) directly into the aquifer at selected locations followed by the injection of oxygen releasing compounds (ORC) to enhance longer term degradation^{(5b(vii-viii))}.

The application of the ISCO was replicated more intensively to reduce the organic contamination to acceptable concentrations. This second phase (comprising two rounds of injections) of treatment was completed in September 2010 and October 2010. A network of approximately 110 permanent injection wells were installed across the treatment area and connected to a Batching Plant that allowed the tailored delivery of reagents across the injection network. The second phase of treatment was completed in October 2010. Both of these rounds comprised the delivery of Fenton's reagent in areas with chlorinated ethanes, and potassium permanganate across the remaining treatment area (for chlorinated ethenes, TPH and PAH)^{(5b(x))}.

Subsequent groundwater validation monitoring and sampling has been completed to verify the efficacy of the works. This has confirmed that the recorded concentrations^{(8b(xii))} are compliant with the controlled waters SSAC and validation metrics set out in the Design^{(5b(vii)-(viii))}, and the Southern Plume Position Paper^(6a), although the PDT have requested a reduced groundwater monitoring regime to continue in this area in order to confirm that the recorded declines in chemical concentrations has continued. This additional monitoring will be incorporated into the additional Southern Plume groundwater monitoring requirements^{(8b(xiv))} and on the basis of this monitoring the need for any further remedial works as required by the Regulator/PDT to fully discharge Condition 35 will be defined.

In addition, remediation trials were undertaken to address elevated arsenic concentrations in the RTD groundwater; however, these did not achieve a reduction.

Arsenic

Whilst arsenic was identified to be a contaminant of concern in the RTD groundwater underlying Banner, it was identified that the source was present in the unsaturated zone. Following further investigation, monitoring and review, it was agreed with the PDT and EA that extensive remediation of RTD groundwater for arsenic throughout the Southern Plume area is not considered necessary for the following reasons^(7b):

- all the identified soil sources for arsenic including the 11kv and Drof areas have been removed (based on the excavation materials, approximately 30.5 tonnes of arsenic);
- review of remediation for arsenic across the Banner area shows that a significant portion of the arsenic mass (50-55% of soil source and approximately 10% of RTD groundwater source) has been remediated by soil source removal and hydraulic capture system across the entire CZ3a Banner area;
- given the Zero Valent Iron (ZVI) trial has not effectively worked in the field, it was considered by the Project Team that there are no other economically feasible or sustainable options to treat the arsenic that is guaranteed to achieve lasting environmental benefits; and
- no identifiable surface water receptor is present at the southern boundary of the Olympic Park, and there is notable background concentrations of arsenic in the greater area around the site associated with the historic industrial usage of the area. Given that there is no receptor in close proximity, the objective of the remediation goal is the long term improvement of the RTD groundwater quality across the southern portion of the Olympic Park.

Consequently, it was agreed that the remedial approach for arsenic will be to comprise source removal from the unsaturated zone and ongoing groundwater monitoring/sampling for arsenic for a minimum of 12 months to demonstrate that the River Terrace Deposits groundwater concentrations outside the source area showing stable or declining conditions. The monitoring data will be supported by updated calculations estimating the rate at which concentrations in the Southern Plume area will decline as the residual mass of arsenic present in the Southern Plume is anticipated to decrease over a long time period. This monitoring will be undertaken as part of the further 12 month post Games ongoing monitoring for the Southern Plume.

Vapour Risk

Following a review of the collected soil and groundwater validation data and subsequent vapour monitoring data, it was identified that the groundwater concentrations continue to exceed the human health Legacy SSACs via the indoor air pathway (volatilisation).

As a result of these vapour exceedances in the saturated zone and delivery timeframes, the London Legacy Development Corporation (or Olympic Park Legacy Company as it was known at the time) confirmed in internal project correspondence on 28th June 2010 that it was their intention to incorporate appropriate gas/vapour mitigation measures beneath all permanent future buildings constructed within the former Banner area. Drawing 2DD-ENL-CK-ZZZ-OLP-SP1-E-0419 entitled Olympic Park South Areas that require Vapour Mitigation Measures or Further Vapour Assessment, which illustrates the locations across the South Park that will potentially require further vapour assessment and potentially further vapour protection measures.

Therefore, the principal pathway - indoor air - for Legacy residential is no longer applicable. Consequently, the CZ3a Banner Area general fill and sub-grade data previously reported was reassessed against the Legacy human health residential SSAC based on the outdoor air pathway and the Olympic Mode indoor air pathway. Based on the re-screened data, there were no Banner Area sub-grade and general fill exceedances of the outdoor air residential SSAC. Subject to the agreed vapour mitigation measures and restrictions being implemented in Legacy, the CZ3a Banner Area does not present an unacceptable risk to human health^{((5b(xiii), 8a(v) & 8b(xii))}.

4.3.2.2 Thanet Sands

Targeted groundwater remediation was required to address identified organic contamination in the in the SSRS Addendum^{(3b(iv))}. Further site investigation works identified DNAPL at two specific locations in the Thanet Sands, which did not contain the same principal contaminants of concern. The DNAPL identified in the southwestern part of Banner (adjacent to the Greenway) was identified to be creosote-based with an associated TPH and PAH dissolved plume. The second location identified DNAPL to be predominantly chlorinated solvent based, which bears similarities with the overlying RTD aquifer. It was subsequently confirmed, through tracer tests, that it is likely these contaminants will have migrated through a potential vertical preferential pathway in the Lambeth Group. Visual evidence of this pathway was not encountered during the earthworks or retrospective intrusive investigations.

The design of the remedial treatment of the Thanet Sands was phased to address the individual components: remove DNAPL present as separated and measurable product, globules, ganglia and/or hydrocarbon sheen, and treat the dissolved phase.

The initial DNAPL source extraction commenced utilising bottom loading pneumatic pumps to recover phase separated product, globules / ganglia and grossly contaminated groundwater. At the same time as the initial DNAPL recovery operation, additional boreholes were installed into the Thanet Sand to enable targeted treatment of DNAPL sources beyond the operation of bottom loading pumps should it be required. These

additional boreholes would allow targeted injection of groundwater and/or in-situ treatment to be utilised.

The second phase of the design was to assess the potential for future chemical oxidation treatment of the dissolved phase in the Thanet Sand^{(5b(xi))}. The reagent trial determined the most efficient and effective reagent to target the hierarchy of the contaminants of concern. The aim of the selected reagent was to stimulate and accelerate the naturally occurring reductive dechlorination process (i.e. biodegradation) that may be taking place. Following these trials it was determined that Emulsified Vegetable Oil (EVO) was the most appropriate remedial technique.

Following EVO treatment into 22 boreholes in February 2011, a subsequent twelve months' worth of groundwater validation monitoring was carried out. These results were incorporated into the final CZ3a Thanet Sand validation report which confirmed::

- No DNAPL has been recorded in any Thanet Sand (or RTD) monitoring wells post cessation of NAPL extraction.
- Monitoring of the EVO injection wells confirms elevated Total Organic Carbon concentrations within five boreholes in the injection area. The remaining 17 wells show no significant increase in organic carbon concentrations
- Monitoring has confirmed the aquifer conditions continue to be strongly reducing within the Thanet Sand throughout the one year post injection monitoring based on field monitoring.
- Gene sequencing analysis shows that while species capable of reductive dechlorination are generally considered to be low to moderate in number, the most recent concentrations of Dehalobacter species are generally considered to be moderate. However, there are significant increases in methanogens, sulphate and iron reducers which is considered to be a function of the strongly reducing conditions.

In the wider plume monitoring elevated concentrations of parent compound chlorinated hydrocarbons have been identified in two Chalk monitoring locations on the western boundary of the site. No adverse concentration trend has been identified within the chlorinated hydrocarbon concentrations although the relatively low vinyl chloride concentrations in the majority of the Thanet Sand wells may be indicative of a stalling in the reductive dechlorination process. It is noted that during the recent round of oxidative treatment of RTD groundwater, potassium permanganate was detected in a localised area in Thanet Sand groundwater three days after treatment. This indicates the presence of a location where rapid downward migration of groundwater occurs. However, permanganate was not detected in the immediate vicinity of this location, indicating that the fast downward migration of groundwater is limited to this location; it is therefore not considered to be representative for the site but a very localised feature. It is still considered that a potential preferential downward vertical migration pathway through the Lambeth Group is present. Downward migration of contaminants through the Lambeth Group outside the identified

location is considered to be slow, as the sandy materials are interbedded with clayey sediments^{(8b(xi))}.

On the basis of the results of the Thanet Sand and Chalk groundwater monitoring it has been decided, following discussion with PDT, to undertake a further twelve months' worth of monitoring across ten boreholes (six Thanet Sands and four chalk boreholes as defined in Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0831) that were previously agreed with the PDT/Regulator. In-situ monitoring in the form of water level, electrical conductivity, temperature, pH, dissolved oxygen, oxidation reduction potential will be undertaken in each of the boreholes. In addition, chemical testing for arsenic (total and dissolved), ammoniacal nitrogen, polycyclic aromatic hydrocarbons, volatile organic carbons, total organic carbon, dissolved methane and ethene will also be undertaken. In all cases the presence or absence of non-aqueous phase liquids (NAPL) will also be recorded.

This monitoring will be undertaken on a monthly basis for six months and then following a review of the data and further discussion with the regulator/PDT then monitoring may reduce to quarterly for the final six months. On the basis of these monitoring works the need for any further remedial works as required by the Regulator/PDT to fully discharge Condition 35 will be defined.

4.3.3 Pumping Station part of CZ3b

The PDZ3b Pumping Station SSRS^(3c) identified elevated concentrations of contaminants that would, in isolation, require, groundwater treatment. However, as this remediation could only be successful as part of a wider treatment of PDZ3b, it was agreed that no further groundwater remediation would be required at this stage as the majority of the site was unavailable for treatment as it was not held within the land ownership of LDA (OPLC or LLDC). Therefore the investigation, remedial design and potential treatment of the soil and groundwater beneath the main CZ3b site, to the west of Pudding Mill Lane, remains an outstanding action that should be undertaken by the landowner for this area post Games.

The Groundwater Treatment Plant was sited within this part of PDZ3b^{(5c(xv))} up until early July 2011 having successfully treated the abstracted groundwater from the RTD. Following assessment of the groundwater validation results post-deactivation and the decommissioning of both of the hydraulic containment system loops, the groundwater treatment plant was removed from site.

4.3.4 Southern Plume

The Southern Plume Position Paper and RMS^(6a&b) specified an ongoing groundwater monitoring strategy across the southern part of the site. The aim of this monitoring network is to determine whether degradation of the chlorinated ethenes and arsenic occurs over time given the extensive remedial works undertaken in both the unsaturated zone across the South Park and discrete in-situ groundwater remediation in the source area within the former Banner Area.

Following completion of the groundwater monitoring, the validation report^(6c) concluded that complete dechlorination was occurring. The evidence for this was through decreasing concentrations of tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cDCE) and vinyl chloride which were less than the SSAC. The recorded arsenic concentrations were compliant with the wider plume objectives, which is primarily as a result of source removal. In summary, this report confirms via monitoring, the Southern Plume COCs do not represent an unacceptable to risk to Human Health and/or Controlled Waters. However, following review of this report, the PDT and the Regulator have requested that monitoring be extended in its geographical extent (as monitoring wells in Cz3a Banner are now included). The monitoring duration is to cover a further 12 month period commencing as soon as reasonably practicable post Games. Monitoring will be undertaken on a monthly basis for the six months and then following PDT/Regulator agreement this may reduce to quarterly monitoring for the remaining six months provided a down ward trend is noted in contaminant concentrations.

It is considered that this additional monitoring will enable the longer term assessment of contaminant trends particularly as the aquifer returns to a state of equilibrium. Hence, the further 12 month period of groundwater monitoring will be undertaken, which will commence as soon as reasonably practicable post Games, in order to establish the long term trends in contaminant concentrations. This monitoring will specifically target the presence of the main contaminants of concern in this area, namely chlorinated ethenes, chlorinated ethanes, methane, arsenic and total organic carbon determinants such as sulphate, iron and chloride. In addition the presence or absence of non-aqueous phase liquids (NAPL) will also be recorded. On the basis of these monitoring works the need for any further remedial works as required by the Regulator/PDT to fully discharge Condition 35 will be defined.

4.4 SSRS Groundwater Monitoring

Groundwater monitoring has been undertaken for a number of purposes with different monitoring and sampling requirements. One of these groundwater monitoring strands ('Validation') aims to validate the remediation works by monitoring/sampling the underlying aquifers within this PDZ before, during and after the bulk remediation works. This requirement originated from the SSRS, where the Designers required the groundwater data gathered as part of the Enabling Works to be assessed to determine the presence or absence of any adverse effects. As such, this data has been utilised as a line of evidence to demonstrate the aquifers conditions within the PDZ has not significantly deteriorated from the conditions at pre-commencement (of earthworks) phase.

Exploratory locations were installed as monitoring wells into the underlying geology, with specific reference to the RTD and Chalk, to record the hydrogeological conditions. The hydrogeochemical data collected prior to, during and following completion of the remedial works has shown there to be no consistent upward trend. It is on this basis that these monitoring wells were appropriately decommissioned in line with Project Documentation⁽¹²⁾ (which is based on the applicable Environment Agency guidance) prevailing at the time as reported in the applicable unsaturated zone validation reports^{(8a(iv)-(vii))}.

However as noted in section 4.3.4 above, groundwater monitoring for a further 12 month period will be undertaken to confirm that the groundwater results are not showing an upward trend, and if required, further remedial work shall be undertaken.

4.5 Other Matters

4.5.1 Non Remediated Areas

A number of discrete areas within PDZ3 have been retained across the Olympic Park in accordance with approved Planning Application conditions and/or due to operational constraints. Within these areas full site investigation coverage has not been possible due to the presence of a particular features that must be retained. Typical retained features include retained buildings and services, third party boundaries, retained roads and other areas of hardstanding, batter exclusion zones and areas of retained vegetation (either confirmed or aspirational). These discrete areas in PDZ3 are discussed further in the individual Validation Reports⁽⁸⁾ and are presented on Figure 9.

To further support these non-remediated areas, the Designers have submitted a site wide retained areas risk assessment report⁽⁹⁾ to the PDT for their approval. This report qualitatively assesses potential risks to human health and controlled waters arising from potentially contaminated land beneath those areas. The assessment considers the nature of the retained features, contamination presence identified in the nearby area, and the final

land use and receptors. Relevant extracts from the latest Retained Areas Risk Assessment Report are presented in Appendix D.

4.5.2 Unexploded Ordnance

BAE Systems was commissioned by Nuttall to carry out a prior risk assessment for German air-dropped unexploded ordnance (UXO). The objective of the study was to assess the potential to encounter UXO during the Project, to evaluate implications of such an occurrence and to determine whether risk mitigation measures are necessary.

The BAE Systems report indicates that a UXO was abandoned at 'Lloyds Shoot' on Marshgate Lane. Bomb disposal reports indicate that the UXO fell in an area that had been subject to uncontrolled waste disposal during and after WWII. Further investigation to locate this potential abandoned UXO proved unsuccessful due to the quantity of metal debris amongst the waste. Given the potential uncertainty and the higher likelihood of encountering this UXO during the significant excavations proposed a precautionary approach was applied and a full time specialist UXO Engineer was employed to oversee the excavation works in these higher risk areas. Aerial photographs indicated that the northern part of the Site is within this area subject to uncontrolled historical waste disposal. The BAE Systems report that there is no known anecdotal or other evidence of abandoned UXO on the site.

The BAE assessment concluded a moderate probability of UXO's being encountered in this area. However, the report notes that if UXO are encountered, the likelihood of initiating the device and causing an explosion was substantially lower. Therefore, in such areas, no special measures were recommended⁽¹⁰⁾.

It should also be noted that several ordnance related items were removed from the Waterworks River prior to Enabling Works and there was considered to a high risk of encountering further items in the watercourses such as the City Mill River, River Lea or River Lea Navigation. This would particularly impact specific activities such as dredging, site investigation or piling within the rivers. However as this area is outside the CZ3a and CZ3b boundary, it is included for information purposes only and not considered further in this report.

Whilst no suspect objects were found during the works, future site users should take appropriate precautions regarding unexploded ordnance if they are to break ground in the future.

4.5.3 Radiological Material

A radiological specific RMS^{(5a(ii))} and Remediation Change Notes⁽¹²⁾ have been prepared as a consequence of the finding of very low-level and some low level radioactive contamination at PDZ3a. The contamination is in the form of materials discovered in discrete areas across this site. Upon identification affected areas were demarcated and access was prohibited to unauthorised personnel. Personal dosimetry and general sampling and metering were established to protect staff involved in the works, other members of the workforce and the general public. A detailed method was established for the safe excavation and removal of the materials to the area authorised for the accumulation of radioactive spoil, already established for the Olympic Park.

Radionuclides dispersed in excavated spoil and exposed excavation faces were detected in discrete locations around the PDZ3a that recorded greater than background levels of radiochemically contaminated soils. The majority of these materials were Normally Occurring Radiological Materials (NORM) determined to be “Exempt” under the relevant Radioactive Substances Act 1993 - now subsumed into the Environmental Permitting (England and Wales) Regulations 2010. However at selected locations ‘non-exempt’ low level radioactive materials were also identified, separated and then placed into barrels. Where both the exempt and non-exempt materials were encountered they were temporarily stockpiled/stored in a discrete area on CZ6a/d for detailed assay prior to appropriate disposal. However, because of the presence of discrete contaminated items, typically comprising radioactive artefacts (instruments) and rocky residues, which were encountered in PDZ3 and elsewhere on the Olympic Park an authorisation under the Radioactive Substances Act 1993 – now subsumed into the Environmental Permitting (England and Wales) Regulations 2010 was applied for and obtained for the accumulation (temporary storage) and consequent disposal of these wastes.

Radiological contamination was encountered were found to be above the sub-grade level (based on the Enabling Works excavation) and were therefore excavated, segregated, validated and appropriately removed from PDZ3a to PDZ6 for assay. These finds in PDZ3a have been recorded and labelled as Areas A to K.

- Area A comprised mixed nuclides of natural uranium, protactinium [231Pa] (part of the 235U decay chain), thorium [232Th] and radium [226Ra], which are NORM. These radioactive materials were used in chemical and industrial processes, but without, so far as is known, any processing intended to alter their radioactivity.
- The main excavation area for the stadium bowl was surveyed and small source areas D, F, G, H and I were identified. All source areas contained 231Pa, 226Ra and 232Th.
- A stockpile (Area B) was known from delivery tickets to have been the destination of material from the source area and this was found to have some contamination.
- Radioactive sources were found in Area C. This is also a NORM source area [232Th], where the contamination is around buried concrete foundations.

- Analytical results and supporting Radiological Protection Advisor (RPA) advice are to the effect that the principal radionuclides present are ^{232}Th , ^{238}U , ^{226}Ra and ^{231}Pa (from the ^{235}U decay chain).

Following the finds of unexpected radiological contamination arising from material excavated in CZ3a, a radiological-specific RMS addendum was prepared to cover these occurrences. The purpose of this report is to describe the process by which remediation of resulting from the unexpected radioactive materials and its subsequent verification at CZ3a will be undertaken. The report included the details of the route the material will take from CZ3a to CZ6a (temporary holding area for assay) to CZ4 (final deposition for exempt radiological materials) and takes into account existing information of ground conditions gained from site investigations, risk assessment and monitoring. The report was submitted to be consistent with the relevant planning approvals and related discussions.

In instances in CZ3a where radioactively contaminated materials were not directly transported to CZ6, the radioactive materials were temporarily stockpiled (Stockpile reference CZ5a/S03) in CZ5a prior to onward transportation to CZ6 for assaying by Nuvia. These radioactively contaminated materials were subsequently determined for either deposition in CZ4 or for appropriate off-site disposal to an appropriately licensed facility. Following the removal of the stockpiled arisings from CZ5a, Nuvia conducted a clearance survey of the temporary stockpile area, which recorded concentrations below the action limits. Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0555 entitled CZ3A Extent of Radioactivity Surveys illustrates both the extent of the radiological surveys and the excavations undertaken to remove radiological contaminants.

The Change Note for PDZ3^(11a) also confirms the final location for the exempt material as being beneath the approach embankment to the L03B bridge abutment in CZ4. The Change Note addendum^(11c) updates the pre-deposition risk assessment (version 3) and assesses the as-built residual risk associated with the burial of the 'exempt' radiological waste beneath L03B. The assessment addresses potential radiation exposures to current and future human health receptors, who we understand will occupy the site. Whilst there are restrictions, the report concludes that the disposal cell is suitable for the deposition of exempt waste.

In addition, this report confirms that the four drums containing radioactive artefacts (non-exempt materials) were appropriately removal off-site. These drums were individually assayed on-site prior to its transfer from the Olympic Park site on the 29th September 2010 by an appropriately licensed contractor for processing at the Winfrith facility in Dorset. The transfer was in accordance with the granted Environment Agency Radioactive Substances Authorisation [Ref.: CB9916/CE0419].

4.5.4 Unexpected Contamination

There were no other areas within PDZ3 that gave rise to unexpected contamination.

4.5.5 Methodology for Assessing Asbestos

The assessment for asbestos and criterion in the HHSL and the below marker layer materials was further developed as the works progressed. This development gave rise to a Site Wide SSRS that revised the SSACs and its assessment methodology.

4.5.6 Pathogens

A bone works, soap works and fertiliser works were all known to have historically existed on the CZ3a site as illustrated on Drawing 2DD-ENL-VL-ZZZ-OLP-SP1-E-0047 entitled a Plan Showing Potential Locations of Pathogens in CZ3 and CZ4. However although visual examination of excavations was undertaken no remains were encountered during the CZ3a works.

4.6 Sampling and Analytical Testing

TES Bretby, or ESGL as they are currently known, was selected to undertake the chemical analysis of the soils and groundwaters (SI phase only) at their off-site laboratory. Bretby's Method Detection Levels were generally able to detect the determinands listed in the SSRS and are suitably accredited through MCerts and UKAS (where appropriate). During the groundwater treatment a number of chemical laboratories were used to the specialist Tier 2 Contractor. Further details pertaining to the sampling strategy and frequency are presented in the respective Validation Reports⁽⁸⁾.

The Planning Application required all validation samples to be collected in-situ. However, in order to reduce the potential for placing non-compliant soils (general fill and separation layer) whilst maintaining the programme, Enabling Works commissioned an on-site chemical laboratory and used field analytics to aid real-time decision making on soil reuse through further characterisation. The on-site chemical laboratory was UKAS accredited (where appropriate) for the main chemical tests on soils. However, these results were not typically utilised in the validation reporting, although they were occasionally used as a secondary lines of evidence.

Table 4.2 above defines the chemical sampling testing that was undertaken on the fill materials, whilst the individual validation reports, which have previously been approved by PDT, confirm that not only backfill but also hotspot and sub-grade sampling and testing have been undertaken in accordance with the prevailing planning conditions.

4.7 Waste Management

The Enabling Works in PDZ3 was completed under Olympic Development Authority [ODA] Environmental Permit (issued as a Waste Management Licence) for the Olympic Park (South) [Reference: EAWML80790 and subsequent Notice of Variation, Modification Number: M0597]. This Environmental Permit enables the ODA to use site-won materials, suitable for use after treatment, but classified as either hazardous or non-hazardous waste, to be used as fill to create the landform required for the redevelopment. This Environmental Permit enables the placed materials to be “recovered”, and as such they cease to be a waste, which minimises disposal to landfill and serves a useful purpose in replacing materials that would otherwise have had to be imported to construct the scheme.

The permit also covers the import and use of waste materials from an alternative source whose works are directly associated with the potential Olympic Park redevelopment. These fill materials can be utilised where they are deemed suitable for use and a need for these materials has been demonstrated. ‘Suitable for use’ will be proved in accordance with the Memorandum of Understanding (MoU) which is an agreement between the ODA and the Environment Agency covering Waste Licensing Issues. The ODA will seek to discharge this upon approval of the Stage 2 CVR.

4.8 Health, Safety and Environment

Remediation works were completed in accordance with Construction (Design and Management) (CDM) Regulations. As CDM Co-ordinator, Arup were responsible for producing the Health and Safety file for PDZ3, in conjunction with the Contractor, Project Manager and Client. A Permit to Work system was in operation for the duration of remediation works. Staff wore suitable Personal Protective Equipment (PPE), with gloves, helmets, boots, eye protection and hi-vis clothing required at all times as a minimum. Environmental monitoring comprising fugitive emissions, air quality, noise, dust (including PM10), nitrogen dioxide and odours was carried out at the site throughout the works, which were progressively presented on a monthly basis in the Tier 1 Environmental Monitoring Monthly Reports^{((8a(iv)-(vii))}.

5. Conclusions

The PDZ3 Validation Reports⁽⁷⁾ conclude that neither the soils nor groundwater in PDZ3 that have been remediated as part of ODA's scope currently pose an unacceptable risk to the SSRS defined critical controlled waters and human health receptors. However, further monitoring is required to assess whether and to what extent contaminants from within the CZ3a Banner source area have increased in concentration or migrated either southward or vertically downward into the underlying Thanet Sands. In addition, this assessment will look to determine whether the groundwater contaminants have had a detrimental impact on the conditions beneath PDZ3, such that an unacceptable risk is posed to the critical human health and controlled water receptors. It is on this basis that this PDZ3 Consolidated Validation Report seeks to gain partial discharge from PDT for the ODA works undertaken in accordance with Condition 35 of the Site Preparation Planning Application. In addition it should be noted that no remediation below existing ground level was undertaken by the Enabling Works project and this remains a residual item (see Item 19 of Table 5.1) for the incumbent or future landowner.

However, it is noted that the separation layer has not been completed at the time of producing this report and it remains the responsibility of the Follow On Projects that, as a minimum, they complete the separation layer to a thickness of no less than 600mm, unless otherwise agreed with the PDT. It is only upon the appropriate completion and validation of the Separation Layer that the remediation works will be considered to be complete. The incoming Project Teams shall be cognisant of the SSRS underlying assumptions of the SSRS and the items noted in Section 5.1 and Table 5.1 below.

In addition it is acknowledged that a further 12 month groundwater monitoring period is required to be undertaken as soon as reasonably practicable post Games. This monitoring will specifically target the presence of the main contaminants of concern in both the River Terrace Deposit, Thanet Sand and Chalk aquifers in this area in order to define the long term trends in contaminant concentrations. On the basis of these monitoring works the need for any further remedial works as required, by the Regulator/PDT to fully discharge Condition 35 will be defined. As a result this 12 month monitoring represents a residual remediation item and until its completion in accordance with the requirements of the Regulator/PDT then Condition 35 of the Olympic, Paralympic and Legacy Transformation Planning Applications: Site Preparation Planning Application⁽¹⁾ can only be partially discharged

5.1 Further Work

The Enabling Works Project records the key outstanding works required to fully complete the remediation measures by the Follow-On Project and restrictions on future works in Tables 5.1 and Figure 10. This table updates similar tables presented in the individual Validation Reports referenced herein⁽⁷⁾.

In addition, Table 5.1 records some key aspects for the Follow On Projects to consider as part of their works. This table does not in any way alleviate the incumbent Project Teams from complying with the full requirements of the remediation documentation, their legal, regulatory and contractual obligations.

Table 5.1: Outstanding Works transferred to the Follow On Project, Restrictions on Future Works and some key aspects for the Follow On Projects to consider as part of their works

Number	Title	Description	Action By
1	Completion of groundwater monitoring for the Southern Plume	<p>'Southern Plume' groundwater monitoring across the southern part of the Olympic Park shall continue for a further period of 12 months , although this will be subject to groundwater monitoring results and any associated remedial actions required by the PDT/Regulator . The proposed LLDC groundwater monitoring period will commence as soon as reasonably practicable post Games in order to establish long term trends in contaminant chemical concentrations. This monitoring will specifically target the presence of the main contaminants of concern in the area, which includes vinyl chloride, chlorinated ethenes, dissolved ethanes, methane, arsenic, and total organic content determinants such as iron and chloride for the River Terrace Deposits. This monitoring will be undertaken in eleven boreholes (as defined in Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0382), which has been previously agreed with the PDT/Regulator. These monitoring locations will be sampled on a monthly basis for six months and then following a review of the data and further discussion with the regulator/PDT the monitoring may reduce to a quarterly frequency for the final six months.</p>	<p>Enabling Works (novated to London Legacy Development Corporation for completion in the Transformation Phase)</p>

Number	Title	Description	Action By
2	Completion of groundwater monitoring for the Thanet Sands	<p>Post-remediation groundwater validation monitoring will continue in the Thanet sands and Chalk in the Banner Area of PDZ3 for a further twelve month period, which will commence as soon as reasonably practicable post Games . . . Monitoring, sampling and testing will be undertaken across boreholes (six Thanet Sand and four Chalk boreholes – see drawing 2DD-ENL-CK-03a-OLP-SP1-E-0831) as previously agreed with the PDT/regulator. The groundwater monitoring will be undertaken on a monthly basis for six months and then following a review of the data and further discussion with the regulator/PDT the monitoring may reduce to quarterly for the final six months. In-situ monitoring in the form of water level, electrical conductivity, temperature, pH, dissolved oxygen, oxidation reduction potential. Chemical testing for arsenic (total and dissolved), ammoniacal nitrogen, polycyclic aromatic hydrocarbons, volatile organic carbons, total organic carbon, dissolved methane and ethene. In all cases the presence or absence of non-aqueous phase liquids (NAPL) will also be recorded.</p>	<p>Enabling Works (novated to London Legacy Development Corporation for completion in the Transformation Phase)</p>
3	Placement of vapour barriers to buildings in accordance with the SSRS.	<p>Assessment of soil gas and soil vapour hazard and appropriate design and construction. Gas and vapour protection measures may be needed in the construction of any inhabited or enclosed spaces. The CZ3b SSRS recommended that a gas and vapour protection membrane is to be installed in the foundation of the 3b Pumping Station building, in order to provide protection against potential VOC vapours (e.g. chlorinated hydrocarbons) from perched water, groundwater and deeper soils. It is also stated that the necessity for this should be confirmed by a soil vapour survey. The London Legacy Development Corporation (or Olympic Park Legacy Company as it was known at the time) confirmed in internal project correspondence on 28th June 2010 that vapour barriers will be installed into future development in the CZ3a Banner area. On this basis reference should be made to Drawing 2DD-ENL-CK-ZZZ-OLP-SP1-E-0419 entitled Olympic Park South Areas that require Vapour Mitigation Measures or Further Vapour Assessment, which illustrates the locations across the South Park that will potentially require further vapour assessment. Depending upon the results of this assessment then further vapour mitigation measures may be required.</p>	<p>Follow on Project and London Legacy Development Corporation in the Transformation and Legacy phases.</p>

Number	Title	Description	Action By
4	Placement of vapour barriers to buildings in CZ3a Banner	The OPLC has confirmed their agreement to the incorporation of appropriate vapour mitigation measures beneath all future (Legacy) structures constructed within the former Banner Area.	Follow on Project
5	Radiation	Radiological screening is required when excavating beneath the marker layer [below the Enabling Works sub-grade level] or into the batter to the raised podium, towards the northern end of CZ3a. Areas where radiological surveys have been undertaken and associated radiological finds are illustrated in Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0555: CZ3A Extent of Radioactivity Surveys (Two sheets)	Follow on Project
6	Works in CZ3b outside the area covered by the CZ3b Pumping Station	Works proposed by the Position Paper are limited to the placement of a minimum 600mm thick human health separation layer and dealing with the protection of indoor airspace against gas and vapour ingress. Liaison with the PDT will be required to ensure that the appropriate validation documents are submitted and planning approval is obtained.	Following On Project (Warm Up Track Team)
7	Placement of additional separation layer over remainder of site, and marker layer/separation layer where previously omitted	The extent of the marker layer placed during the Enabling Works is shown on drawings Figures 8, 9 and 10. In these areas, the Follow-on Project must place an additional minimum of 300mm human health separation layer. Where omitted by Enabling Works, the follow-on contractor is responsible for the placement of the marker layer and full [minimum 600mm thickness] human health separation layer. Where the required additional separation layer outlined above cannot be placed, reassessment must be undertaken to demonstrate that a suitable barrier to protect human health exists [e.g. hardstanding] and Regulatory approval must be sought and achieved.	Follow on Project
8	Provision of survey plans of final separation layer	Provide survey plans within one month of completion of the entire (minimum 600mm thickness) separation layer to demonstrate to the planning authority an acceptable thickness of separation layer. These survey plans should also identify any areas where the marker layer is not laid. Where Enabling Works have placed separation layer, the Follow-On Project must place an additional minimum of 300mm human health separation layer, except within the LOCOG area, where a minimum of 110mm additional thickness is required due to the 490mm thick separation layer placed by Enabling Works in that area.	Follow on Project

Number	Title	Description	Action By
9	Suitable infrastructure design	Structures should be designed recognising the chemical and other characteristics of the stratum in which they are founded. Sections in contact with potentially contaminated materials may need to be resistant to chemical attack, particularly by sulphates.	Follow on Project
10	Suitable methods to protect pathways	Consideration of design and construction methods (for example, choice of suitable pile design and construction methods) to avoid creation of pathways to lower aquifers.	Follow on Project
11	Protection of monitoring and groundwater remediation installations and facilities	Undertake any required measures to protect monitoring and groundwater remediation installations and facilities across the PDZ3 Site. Any damage to such installations or facilities is to be reported to the PTP team (or equivalent) as soon as practicable so that remedial works / decommissioning (as appropriate) can be undertaken. Although groundwater treatment plants for the CZ3a hydraulic capture system, CZ3a Banner RTD injection and CZ3a Banner Thanet Sand NAPL removal / EVO delivery have been decommissioned, the underground pipework and selected wells remain in the event that these systems require reactivation in the future. As such, this pipework must be protected until such time as they are confirmed by the Client as no longer required. Should pipework be damaged then the RemTech (or equivalent) should be notified. Reference should be made to Drawing 2DD-ENML-CE-03a-OLP-SP1-E-0811 entitled CZ3a LOCOG – Remaining Groundwater Infrastructure.	Follow on Project
12	Verification of breaches of marker layer	Where the follow-on contractor works involve excavation below the marker layer, backfill will need to be verified against SSAC; marker layer re-instatement must be verified. Any damage to such installations or facilities shall be reported to the client delegated team (PTP team or equivalent) as soon as practicable so that remedial works / decommissioning (as appropriate) can be undertaken	Follow on Project
13	Final validation report	Produce and gain approval of final validation report on completion of overall construction or of construction required to complete above remediation requirements, primarily the provision of the full human health separation layer. In addition, post Games validation reporting will also have to report on the results of the proposed groundwater monitoring in the River Terrace Deposit, Thanet Sand and Chalk aquifer. In addition the report will also detail any additional remediation works that are required to be undertaken following review of the groundwater monitoring results.	Follow on Project

Number	Title	Description	Action By
14	Excavation of soils at the Site	<p>The Permit To Proceed Protocol (Appendix E) must be implemented when excavating at the site. Arisings from excavations shall be treated as contaminated unless proven otherwise.</p> <p>A review of available data relating to the condition of the soils at the Site should be undertaken prior to any excavation and appropriate precautions must be undertaken.</p> <p>The human health assessment presented in this report was based on long-term risks to the end-user assuming the Legacy end use stated in the SSRS and does not consider risks to construction or maintenance workers when validating the site. It is considered that following an appropriate risk assessment, any risks to construction workers may be safely mitigated through PPE and suitable engineering precautions.</p>	Follow on Project
15	Restrictions to remediation	<p>Restrictions to remediation exist in defined areas of PDZ3 as shown on Figure 9. These restrictions include:</p> <ul style="list-style-type: none"> • Greenway and retained vegetation area between CZ3a and CZ3b. • Ecological area in the southwest of CZ3a. • Offset from railway line in southeast of CZ3a and in CZ3b. • Offset from River Lea to maintain towpath. • Parts of Pudding Mill Lane and Marshgate Lane. <p>If these areas are developed in the future, an assessment will be required to determine if remediation is required. In the meantime, any construction adjacent to the areas should consider available evidence from samples taken at the limits of the remediation works.</p> <p>It is noted that an assessment of the retained areas is being undertaken in the Retained Areas Risk Assessment Report prepared by the Designers for PDT approval in due course.</p>	Follow on Project
16	Risk assessments	<p>In addition to risk assessments outlined above regarding excavation of soils at the Site, appropriate risk assessments would need to be undertaken with respect to UXO, pathogens, radiation, asbestos and ground gas/vapours when undertaking excavations at the Site.</p>	Follow on Project
17	Future land use	<p>Any future uses of the Site must comply with the SSRS definition and therefore must not include private gardens. The areas designated for different land uses shall not be amended without reassessment of the soil conditions. The Site shall not be used for growing edible crops. All future buildings must have appropriate vapour mitigation/membrane measures as agreed by OPLC.</p>	Follow on Project

Number	Title	Description	Action By
18	Changes in final level	Changes to final levels reducing them at all will need a reassessment of the underlying soil and potentially additional investigation or remediation.	Follow on Projects
19	Investigation of the western portion of the CZ3b site	The main portion of the CZ3b site, which lies to the west of the Pudding Mill Lane, was neither investigated nor remediated by either the London Development Agency or the Olympic Delivery Authority as neither organisation owned the land. Therefore following the removal of the Warm-Up track and hand back of the site, the existing land owner should give consideration to the investigation of the site; in order to confirm if the soil and groundwater beneath the original ground level represents and unacceptable risk to the health of future site operatives or the surrounding controlled waters (in the form of the nearby rivers or the underlying aquifers).	CZ3b Land Owner.

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2. Planning Application Approval (Olympic, Paralympic and Legacy Transformation Planning Applications: Site Preparation Planning Application, Application No – 07/90010/FUMODA, Date of Application - 7th February 2007): Condition 36.
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 - b) PDZ3a Banner Areas SSRS
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 - v. Atkins. REP-ATK-CM-03a-OLP-XXX-E-0002. CZ3a Banner Area SSRS Addendum No.1 – Revised Controlled Waters DQRA, June 2008 (ODA Ref.: 08/90182/AODODA)
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 - c) PDZ3b Pumping Station SSRS
 - ix. Atkins. REP-ATK-CM-03b-OLP-XXX-E-0019. CZ3b Pumping Station and Surrounding Land SSRS, March 2008 (ODA Ref.: 08/90096/AODODA)
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- e) Atkins. 0241-ENW-ATK-LET-00276. Site Wide SSRS Addendum - Criteria for Asbestos in Fill Material. March 2009. (ODA Refs: 08/90083/AODODA, 08/90181/AODODA, 08/90216/AODODA, 08/90217/AODODA, 08/90218/AODODA, 08/90219/AODODA, 08/90220/AODODA, 08/90221/AODODA, 08/90222/AODODA 08/90223/AODODA, 08/90281/AODODA and 08/90326/AODODA)
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- b) Capita Symonds. REP-CSP-VZ-ZZZ-OLP-XXX-E-0866. Lower Lea Valley Groundwater Model. July 2008.
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- xii. BAM Nuttall/WSP Remediation. MST-ENL-CK-03a-OLP-SP1-E-0233. CZ3a RMS Groundwater Addendum for Banner Area (NAPL in Thanet Sands No.3), February 2011 (ODA Ref.: 10/90460/AODODA)
 - xiii. BAM Nuttall. REP-ENL-CE-03a-OLP-SP1-E-0325. CZ3a RMS Addendum for Banner Area (vapour membrane). December 2010 (ODA Ref.: 11/90001/AODODA)
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 - iii. BAM Nuttall. REP-ENL-CK-03a-OLP-SP1-E-0235. CZ3a South of Main Stadium Human Health Validation, March 2009 (ODA Ref.: 09/90130/AODODA)
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DRAWINGS

- 2DD-ATK-CM-03a-OLP-XXX-E-0045: Schematic Conceptual Site Model for Human Health Assessment for CZ3a Main Site (reproduced from the CZ3a Main Site SSRS)
- 2DD-ATK-CM-03a-OLP-XXX-E-0046: Schematic Conceptual Site Model for Controlled Waters Assessment for CZ3a Main Site)
- 2DD-ATK-CM-03a-OLP-XXX-E-0044: Zonation of Site for Human Health Assessment (reproduced from the CZ3a Main Site SSRS)
- 2DD-ATK-CM-03a-OLP-XXX-E-0048: Controlled Waters Risk Assessment Zoning of the Site (reproduced from the CZ3a Main Site SSRS)
- 2DD-ATK-CM-03a-OLP-XXX-E-0079: Schematic Controlled Waters QRA Conceptual Site Model (reproduced from the CZ3a Banner SSRS Addendum)
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- 2DD-ATK-CM-03b-OLP-XXX-E-0029: PDZ3b Pumping Station Schematic Conceptual Site Model for Human Health Assessment (reproduced from the PDZ3b Pumping Station SSRS)
- 2DD-ATK-CM-03b-OLP-XXX-E-0033: PDZ3b Pumping Station Schematic Conceptual Site Model for Controlled Waters Assessment (reproduced from the PDZ3b Pumping Station SSRS)
- 2DD-ENL-CK-03a-OLP-SP1-E-0555: CZ3A Extent of Radioactivity Surveys (Two sheets).
- Figure 2: Thanet Sand NAPL boreholes and Infrastructure Plan
- 2DD-ENML-CE-03a-OLP-SP1-E-0811: CZ3a LOCOG – Remaining Groundwater Infrastructure (Two sheets)
- 2DD-ENL-CK-ZZZ-OLP-SP1-E-0419: Olympic Park South Areas that require Vapour Mitigation Measures or Further Vapour Assessment
- 2DD-ENL-VL-ZZZ-OLP-SP1-E-0047: Plan Showing Potential Locations of Pathogens in CZ3 and CZ4
- 2DD-ENL-CK-03a-OLP-SP1-E-0831: CZ3a Post Enabling Works Thanet Sand and Chalk Groundwater Monitoring Locations
- 2DD-ENL-CK-03a-OLP-SP1-E-0832: Post Enabling Works CZ3a Banner and Southern Plume RTD Groundwater Monitoring Locations

APPENDICES

Appendix A: Glossary of Terms and Definitions

Appendix B: Schedule of Key Documentation (including summary of contents)

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Appendix E: Permit to Proceed Protocol (CD only)

APPENDIX A:

Glossary of Terms and Definitions

Glossary of Terms and Definitions

Term	Meaning / Definition
BNL	BAM Nuttall Limited (Enabling Works)
CoC	Contaminant(s) of Concern
CSM	Conceptuel Site Model
CVR	Consolidated Validation Report
CZ	Construction Zone
DPVE	Dual Phase Vapour Extraction
DQRA	Detailed Quantitative Risk Assessment
EA	Environment Agency
EQS	Environmental Quality Standard
ESGL	Environmental Scientifics Group Limited
EWFL	Enabling Works Formation Level
FFL	Final Finished Level
GRS	Global Remediation Strategy
GQRA	Generic Quantitative Risk Assessment
GWAC	Groundwater Assessment Criteria
HHSL	Human Health Separation Layer
LDA	London Development Agency (See OPLC)
LNAPL	Light Non-Aqueous Phase Liquid
NORM	Naturally Occurring Radioactive Materials
ODA	Olympic Delivery Authority
ORC	Oxygen Release Compound
PAH	Polycyclic Aromatic Hydrocarbons
ODA PDT	Olympic Delivery Authority Planning Decisions Team
OPLC	Olympic Park Legacy Company (formerly known as LDA)
PDZ	Planning Delivery Zone
RMS	Remediation Method Statement
RTD	River Terrace Deposits
SSAC	Site Specific Assessment Criteria
SSRS	Site Specific Remediation Strategy
SSRSpec	Site Specific Remediation Specification

SSRT	Site Specific Remediation Target
UXO	Unexploded Ordnance
WSP	WSP Group Plc
WYGE	White Young Green Environmental

APPENDIX B:
Schedule of Key Documentation
(including summary of contents)

SUMMARY OF CONTENTS

This section provides a summary of the development of remedial design, implementation and validation relevant to this Planning Delivery Zone. In addition, we have summarised two site wide documents that form the basis for design and five that have resulted in changes to the SSACs for clarity. In the case of the latter five documents, whilst these are referred to the applicable Validation Reports, and in some cases the RMS's, it is felt that given the impact these reports have had, that these should be specifically discussed in this section. This section should be read in conjunction with the text of this CVR and the reference list presented in Section 6.

Site Wide Documents

Capita Symonds. MST-CSP-CM-ZZZ-OLP-XXX-E-0040. Intrusive Investigation Method Statement (IIMS). November 2006. (ODA Ref: 07/90216/AODODA)

The IIMS presents a framework and provides a generic specification for undertaking contamination intrusive investigations across the Olympic Park to gather sufficient information to support planning applications and scheme design. It has been prepared with reference to the Environment Agency Model Procedures for the Management of Land Contamination CLR 11.

The intrusive investigation works outlined in this document gathered sufficient information to inform production of Site Specific Remediation Strategies (SSRS) to support planning application requirements and detailed design.

In particular the intrusive investigation works provided sufficient information to:

- (i) assess the nature, extent and source of soil and groundwater contamination;
- (ii) assess the soil gas generation potential;
- (iii) prepare site conceptual model;
- (iv) undertake generic and detailed quantitative risk assessment; and
- (v) identify of areas requiring remediation.

Capita Symonds. REP-CSP-VZ-ZZZ-OLP-XXX-E-0076. Global Remediation Strategy, (Version 2.0, Rev B), January 2007. (ODA Ref.: 07/90011/FUMODA)

Given the scale and the strict delivery requirements of the Olympics, the GRS has been prepared to provide a common resource for remediation strategy related work, thus minimising duplication of design, regulatory requirements and programme risk.

To this end the GRS sets out site wide principles and procedures for taking forward the SSRSs, which are, and have been, prepared for individual Construction Zones/Sub Zones. Specifically the following principles and technical resources have been established:

- (i) a 'Global Conceptual Site Model' (GCSM) for the Olympic Park identifying the major potential contamination related risks; and
- (ii) a wide range of soil and groundwater 'Generic Assessment Criteria' (GAC) for screening of chemical testing results to identify potential contamination risks.

With regard to (ii) above computer based generic quantitative risk assessment (QRA) has been undertaken to derive generic screening values for areas potentially requiring remediation.

The Environment Agency document 'Model Procedures for the Management of Land Contamination' (CLR11) has been consulted in production of this document. In this respect this document broadly represents the Generic Quantitative Risk Assessment process outlined within CLR 11.

Atkins. REP-ATK-CM-ZZZ-OLP-ZZZ-E-0004. Proposed changes to the Human Health SSAC values for Lead, General Metals, and PAHs in the Separation Layer and General Fill. August 2008. (ODA Ref.: 08/90265/AODODA)

Revised SSAC were calculated for lead using the Provisional Tolerable Weekly Intake method for the Soft Landscaping Legacy end use, for general metals using a single Soil Ingestion Rate, and for PAHs assessing the potential contribution from each of the vapour inhalation pathways based on the Henry's Law Constant.

Atkins. REP-ATK-CM-ZZZ-OLP-ZZZ-E-0004 Errata to Document entitled 'Proposed changes to the Human Health SSAC values for Lead, General Metals, and PAHs in the Separation Layer and General Fill'. September 2008. (ODA Ref.: 08/90265/AODODA)

This report recalculated the lead SSAC using the inhalation Tolerable Daily Intake and the dermal pathway. This resulted in a new SSAC for areas of soft landscaping not associated with commercial buildings.

Atkins. ENW-ATK-LET-00269. Site Wide RMS Addendum (Use of Hardcover as a Substitute to the Separation Layer). February 2009. (ODA Ref.: 08/90292/AODODA)

Under this site wide RMS addendum the remedial designers developed a framework for reducing the thickness of the HHSL under suitably robust hardstanding. The basic premise behind this design change was that hardstanding would act as a suitable barrier to certain pollution pathways (namely ingestion, dermal contact and dust inhalation) and reduce the requirement for a full-thickness HHSL.

Nuttall. MST-ENL-CE-ZZZ-OLP-SP1-E-0159 Rev 05. Site Wide RMS Addendum (Asbestos in the Sub-grade & General Fill), March 2009. (ODA Refs: 08/90083/AODODA, 08/90181/AODODA, 08/90216/AODODA, 08/90217/AODODA, 08/90218/AODODA, 08/90219/AODODA, 08/90220/AODODA, 08/90221/AODODA, 08/90222/AODODA 08/90223/AODODA, 08/90281/AODODA and 08/90326/AODODA)

The SSACs and methodology for assessing asbestos in the HHSL and below marker layer materials was further developed as the works progressed as set out in the Site Wide SSRS Addendum - Criteria for Asbestos in Fill Material (0241-ENW-ATK-LET-00276) detailed below. In addition, this RMS details the sampling strategy to be utilised when an asbestos value of >0.1% w/w is encountered within emplaced materials.

Atkins. MEM-ATK-CM-ZZZ-OLP-ZZZ-0004 Rev 2. Site Wide SSRS Addendum (Justification of Deviation from the GRS in the Derivation of SSAC). September 2009. (ODA Ref.: 09/90233/AODODA)

This document details the changes applied in the derivation of SSAC from the methodology or data sources presented in the GRS along with justification for the changes.

This memorandum has been produced to support any deviations from the GRS specifically in relation to TPH and PAH. It documents the changes Atkins has applied in the derivation of the SSAC from the methodology or data sources presented in the GRS. Where changes have been made from the GRS, these have been justified. Updated versions of the TPH and PAH criteria summary tables are appended to this document and in the case of TPH is based on differing FOC.

Site-Specific Documents

Construction Zone PDZ3a Main Site & Banner

Atkins. REP-ATK-CH-03a-OLP-XXX-E-0002. CZ3a Main Site SSRS, December 2007. (ODA Ref.: 07/90196/AODODA)

The report outlines the CSM, detailed risk assessment and specifies the remedial strategy. The remedial strategy includes derivation of SSACs, remediation requirements and the installation of chemically and geotechnically compliant materials to the EWFL. The Designers identified inorganic and organic contaminant exceedances at four locations in the unsaturated zone requiring treatment to be protective of Human Health and 24 unsaturated zone locations to be protective of Controlled Waters (Scenario 1 – EQS). One of these locations represented an exceedance to both human health and controlled waters criteria. The Designers also identified the presence of organic and inorganic contamination in the RTD, most notably with respect to ammoniacal nitrogen. In addition, the Designers recommended the collection of additional data to further refine the CSM and remedial strategy.

BAM Nuttall. MST-ENL-CE-03a-OLP-SP1-E-0067. CZ3a Main Site RMS. December 2007 (ODA Ref.: 07/90215/AODODA)

The main purpose of this document is to detail the implementation and validation of the remedial strategy in the unsaturated zone including an outline of the remedial measures proposed. In addition, this report defines the extent of the remediation required by the current design and any additional areas identified in the SI review as well as detailing how the prevailing Planning Conditions will be discharged. There was no change to the specified number of hotspots.

**Atkins. REP-ATK-CM-03a-OLP-XXX-E-0001. CZ3a Banner Area SSRS, April 2008
(ODA Ref.: 08/90047/AODODA)**

The report outlines the CSM, detailed risk assessment and specifies the remedial strategy. The remedial strategy includes derivation of SSACs, remediation requirements and the installation of chemically and geotechnically compliant materials to the EWFL. The Designers identified eight Human Health and 9 controlled water hotspots for inorganic and organic contaminants in the unsaturated zone requiring treatment, excluding the site wide exceedances of ammoniacal nitrogen. The Designers also noted that significant contamination of the RTD is also present with both organic and inorganic contaminants, most notably with ammoniacal nitrogen representing both a risk to Human Health and Controlled Waters. Discontinuous perched water has also been found to present a risk to both Human Health and Controlled Waters and will require treatment. The Designers recommend additional data is collected to further refine the CSM and remedial strategy including data from the underlying Thanet Sands, which was visually recorded with organic contamination in discrete areas.

**BAM Nuttall. MST-ENL-CE-03a-OLP-SP1-E-0096. CZ3a RMS Addendum for Banner
Area. April 2008 (ODA Ref.: 08/90103/AODODA)**

The main purpose of this document is to detail the implementation and validation of the remedial strategy in the unsaturated zone including an outline of the remedial measures proposed. In addition, this report defines the extent of the remediation required by the current design, define and implement the additional SI required to augment the existing CSM in order to understand further the nature and extent of contamination in the Thanet Sands and enable design of the groundwater treatment schemes to be more effectively tailored. This report also reiterates the proposed intention for primary source removal of the unsaturated zone in accordance with the SSRS.

**Atkins. REP-ATK-CM-03a-OLP-XXX-E-0002. CZ3a Banner Area SSRS Addendum
No.1 – Revised Controlled Waters DQRA, June 2008 (ODA Ref.: 08/90182/AODODA)**

This report addendum has been prepared to present the revised controlled waters DQRA on the basis of discussion with the Environment Agency and results of predictive groundwater flow modelling work undertaken by Capita Symonds Limited (CSL) for the Olympic Park under the proposed surface water impoundment conditions. The changes to the controlled waters DQRA comprise:

- amending the controlled waters CSM – amendments are based on discussions with the Environment Agency concerning the recent results of the groundwater modeling undertaken by CSL. According to these results, the Waterworks River 270m to the east of the site would be a more appropriate controlled water receptor than the City Mills River immediately adjacent to the CZ3a Banner Chemical Works site;
- introducing a pathway length taking into account the potential for contaminant transport to the Waterworks River approximately 300m to the east of the site;
- modifying the methodology for assessing the potential risks to the Thanet Sand / Chalk Major Aquifer – introduction of dilution in the receiving Thanet Sand / Chalk groundwater underlying the site;
- removing the unsaturated pathway from the CSM. It is understood from discussions with the site personnel that the Alluvium layer overlying the RTD has been removed during the earthworks activities. Hence any fill materials will be placed directly over the RTD groundwater so a direct pathway exists and therefore the risk assessment has been amended appropriately; and

- production of a revised list of SSAC for the protection of controlled waters. SSAC have been produced for validation of in-situ and backfill unsaturated and RTD groundwater.

The SSRS also notes that the Enabling Works Contractor has removed the unsaturated soils to the top of the River Terrace Deposits so as to remove all of the unsaturated soil sources.

Atkins. LET-ATK-TZ-03a-OLP-SP1-E-0003. Banner Validation Process Letter, September 2008 (ODA Ref.: 08/90185/AODODA)

The letter outlines the methodology by which the Banner site will be validated on a receptor basis to take into account the complex remedial methods required to ensure the unsaturated and saturated zones are protective of both human health and controlled waters.

Atkins. REP-ATK-CM-03a-OLP-XXX-E-0003. CZ3a Main Site SSRS Addendum No.2: Controlled Waters DQRA, November 2008. (ODA Ref.: 08/90246/AODODA)

This report has been prepared to present the revised controlled waters DQRA. This DQRA has been revised on the basis of further discussions with the EA and results of predictive groundwater flow modeling work undertaken by Capita Symonds Limited for the Olympic Park under the assumed surface water impoundment conditions. The revised SSAC supersede those presented in the original SSRS for the CZ3a Main Site and in accordance with the CZ3a Banner Addendum No.1 (see REP-ATK-CM-03a-OLP-XXX-E-0002), for which similar modifications were made to the CSM. These changes to the controlled waters DQRA comprise:

- amending the controlled waters CSM – amendments are based on discussions with the Environment Agency concerning the results of the groundwater modeling undertaken by CSL. According to these results, the Waterworks River approximately 300m to the east of the site would be a more appropriate controlled waters receptor than the City Mills River and River Lea immediately adjacent to the CZ3a site;
- introducing a pathway length taking into account the potential for contaminant transport to the Waterworks River approximately 300m to the east of the site;
- modeling the site as one source zone rather than the previous seven zones used when considering the adjacent City Mills River and River Lea as the relevant receptors; and
- production of a revised list of SSAC for the protection of controlled waters. SSAC have been produced for validation of excavations backfill materials and River Terrace Deposit groundwater.

BAM Nuttall. REP-ENL-CE-03a-OLP-SP1-E-0175 CZ3a Main Site Human Health Validation Report, December 2008 (ODA Ref.: 08/90079/AODODA)

This report validates the site in relation to Human Health only. Following site clearance across the site, the main excavation works included excavation and validation of the one human health hotspot (Hotspot A) in the unsaturated zone, which was backfilled with chemically and geotechnically acceptable materials. This report also discusses the radiological contamination encountered in CZ3a (further details are provided below).

**BAM Nuttall. REP-ENL-CE-03a-OLP-SP1-E-0187 CZ3a H17 and Loop Road West
Human Health Validation, March 2009 (ODA Ref.: 08/90271/AODODA)**

This report validates the site in relation to Human Health only. Following site clearance across the site, the main excavation works comprised excavation and validation of the one human health hotspot (Hotspot C) in the unsaturated zone which was backfilled with compliant materials.

**BAM Nuttall. REP-ENL-CK-03a-OLP-SP1-E-0235. CZ3a South of Main Stadium
Human Health Validation, March 2009 (ODA Ref.: 09/90130/AODODA)**

This report validates the site in relation to Human Health only. Following site clearance across the site, the main excavation works comprised excavation and validation of the two human health hotspots (Hotspot B and D) present in the Main Stadium as well as the Human Health unsaturated zone hotspots present in the Banner Area, which was backfilled with generally compliant materials. Residual contamination remains in the materials below the existing sub-grade level beneath a restriction associated with an existing high voltage (HV) cable in the Banner area. The report also identified exceedances in the general fill and human health separation materials representing a risk to human health in discrete locations, which are earmarked for removal and reporting in an addendum. A radiological walkover was also carried out following the removal of the encountered radiologically contaminated materials. These materials were recorded as being at background concentrations (further details are provided below).

**Atkins. REP-ATK-CM-03a-OLP-XXX-E-0004. CZ3a Banner Area SSRS Addendum
No.2 - Revised CSM for Chalk Aquifer Receptor, May 2010 (ODA Ref.:
10/90225/AODODA)**

This report was prepared as a result of additional information collected during the recent ground investigation. The additional information has provided further evidence of contamination within the Thanet Sand and has also indicated the discontinuous presence of putty chalk on top of the Upper Chalk. Information provided on borehole logs has indicated a wider presence of contamination in the Lambeth Group, which indicates that contaminant migration does occur. The revised CSM and SSAC protective of the Chalk aquifer therefore considers attenuation of contaminants in the form of retardation, dispersion and degradation along the pathway through the Lambeth Group to the underlying Thanet Sand and Chalk aquifers. As a consequence, and considering the results of groundwater elevation and quality monitoring, the Thanet Sand groundwater is still considered to be in hydraulic continuity with the Chalk groundwater. Therefore, the criteria for the Thanet Sand groundwater are the same as those applied to the Chalk Aquifer.

The revised SSAC for import material and groundwater within the RTD are generally higher (less stringent) than those previously presented in Addendum No. 1 as a result of the modifications made to the Lambeth Group pathway. The combined SSAC (protective of both the Waterworks River and Chalk) are now largely dominated by SSAC protective of the Waterworks River.

BAM Nuttall. REP-ENL-CE-03z-OLP-SP1-E-0186 CZ3a Unsaturated Zone Validation Report (including late release of pylon areas), September 2010 (ODA Ref.: 10/90348/AODODA)

The report discusses the remedial works completed to date including the excavation (in total) of seven contaminant hotspots as identified by the SSRS/RMS (four for human health, two for controlled waters and one hotspot for both). This number excludes hotspots from with the CZ3a Banner, as all the hotspots in this zone were considered to be removed by the excavation of the entire unsaturated zone. These hotspots include those already noted in the preceding Human Health specific Validation Reports.

This excludes the Banner hotspots which were removed is recorded previously.

A radiological walkover identified slightly elevated concentrations of NORM, which was excavated, validated and backfilled with chemically and geotechnically acceptable materials. Radionuclides dispersed in excavated spoil and exposed excavation faces were detected in discrete locations around that recorded greater than background levels of radiochemically contaminated soils. These materials were Normally Occurring Radiological Materials (NORM) determined to be "Exempt" under the relevant Radioactive Substances 1993 – now subsumed into the Environmental Permitting (England and Wales) Regulations 2010. Where these materials were encountered they were removed to PDZ6 and temporary stockpiled and assayed prior to appropriate disposal.

Radiological contamination encountered was found to be above the sub-grade level (based on Enabling Works excavation) and were therefore excavated, segregated, validated and appropriately removed to PDZ6. These finds in PDZ3a have been recorded and labeled as Areas A to K, as illustrated in Drawing 2DD-ENL-CK-03a-OLP-SP1-E-0555 entitled CZ3A Extent of Radioactivity Surveys.

- Area A comprised mixed nuclides of natural uranium, protactinium [231Pa] (part of the 235U decay chain), thorium [232Th] and radium [226Ra], which are NORM. These radioactive materials were used in chemical and industrial processes, but without, so far as is known, any processing intended to alter their radioactivity.
- The main excavation area for the stadium bowl was surveyed and small source areas D, F, G, H and I were identified. All source areas contained 231Pa, 226Ra and 232Th.
- A stockpile (Area B) was known from delivery tickets to have been the destination of material from the source area and this was found to have some contamination.
- Radioactive sources were found in Area C. This is also a NORM source area [232Th, where the contamination is around buried concrete foundations.
- Analytical results and supporting Radiological Protection Advisor (RPA) advice are to the effect that the principal radionuclides present are 232Th, 238U, 226Ra and 231Pa (from the 235U decay chain).

In instances in CZ3a where radioactively contaminated materials were not directly transported to CZ6, the radioactive materials were temporarily stockpiled (Stockpile reference CZ5a/S03) in CZ5a prior to onward transportation to CZ6 for assaying by Nuvia. These radioactively contaminated materials were subsequently determined for either deposition in CZ4 or for appropriate off-site disposal to an appropriately licensed facility. Following the removal of the stockpiled arisings from CZ5a, Nuvia conducted a clearance survey of the temporary stockpile area, which recorded concentrations below the action limits.

BAM Nuttall. REP-ENL-CE-03a-OLP-SP1-E-0325. CZ3a RMS Addendum for Banner Area (vapour membrane). December 2010 (ODA Ref.: 11/90001/AODODA)

The human health assessment within the CZ3a South of Main Stadium Human Health Validation Report (REP-ENL-CK-03a-OLP-SP1-E-0235) identified volatile exceedances of the residential Legacy land use SSAC in materials below the human health separation layer [general fill and sub-grade] that were being driven by the indoor air inhalation pathway.

The purpose of this RMS addendum is to update the CSM and therefore the applicable human health SSAC as the result of an agreement with the landowner - OPLC - that a vapour membrane must be incorporated into future buildings that are to be constructed on the site and remain into Legacy phase. It should be noted that it is not currently considered necessary to adopt vapour protection measures for the Olympic land use.

BAM Nuttall. REP-ENL-CE-03z-OLP-SP1-E-0358 PDZ3 Unsaturated Zone Validation Report Addendum, March 2011 (ODA Ref.: 10/90458/AODODA)

This report confirms the completion of the corrective actions noted in the preceding reports as well as completion of the remaining remediation scope for areas not previously validated (there were no SSRS/RMS defined hotspots located in these areas). These works relate to:

- Completion of Late Enabling Works Scope associated with the removal of T03, T04 and E36 and the area between the H06 bridge and the former T03 bridge.
- excavation of previously identified contamination beneath a former high voltage [HV] cable and associated backfill with geotechnically and chemically compliant material.
- Excavation of the materials associated with the two SSAC exceedances for benzo(a)pyrene in the human health separation layer. These excavations were validated and backfilled with acceptable materials.
- Following further assessment of the volatile exceedances in the CZ3a Banner area, it was agreed that the landowner will incorporate vapour mitigation measures for the Legacy land use only (as noted in REP-ENL-CE-03a-OLP-SP1-E-0325).

BAM Nuttall. REP-ENL-CE-03z-OLP-SP1-E-0376 PDZ3 Unsaturated Zone Validation Report Addendum No. 2, March 2011 (ODA Ref.: 11/90240/AODODA)

This report details the implementation of the remedial scope following a design change in the topographic levels within the Banner Area. It also discusses the completion of the soft bank works adjacent to and beneath the H06 Bridge. In both instances, compliant backfill materials were utilised and no corrective actions were considered necessary.

BAM Nuttall. REP-ENL-CE-03z-OLP-SP1-E-0400 PDZ3 Unsaturated Zone Validation Report Addendum No. 3, November 2011 (ODA Ref.: 11/90574/AODODA)

This report present the findings of the additional works completed in the following areas, noting there were no no SSRS/RMS defined hotspots located in these areas:

- Validation of the works completed south of the loop road, including the isolated controlled waters exceedances of inorganic contaminants which were then assessed to not present an unacceptable risk to controlled waters based on the available lines of evidence.
- Excavation of the materials associated with the arsenic SSAC exceedance in the human health separation layer beneath the former CZ3b groundwater treatment plant (as noted below in REP-ENL-CE-03b-OLP-SP1-E-0328, see below). The excavation as validated and backfilled with acceptable materials.

Construction Zone PDZ3b

Atkins. REP-ATK-CM-03b-OLP-XXX-E-0019. CZ3b Pumping Station and Surrounding Land SSRS, March 2008 (ODA Ref.: 08/90096/AODODA)

The report outlines the CSM, detailed risk assessment and specifies the remedial strategy. The remedial strategy includes derivation of SSACs, remediation requirements and the installation of a chemically and geotechnically compliant materials to the EWFL. The Designers identified inorganic and organic contaminant exceedances in the unsaturated zone at four locations which require treatment to be protective of Human Health (two) and Controlled Waters (two). In addition, treatment of the perched water to be protective of human health (via volatilization to indoor air) is also considered necessary.

Atkins. REP-ATK-CM-03b-XXX-XXX-E-0003. PDZ3b Contamination Assessment Position Paper. December 2008 (ODA Ref.: 09/90006/AODODA)

This document presents the ground conditions and contamination assessment of the main part of PDZ3b. This document is intended to provide an indication of the soil and groundwater quality in terms of the risks to human health during the Olympic phase only. Upon completion of the Olympic use in 2012 the site will return to its current (private) land owner, and therefore the legacy end-use is not considered. Minimal earthworks are being considered for the site and no specific remediation is considered necessary as part of this assessment. A GQRA for human health has been undertaken for the Olympic use only. Due to the temporary nature of the Olympics site usage (athlete warm up area, transport area and part of an accreditation checking area) and the fact that no significant intrusive earthworks are required, no controlled waters risk assessment has been undertaken, although receptors and pathways are discussed within this report as part of the CSM development.

BAM Nuttall. MST-ENL-CE-03b-OLP-SP1-E-0115 CZ3b RMS, July 2008 (ODA Ref.: 08/90154/AODODA)

The main purpose of this document is to support ground contamination remediation, including verification, provide an outline of the remedial measures proposed and then implementation. In addition, this report defines the extent of the remediation required by the current design and any additional areas identified in the SI review. This RMS specifies four unsaturated zone hotspots (two Human Health and two Controlled Waters) requiring remediation in accordance with the SSRS.

BAM Nuttall. MST-ENL-CE-03b-OLP-SP1-E-0112 CZ3b Soil Treatment RMS, August 2008 (ODA Ref.: 08/90176/AODODA)

This report was prepared to outline the treatment process of the groundwater treatment plant within PDZ3b as well as the visual impact of the actual plant itself through a series of schematics. This STRMS is required to also discharge SP.0.41.

BAM Nuttall. REP-ENL-CE-03b-OLP-SP1-E-0219 CZ3b Human Health Validation Report, January 2010 (ODA Ref.: 09/90032/AODODA)

This report validates the site in relation to Human Health only. Following site clearance across the site, the main excavation works comprised excavation and validation of the four aforementioned

unsaturated zone hotspots (two human health and two controlled waters) and backfilled with generally compliant materials. An addendum will be prepared to assess the risk to controlled waters and to validate the backfill materials that exceed the SSAC.

BAM Nuttall. REP-ENL-CE-03b-OLP-SP1-E-0273 CZ3b Human Health Validation Report Addendum No. 1, February 2010 (ODA Ref.: 09/90032/AODODA)

The corrective items identified in the Human Health Validation Report (REP-ENL-CE-03b-OLP-SP1-E-0219) have largely been addressed in this Addenda.

Vapour monitoring was carried out to assess the 1, 2-dichloroethane exceedances in the general fill, which concluded that the concentrations do not pose an unacceptable risk to human health for the proposed site end users. In addition, the TPH Aliphatic >C12-16 exceedances in the human health separation layer were reassessed following the revision of the SSAC by the Designers. This concluded that the concentrations at the site do not pose an unacceptable risk to human health.

BAM Nuttall. REP-ENL-CE-03b-OLP-SP1-E-0328 CZ3b Human Health Validation Report Addendum No. 2, May 2010 (ODA Ref.: 10/90135/AODODA)

This report closes out a highlighted outstanding action noted in the preceding Validation Report. These corrective actions focused on the removal of the exceedances of asbestos, arsenic and benzo(a)pyrene in the Human Health separation layer. These were validated and backfilled with chemically and geotechnically acceptable materials.

It should be noted that the final outstanding action remaining - removal of material associated with separation layer sample N03b-FVP084-340147 – was to be completed by the Follow-On Project at the time of decommissioning the existing groundwater treatment plant. Following a change in circumstances, the outstanding action was actually completed by BAM Nuttall and discussed further in the CZ3a Unsaturated Zone Validation Report Addendum No. 3 (REP-ENL-CE-03z-OLP-SP1-E-0400).

Hydraulic Containment

Atkins. REP-ATK-CM-03a-OLP-ZZZ-E-0002. CZ3a Groundwater Treatment Exit Strategy. August 2009 (submitted for information purposes only)

An exit strategy for deactivation / decommissioning of the hydraulic containment system was developed that defined the Remedial Action Objectives (RAO) taking into account background concentrations of ammoniacal nitrogen in up-hydraulic gradient monitoring locations. The criterion for deactivation of the system is now set at 26.0mg/l (as NH₄) and permanent decommissioning of the system at 18.9 mg/l (as NH₄). The hydraulic containment system beneath the Stadium site exerts a major control over the groundwater flow pattern in the RTD. Under natural (original) conditions, groundwater flows onto the site from the northwest (from CZ4) and then towards the Waterworks River. When the containment system is in operation, the abstraction boreholes located at the site perimeter draw groundwater from the interior of CZ3a Stadium, and from adjacent sites. The changed groundwater flow regime during operation of the capture system was considered during the definition of appropriate RAO and monitoring requirements.

Atkins. 0241-ENW-ATK-LET-00701 CZ3a Hydraulic Containment System (Northern Stadium Loop): Assessment of post-deactivation Ammoniacal Nitrogen, Data. September 2010 (ODA Ref.: 10/90448/AODODA)

This memorandum validates the remediation works undertaken for the protection of controlled waters with respect to the treatment of ammoniacal nitrogen by presenting a review of the post deactivation data supporting the decommissioning of the Hydraulic Containment System (Stadium Loop).

This report presents a review of the first six months of post deactivation data. In summary, six out of the ten boreholes with incomplete data show concentrations below the RAO for decommissioning or declining trends. Concentrations at two boreholes showed considerable variation but without clear overall trends; at one of these locations there were two occasions when concentrations were recorded as being below the RAO. Only two locations showed evidence of rising trends, one of which includes two values below the RAO for decommissioning. Consequently, in view of the observed trends in eight of the ten monitoring locations with incomplete datasets, it is considered that collection of samples from inaccessible boreholes during the monitoring period under discussion is not likely to have affected the decision presented in this document.

It was therefore agreed that the data presented complies with the agreed criteria for completion and decommissioning of the CZ3a Stadium ('northern loop') component of the hydraulic containment system. On this basis the northern Stadium loop was decommissioned.

BAM Nuttall. REP-ENL-CE-03a-OLP-SP1-E-0264 CZ3a Hydraulic Containment System (Northern Stadium Loop) Verification Report, October 2010 (ODA Ref.: 10/90193/AODODA)

This document summarises the operational status and performance of the hydraulic containment system operating on CZ3a and forms a revision to the previous issue of this report. The 'northern loop' was designed to prevent the off-site migration of dissolved phase organic and inorganic contaminants within the RTD aquifer.

During the operation of the HC system, a process of physical data gathering has been undertaken to establish lines of evidence to validate that the system is achieving hydraulic containment.

The purpose of this document is to provide a verification of effectiveness of the northern loop system in its current configuration and review the original design assumptions to assess their validity against the conditions encountered through the operational phase.

**BAM Nuttall/WSP Remediation. MST-ENL-CE-03a-OLP-SP1-E-0133. CZ3A
Groundwater RMS Addendum (Archae), October 2008 (ODA Ref.:
08/90256/AODODA)**

This reports relates solely to the proposed use of Archaea for the groundwater remedial activities as a secondary treatment option within CZ3a northern stadium loop only. The hydraulic containment of the RTD remains the primary objective, although biological and chemical treatment can be encouraged through the application of archaea as part of the pump, treat and reinjection system. Further laboratory and field trials were undertaken and these data are discussed herein.

**Atkins. Hydraulic Containment System (Banner Loop) Requirements for
Deactivation and Decommissioning, November 2011 (ODA Ref.:
10/90574/AODODA)**

The aim of this document is to update the strategy for deactivation and decommissioning of the CZ3a Banner southern loop of the hydraulic containment system, following completion of Atkins' Southern Plume position paper (see below). Specific aims of this document are to confirm the list of contaminants of concern and associated target values; and outline the monitoring requirements and data assessment methodology.

The strategy for decommissioning and deactivating the southern Banner loop of the hydraulic containment system sets out how to achieve initial deactivation following the assessment of the monitoring data. Should this be achieved, this will be followed by a period of groundwater monitoring.

**BAM Nuttall/WSP Remediation. REP-ENL-CE-03a-OLP-SP1-E-0397. CZ3a Banner
Hydraulic Containment System Assessment of Post-Deactivation Groundwater
Monitoring Data, June 2011 (ODA Ref.: 11/90403/AODODA)**

This report presents an assessment of groundwater monitoring data collected for a six month period following deactivation of the southern Banner loop of the hydraulic containment system. The chemical data recorded the mean concentrations for each monitoring round to demonstrate compliance with the SSAC for all contaminants of concern over the six month monitoring period following deactivation. It was also been agreed with the regulators that the selenium exceedances do not warrant further monitoring. In accordance with the approach outlined in the Atkins memo (0241-ENW-ATK-LET-00701) and subsequent agreement with the regulators, the southern Banner loop was decommissioned.

River Terrace Deposits (RTD)

BAM Nuttall. MST-ENL-CE-03a-OLP-SP1-E-0111. CZ3A Groundwater RMS Addendum, July 2008 (ODA Ref.: 08/90145/AODODA)

This report presents the proposed remedial scheme for the mitigation of risks posed to controlled waters from any residual unsaturated zone contamination and contaminants in the RTD within CZ3a Main Stadium. The principal objectives of these activities are to prevent contaminants entering surface waters, specifically the City Mill River and River Lea through hydraulic control. In addition, the RMS also details the proposed the medium to long term improvement of groundwater quality within the RTDs through the remedial technique of 'pump and treat' of VOC and the biological treatment of ammoniacal nitrogen. This addendum also includes the findings of pump tests, chemical oxidation field trials and archaea feasibility trials.

BAM Nuttall/WSP Remediation. MST-ENL-CE-03a-OLP-SP1-E-0125. CZ3a RMS Groundwater Addendum for Banner Area. July 2008 (ODA Ref.: 08/90237/AODODA)

This report provides the detailed site data and infrastructure installations required to carry out groundwater remediation via the injection of chemical reagentss. The primary objective of the remediation is to provide a significant reduction in the contaminant mass of dissolved phase contaminants of concern (principally chlorinated ethanes and ethenes, PAH, and TPH) in the short term. This will then allow the medium to long term improvement (betterment) of groundwater quality within the RTDs through operation of the CZ3a Banner southern loop RTD hydraulic control and treatment system. The second objective of this injection is to remove the recoverable DNAPL.

The chemical oxidation injection works will comprise targeted treatment of the dissolved phase organic contaminants via a series of up to 20 injection wells installed in the treatment zone.

Further investigations are proposed to delineate the DNAPL around the impacted borehole. Should DNAPL be encountered within the base of the remediation boreholes it is proposed to undertake DNAPL source reduction via active recovery utilising a bottom loading pump if a recoverable quantity of DNAPL is present.

BAM Nuttall/WSP Remediation. MST-ENL-CE-03a-OLP-SP1-E-0123. CZ3a RMS Groundwater Addendum for Banner Area. November 2008 (ODA Ref.: 08/90237/AODODA)

This report has been prepared to specifically address the shallow groundwater remediation required for the area in and around the Banner site. Following the completion of the additional site investigation to characterise and delineate the contamination, this addenda discusses the findings and carries out an option appraisal for the treatment of DNAPL, LNAPL and dissolved phase. In summary, the DNAPL will be removed using bottom loading hydrophobic pumps until no discernible benefit is gained, which may be complemented by the application of in-situ chemical oxidation (sodium persulphate) to treat the dissolved phase. These works will be supported by the two loops of the hydraulic containment system (Main Site and Banner Site). The groundwater abstracted from the Banner loop will be passed through the Groundwater Treatment Plant (located in the Pumping Station part of the CZ3b) prior to discharge to foul sewer.

BAM Nuttall. MST-ENL-CE-03a-OLP-SP1-E-0174. CZ3a RMS Addendum for Banner Area (Additional Remediation), June 2010 (ODA Ref.: 09/90358/AODODA)

This report discusses the groundwater monitoring results following the initial phase of in-situ chemical oxidation in the RTD at the Banner site. This data has identified continued exceedances of selective contaminants of concern that requires another phase of injections to address both the main RTD groundwater source area of the Banner Area and the down-gradient diffuse plume, with regard to achieving Legacy human health SSAC.

BAM Nuttall/WSP Remediation. MST-ENL-CK-03a-OLP-SP1-E-0213. CZ3a RMS Groundwater Addendum for Banner Area (Additional Remediation for ISCO Injection and Monitoring), July 2010 (ODA Ref.: 10/90226/AODODA)

This report presents supplementary information for the remediation of the RTD in the Banner Area and provides further clarification with respect to the remediation objective, reagents selection process including its application, monitoring and the validation process of the proposed groundwater treatment.

BAM Nuttall/WSP Remediation. REP-ENL-CK-03a-OLP-SP1-E-0330. CZ3a Banner RTD Groundwater Verification Report, August 2011 (ODA Ref.: 11/90385/AODODA)

This report confirms that the first two rounds of ISCO works associated with the groundwater remediation at the site have been completed in accordance with the RMS. The works were implemented to reduce the concentrations of the principal contaminants of concern comprising chlorinated ethenes and ethanes, PAH and TPH in the RTD aquifer.

Assessment and validation of the controlled waters and human health SSAC has been undertaken on a well by well basis. Short-term trends in groundwater quality for the contaminants of concern have also been assessed as a secondary line of evidence. The findings to date have shown that full verification of the site area has not been possible due to the persistence of potassium permanganate and in isolated locations temporary construction activities, such as cofferdams for the construction of the U02 underpass. In addition, exceedances of the controlled waters and human health SSAC for the contaminants of concern remain in a number of locations although trends in post-remediation groundwater quality show significant reductions (orders of magnitude) in concentrations for all contaminants of concern across the site area.

Groundwater monitoring will continue to provide at least one year of post-remediation monitoring data, which will assess trends to determine the requirement for any deviation from the verification plan.

The Southern Plume monitoring programme addresses contamination risk to down-gradient sites.

BAM Nuttall/WSP Remediation. REP-ENL-CE-03a-OLP-SP1-E-0398. CZ3a Banner RTD Groundwater Verification Report – Vapour Assessment, June 2011 (ODA Ref.: 11/90412/AODODA)

This report follows on from the main report, which identified exceedances of the Olympic land use human health GAC and Legacy land use human health SSAC in RTD groundwater. These exceedances were recorded in the RTD following the injection of in-situ chemical oxidation. This addendum report presents the results of a targeted vapour monitoring programme and provides an assessment against vapour screening criteria derived by the Designers for the applicable Olympic and Legacy land use. The vapour monitoring and assessment confirmed residual exceedances of a selective VOC when compared to the groundwater Olympic GAC and Legacy SSAC, which represents an unacceptable risk to the human health of future site users based on measured vapour concentrations. It has therefore been agreed with the landowner that vapour mitigation measures will be necessary for the Legacy land use, which is based on the indoor air pathway. Therefore, with the installation of the vapour membrane, the indoor air pathway will revert to outdoor air inhalation pathway. No such measures are considered necessary for the Olympic land use as the contaminant concentrations comply with the outdoor air driven SSACs (REP-ENL-CE-03z-OLP-SP1-E-0358).

BAM Nuttall/WSP Remediation. REP-ENL-CK-03a-OLP-SP1-E-0331. CZ3a Banner RTD Groundwater Verification Report Addendum, January 2012 (ODA Ref.: 12/90050/AODODA)

This report summarises the two rounds of ISCO injections and presents the final RTD groundwater validation report following the 12 months of post-injection groundwater monitoring. Although, there are a discrete number of localised exceedances when compared to the CW SSAC remaining, notably for TCE and vinyl chloride. Notwithstanding this, it has been agreed with the Regulators that the representative mean concentration of these two organic contaminants do not exceed the CW SSAC. Therefore to support this agreement, a reduced groundwater monitoring regime will continue in this area, which will be incorporated into the additional Southern Plume groundwater monitoring requirements and is detailed within the Southern Plume groundwater validation report. On the basis of these monitoring works the need for any further remedial works as required by the Regulator/PDT to fully discharge Condition 35 will be defined.

Vapour mitigation measures are still required in all Legacy buildings in accordance with the preceding validation report (ODA Ref.: REP-ENL-CE-03a-OLP-SP1-E-0398).

Southern Plume

Atkins. 0241-ENW-ENW-CM-REP-0007. Southern Plume Position Paper: SSRS Addendum for CZ2a, CZ2b, CZ3a (Banner Chemicals), CZ3b (Pumping Station), CZ8a, CZ8b, CZ8c North and CZ8c South. April 2011. (ODA Ref: 10/90567/AODODA)

This report presents a detailed technical review of the distribution of contaminants in RTD groundwater in the area referred to as the Southern Plume (CZ2a, CZ2b, CZ3a, CZ3b, CZ8a, CZ8b and CZ8c). The following contaminants of concern (COC) are considered relevant to the Southern Plume - tetrachloroethene (PCE); trichloroethene (TCE); cis1,2-dichloroethene (cDCE); vinyl chloride (VC); and arsenic. This report also sets out the requirements for remediation and monitoring of the COC concentrations (as appropriate) in the Southern Plume and as such,

constitutes an SSRS addendum for the construction zones listed above. Quarterly monitoring for chlorinated ethenes, ethene and arsenic will be carried out and the monitoring results will be evaluated to demonstrate the validation criteria is being met. These assessments were presented at meetings with the Regulators. In addition, quarterly monitoring reports were produced and submitted to the PDT as informatives prior to the final validation report. If the validation requirements are met monitoring will cease after a period of one year.

Nuttall. MST-ENL-CE-ZZZ-OLP-SP1-E-0270. Southern Plume RMS. April 2011. (ODA Ref.: 10/90606/AODODA)

This reports outlines how the remediation and monitoring strategy defined in the SSRS addendum will be implemented and sets out the validation objectives and the proposed content of the validation report.

Nuttall. REP-ENL-CE-ZZZ-OLP-SP1-E-0458. CZ2a, CZ2b, CZ3a, Cz3b (Pumping Station), CZ8a, CZ8b and CZ8c Southern Groundwater Plume Validation Report. October 2011 (ODA Ref.: 11/90733/AODODA)

This report assesses and provides a commentary upon the contaminant data collected from the specified monitoring network. This report concludes that complete dechlorination is occurring resulting in concentrations of PCE, TCE, cDCE and VC being less than the SSAC and recorded arsenic concentrations being compliant with the wider plume objectives primarily as a result of source removal. In summary, this report confirms via monitoring, that the Southern Plume COCs do not represent an unacceptable to risk to Human Health and Controlled Waters. Following review of this report, the PDT has requested that monitoring be extended both in its geographical extent (as monitoring wells in CZ3a Banner are now included) and duration (monitoring to be undertaken for a further 12 months based on monthly monitoring for the first quarter and then quarterly thereafter), although the overall number of monitoring wells has significantly reduced.

In addition to the discrete fluctuation of cDCE and Vinyl Chloride in NBHCZ3a-1043 and NBHCZ3a-889 in the final two rounds of the initial groundwater monitoring regime, during further discussions with the PDT it was agreed that groundwater monitoring would continue to understand further the ongoing stability of the residual plume, following completion of the in-situ remedial works in the former Banner Chemicals area. It is considered that this additional monitoring will enable the longer term assessment of these contaminant trends particularly as the aquifer returns to a state of equilibrium and hence a further 12 month period of groundwater monitoring will be undertaken which will commence as soon as reasonably practicable post Games in order to establish the long term trends in contaminant concentrations. This monitoring will specifically target the presence of the main contaminants of concern in this area, which includes vinyl chloride, chlorinated ethanes, dissolved ethanes, methane, arsenic, and total organic content determinants such as sulphate, iron and chloride. In addition the presence or absence of non-aqueous phase liquids (NAPL) will also be recorded. On the basis of these monitoring works the need for any further remedial works as required by the Regulator/PDT to fully discharge Condition 35 will be defined.

Atkins. 0241-ENW-PWD-C-REP-0021. Groundwater Remediation Exit Strategy: Southern Plume. November 2011 (submitted for information purposes only)

The objective of this report is to communicate an agreed exit strategy for groundwater remediation in the RTD across the Southern Plume (CZ2a, CZ2b, CZ3a, CZ3b, CZ8a, CZ8b and CZ8c). This report discusses the substantial work already completed at the source area (considered to originate from historical contaminative activities in the vicinity of the Banner Area) in terms of removal of the unsaturated zone and treatment of the secondary source in the RTD groundwater. Following review of the post-remediation monitoring data to date, it is considered that these works will in the mid and long term act to reduce the concentrations across the Southern Plume. It is therefore considered that there is little additional advantage, as it is not sustainable, to spend a substantial amount of money and energy to actively remediate the groundwater across the entire Southern Plume.

Validation of the Southern Plume will be based on a series of indicators, most notably; attainment of revised RTD groundwater SSAC, demonstration that concentrations of chlorinated ethenes are declining in monitoring data obtained from the wider plume area and of the presence of ethene as an indicator of complete degradation of chlorinated ethenes and demonstration that concentrations of arsenic are stable or declining in monitoring data obtained from the wider plume area. If the validation requirements are met and subject to approval by the EA/PDT, monitoring will cease after a period of one year.

Thanet Sands

BAM Nuttall/WSP Remediation. MST-ENL-CK-03a-OLP-SP1-E-0195. CZ3a RMS Groundwater Addendum for Banner Area (NAPL in Thanet Sands), May 2010 (ODA Ref.: 09/90402/AODODA)

The SSRS identified visually impacted groundwater in the Thanet Sand aquifer underlying the Banner site. This RMS presents the methodology for the extraction of recoverable NAPL from and specifies the further works required to determine potential future options for monitoring and remediation of dissolved phase contaminants. In addition, it specifies the collection of site specific parameters to further inform the CSM and risk assessment. This RMS presents a phased remedial approach to treat gross contamination and NAPL, present as separated and measurable product and gross contamination and globules, ganglia and/or hydrocarbon sheen.

Initial NAPL and source extraction will commence utilising bottom loading pneumatic pumps to recover phase separated product, globules / ganglia and grossly contaminated groundwater. At the same time as the initial NAPL recovery operation, it is proposed to carry out additional boreholes into the Thanet Sand to enable targeted treatment of NAPL sources beyond the operation of bottom loading pumps to allow targeted injection of groundwater and/or in-situ treatment. Prior to the implementation of any form of treatment, additional hydrogeological assessment of the Thanet Sand will be conducted.

To assess the potential for future reagent injection into the Thanet Sand, this RMS proposes to investigate a number of reagents to assess the most effective in terms of cost and contaminant removal in the aquifer. The reagents trial will determine the most efficient and effective reagent for the specific contaminants present on site and the contaminant loading.

BAM Nuttall/WSP Remediation. MST-ENL-CK-03a-OLP-SP1-E-0208. CZ3a RMS Groundwater Addendum for Banner Area (NAPL in Thanet Sands No.2), September 2010 (ODA Ref.: 10/90231/AODODA)

This document develops the initial RMS Addendum remedial strategy for the extraction of recoverable NAPL from the Thanet Sand. It also provides an update of the CZ3a Thanet NAPL extraction works undertaken to date (Phase 1), and details transition from Phase 1 to Phase 2, and the design of the next phase of enhancement; recirculation of groundwater. This RMS presents the findings of the additional SI referred to previously and bases its design on this information. This RMS does not cover the remediation of dissolved phase contaminants within the Thanet Sand will be captured in a further RMS Addendum (No.3) which would be submitted following the collection, review and interpretation of on-going works and data.

Atkins. 0241-ENW-SPK-CM-REP-0001. CZ3a Banner Area SSRS Addendum No. 3 – Revision of Vertical Pathway SSAC December 2010 (ODA Ref.: 10/90616/AODODA)

This report relates to the CZ3a Banner SSRS. It follows discussions with the EA and PDT regarding the achievability of the SSAC considering downward migration of contamination from the RTD groundwater into the Thanet Sand aquifer. A discussion of this pathway was previously presented in CZ3a Banner SSRS Addendum No. 2 (REP-ATK-CM-03a-OLP-XXX-E-0004). As the Thanet Sand groundwater is considered to be in hydraulic continuity with the Chalk groundwater these SSAC address the risk of contamination migrating vertically from the RTD into the Thanet Sand and Chalk aquifers.

Acknowledging that the Thanet Sand and Chalk aquifer at the site have already been impacted it has been agreed with the EA and PDT that it is not practical to achieve SSAC derived on the basis of Drinking Water Standards (DWS). Therefore, the vertical pathway SSAC for the RTD groundwater has been revised, taking into account new recent chemical quality data, to provide more realistic, achievable criteria which will prevent any further deterioration of the quality of the Thanet Sand and Chalk groundwater.

The RTD groundwater quality in Banner was impacted by NAPL, dissolved phase organic and inorganic contamination. Following removal of unsaturated zone soils throughout the CZ3a Banner area and recovery of DNAPL, the RTD groundwater is considered to be the primary source of contamination in the CZ3a Banner area (please refer to RTD below).

Vertical migration of contaminants from the RTD groundwater has impacted the underlying Thanet Sand aquifer, presenting a potential risk to the Chalk aquifer and has also resulted in contamination migrating horizontally within the RTD itself beyond the boundaries of the CZ3a Banner area (please refer to the Southern Plume).

This addendum evaluates solely the vertical migration pathway to the Thanet Sand and the subsequent derivation of revised, more achievable SSAC. Major remediation activities have been undertaken since the preparation of the original SSRS including the complete removal of unsaturated soils, the partial removal of saturated soils, groundwater extraction and oxidative treatment. These activities have resulted in a significant reduction in contaminant mass in unsaturated and saturated soils and are expected to have also reduced the contaminant mass dissolved in groundwater.

Based on the data assessment, it is considered that there is no requirement for further remedial action. The remaining contaminant mass is considered to be present mainly as contaminants sorbed to the saturated RTD soils and as residual, unrecoverable DNAPL. Removal of the saturated RTD soils would be technically challenging and not cost effective. In addition, any such

action could result in the re-mobilisation of contamination which is currently immobile whilst sorbed to the RTD soils.

BAM Nuttall/WSP Remediation. MST-ENL-CK-03a-OLP-SP1-E-0233. CZ3a RMS Groundwater Addendum for Banner Area (NAPL in Thanet Sands No.3), February 2011(ODA Ref.: 10/90460/AODODA)

This RMS relates to the long term reduction in the concentrations (i.e. treatment) of dissolved phase chlorinated ethenes and associated breakdown products present in the Thanet Sand through the creation of conditions conducive to the stimulation and acceleration of the naturally occurring reductive dechlorination process (i.e. biodegradation) that may be taking place. This report also sets out the products to be injected into the Thanet Sand and the groundwater monitoring requirements post-injection.

BAM Nuttall/WSP Remediation. REP-ENL-CK-03a-OLP-SP1-E-0332. CZ3a Banner NAPL Extraction and Enhancement of the Thanet Sand Validation Report, August 2011 (ODA Ref.: 11/90411/AODODA)

The primary objective of this report is to confirm that the physical site works were undertaken and present the available monitoring results received at the time of reporting (i.e. two rounds of post-injection monitoring and ten months of post NAPL extraction monitoring). The final verification of the project objectives will be presented in an addendum to this verification report, which will be submitted following the completion of one year post Emulsified Vegetable Oil (EVO) injection monitoring and over 18 months of post NAPL extraction monitoring.

Verification monitoring has been completed for ten months post NAPL extraction and on two occasions to date since the completion of EVO injection in February 2011:

- To date, no NAPL has been recorded in any Thanet Sand (or RTD) monitoring wells post cessation of NAPL extraction.
- Monitoring of the EVO injection wells confirms elevated TOC concentrations within the injection area. Monitoring continues for a minimum of one year from the injections.
- Two rounds of wider plume monitoring have been conducted. Trends in longer term concentrations will be assessed following the receipt of further monitoring data.

BAM Nuttall/WSP Remediation. REP-ENL-CK-03a-OLP-SP1-E-0333. CZ3a Banner NAPL Extraction and Enhancement of the Thanet Sand Validation Report, February Addendum, February 2012 (ODA Ref.: 12/90107/AODODA)

This report details the remediation work that was undertaken in the CZ3a Banner Thanet sands, which involved the injection of Emulsified Vegetable Oil in 22 Thanet Sand boreholes in order to stimulate the natural degradation of chlorinated solvents within the Thanet Sand groundwater. .

Following EVO treatment a subsequent twelve months' worth of groundwater validation monitoring was carried out. These results were incorporated into the final CZ3a Thanet Sand validation report which confirmed::

- No DNAPL has been recorded in any Thanet Sand (or RTD) monitoring wells post cessation of NAPL extraction.

- Monitoring of the EVO injection wells confirms elevated Total Organic Carbon concentrations within five boreholes in the injection area. The remaining 17 wells show no significant increase in organic carbon concentrations
- Monitoring has confirmed the aquifer conditions continue to be strongly reducing within the Thanet Sand throughout the one year post injection monitoring based on field monitoring.
- Gene sequencing analysis shows that while species capable of reductive dechlorination are generally considered to be low to moderate in number, the most recent concentrations of Dehalobacter species are generally considered to be moderate. However, there are significant increases in methanogens, sulphate and iron reducers which is considered to be a function of the strongly reducing conditions.

In the wider plume monitoring elevated concentrations of parent compound chlorinated hydrocarbons have been identified in two Chalk monitoring locations on the western boundary of the site. No adverse concentration trend has been identified within the chlorinated hydrocarbon concentrations although the relatively low vinyl chloride concentrations in the majority of the Thanet Sand wells may be indicative of a stalling in the reductive dechlorination process.

On the basis of the results of the Thanet Sand and Chalk groundwater monitoring it has been decided to undertake a further twelve months' worth of monitoring across ten boreholes (six Thanet Sands and four chalk boreholes). In-situ monitoring in the form of water level, electrical conductivity, temperature, pH, dissolved oxygen, oxidation reduction potential will be undertaken in each of the boreholes. In addition, chemical testing for arsenic (total and dissolved), ammoniacal nitrogen, polycyclic aromatic hydrocarbons, volatile organic carbons, total organic carbon, dissolved methane and ethene will also be undertaken. In all cases the presence or absence of non-aqueous phase liquids (NAPL) will also be recorded.

This monitoring will be undertaken on a monthly basis for six months and then following a review of the data and further discussion with the regulator/PDT then monitoring may reduce to quarterly for the final two rounds. On the basis of these monitoring works the need for any further remedial works as required by the Regulator/PDT to fully discharge Condition 35 will be defined.

Radiological Issues

Atkins. REP-ATK-CM-06a-OLP-SP1-E-0003. CZ6a Remediation Change Note - Discovery of Radioactive Substances, November 2007 (ODA Ref.: 09/90048/AODODA)

This report presents a summary of the issues and consequences of finding of radioactive contamination within CZ6a and 6d (PDZ6). The purpose of this report was to present a summary of the occurrence, the evaluation of the potential impact this could have on the prevailing SSRs and to specify the methodology to be applied for its management, storage and appropriate disposal.

Atkins. REP-ATK-CM-03a-OLP-SP1-E-0001. Remediation Change Note for CZ3a, April 2008 (ODA Ref.: 07/90242/AODODA)

This report presents a summary of the issues and consequences of finding Very Low-Level and some Low Level Radioactive waste at CZ3a. The purpose of this report is to specify how it is intended that the remediation process will be amended to take into account the unexpected contamination. The contamination is in the form of contaminated wastes discovered in discrete patches across CZ3a, including broken pipes. No isolated hot-spots were discovered within CZ3a, but some radioactive artefacts were found and are recorded in the CZ6a Change Notice (see above).

BAM Nuttall. MST-ENL-CE-03a-OLP-SP1-E-0106. CZ3A Addendum (Radioactivity), June 2008 (ODA Ref.: 08/90127/AODODA)

Following the finds of unexpected radiological contamination arising from material excavated in CZ3a, BNL prepared this addendum to the RMS to cover radiological occurrences in the Main Stadium Area. The purpose of this report is to describe the process by which remediation of resulting from the unexpected radioactive materials and its verification at CZ3a will be undertaken, including the route the material will take from CZ3a to CZ6a (temporary holding area) to CZ4 (final deposition for exempt radiological materials), taking into account existing information of ground conditions gained from site investigations, risk assessment and monitoring, and to be consistent with the relevant planning approvals and related discussions.

In the instances in CZ3a where radioactively contaminated materials were not directly transported to CZ6, the radioactive materials were temporarily stockpiled (Stockpile reference CZ5a/S03) in CZ5a prior to onward transportation to CZ6 for assaying by Nuvia. These radioactively contaminated materials were subsequently determined for either deposition in CZ4 or for appropriate off-site disposal to an appropriately licensed facility. Following the removal of the stockpiled arisings from CZ5a, NUVIA conducted a clearance survey of the temporary stockpile area which recorded concentrations below the action limits.

The report also sets out the safety measure to be utilised such that where radiological materials were encountered these areas were demarcated and access prohibited to unauthorised personnel. Personal dosimetry and general sampling and metering were established within the Method Statement to protect staff involved in the works, other members of the workforce and the general public. The method statement also covered the establishment for the safe excavation and removal of the materials to the area authorised for accumulation of radioactive spoil, already established in the Olympic Park in PDZ6.

This report also confirms that the final location for the exempt material as being beneath the approach embankment to the L03B bridge abutment in CZ4. The non-exempt materials are

discussed below in the Remediation Change Note Addendum 0241-ENW-ATK-LET-00854. Reference should also be made to the CZ3a Unsaturated Validation report above, which details the radiological materials encountered.

Atkins. 0241-ENW-ATK-LET-00854. Remediation Change Note Addendum, May 2011 (ODA Ref.: 11/90386/AODODA)

The report sets out the identification, recording and controls put in place to appropriately manage and mitigate the risks associated with the presence of NORM found during the Enabling Works phase of the redevelopment. This report specifically refers to the appropriate disposal/deposition of these NORM wastes and thus the surrender of the Radioactive Substances Authorisation following the accumulation and storage on-site during the Enabling Works phase of works. The radionuclides identified dispersed in excavated spoils in discrete locations around the Olympic Park were determined to be 'exempt' under the relevant radioactive waste legislation. These materials were appropriately deposited in a specially constructed disposal cell beneath the approach embankment beneath the L03B bridge abutment in CZ4.

This addendum includes a report that updates the pre-deposition risk assessment (version 3) and assesses the as-built residual risk associated with the burial of radiological 'exempt' waste beneath L03B bridge abutment in CZ4. This radiological risk assessment determines the impacts of the deposition of this radiological impacted site derived arisings. The assessment addresses potential radiation exposures to current and future human health receptors, who will occupy the site. Whilst there are restrictions, the report concludes that the disposal cell is suitable for the deposition of NORM waste arisings from the redevelopment works.

In addition, this report also confirms the appropriate removal off-site of the four drums containing radioactive artefacts (non-exempt materials). These drums were individually assayed on-site prior to its transfer from the Olympic Park site on the 29th September 2010 by an appropriately licensed contractor for processing at the Winfrith facility in Dorset. The transfer was in accordance with the granted Environment Agency Radioactive Substances Authorisation [Ref.: CB9916/CE0419].

APPENDIX C:

Key Parties

Key Parties for PDZ3

Responsibility	Organisation
Client:	Olympic Delivery Authority (ODA)
Land owner:	Olympic Park Legacy Company (OPLC) (this was transferred from London Development Agency)
Local Planning Authority:	ODA Planning Decisions Team - PDT
Key Stakeholders:	British Waterways Environment Agency London Borough of Newham
Client's Project Manager:	Atkins
Designer:	Atkins
CDM Coordinator:	Arup
Enabling Works Tier 1 Contractor:	BAM Nuttall Limited (Nuttall)
Enabling Works Tier 1 Contractor Technical Adviser – Remediation:	Halcrow
Main soil treatment contractors (Tier 2 Contractor):	DEME Environmental Contractors (DEC)
Groundwater Monitoring – Enabling Works:	Nuttall
Groundwater Monitoring – Post Enabling Works:	WSP Environmental
Chemical Testing Laboratory:	TES Bretby (ESGL)
Geotechnical Testing Laboratory:	Environmental Services Group Limited (ESGL)
Groundwater remediation in PDZ3 (Tier 2 Contractor)	Erith/WSP Remediation
UXO Study:	BAE Systems
UXO Site Specialists:	MACC International

APPENDIX D:

Areas to be retained within PDZ3

APPENDIX E:

Permit to Proceed Protocol (CD only)

