



PLANNING AND ENVIRONMENT

Water Resources Strategy

Document Number: CR-PN-PRW-EN-SY-00002

Document History:

Version:	Date:	Drafted by:	Authorised by:	Reason for Revision:
1.0	12-01-2009	[REDACTED]	[REDACTED]	For issue
2.0	12-02-2009	[REDACTED]	[REDACTED]	Revised further to Environment Agency review

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Glossary

BWB	British Waterways Board
COSHH	Control of Substances Hazardous to Health
CLRL	Cross London Rail Links
ELReD	(Thames Water) East London Resource Development scheme
EMP	Environmental Management Plan
EMR	Environmental Minimum Requirements
EMS	Environmental Management System
ES	Environmental Statement

FRA	Flood Risk Assessment
PLA	Port of London Authority
PPG	(Environment Agency) Pollution Prevention Guide
PPS	Planning Policy Statement
SPZ	(groundwater) Source Protection Zone
STR	Specialist Technical Report
SuDS	Sustainable Drainage Systems
TBM	Tunnel boring machine

Learning Legacy

1 Introduction

Cross London Rail Links (CLRL) is working closely with the Environment Agency and other key stakeholders to help ensure the effective protection and management of water resources during the design, consenting and construction of Crossrail. In accordance with the Crossrail Act (2008), Environment Agency approval must be obtained for specified work likely to affect any surface or groundwater resources. Site specific water management plans are contained within the overall site environmental management plans (EMPs) for each construction site. These will present the working methods that will be implemented to help prevent impacts on surface and groundwater. Where risks to water resources are identified, mitigation measures will be implemented to avoid or minimise adverse effects.

This Water Resources Strategy provides an overview of the Crossrail scheme and the legislative background, the various documents and systems that are in place to help ensure the protection of water resources and the major water resources stakeholders and their remits during construction of Crossrail. It also highlights the key water resources issues and how these will be addressed throughout the construction process.

1.1 Project Description

Crossrail will provide a new rail route running from Maidenhead and Heathrow in the west through new twin-bore tunnels under Central London to Shenfield and Abbey Wood in the east. Its main objectives are to relieve congestion and the shortage of capacity on the existing network, to support London's role as a leading financial and commercial centre, and to help kick-start regeneration and renewal in several key geographical areas.

The project includes the construction of eight new underground Crossrail stations (seven in the central London section, and Woolwich on the south-east branch) and the upgrading of existing National Rail lines outside central London to provide interchange with London Underground, National Rail and local bus services. The Crossrail route is shown in **Figure 1.1**.

The main construction worksites will be associated with the tunnel portals at Royal Oak (west of Paddington), Pudding Mill Lane (west of Stratford), Victoria Dock (west of Custom House), North Woolwich (east of Silvertown) and Plumstead (east of Woolwich), tunnelling works at Limmo (Canning Town) and the seven new underground stations in the central area (at Paddington, Bond Street, Tottenham Court Road, Farringdon, Liverpool Street, Whitechapel and Isle of Dogs). Outside central London the main infrastructure changes are associated with a new train maintenance depot and stabling sidings at Old Oak Common and further stabling facilities at Maidenhead, Ilford, Gidea Park and Shenfield. Other significant works include the construction of a flyover structure at Stockley to allow Crossrail trains to access Heathrow, the provision of a rail underpass west of Acton Yard and the upgrading or renewal of existing stations including extensive improvements at Ealing Broadway, Romford, Abbey Wood and Custom House.



Figure 1.1: The Crossrail Route

1.2 Legislative Background

The Crossrail Hybrid Bill was introduced to the House of Commons on 22 February 2005. The Bill was accompanied by an Environmental Statement¹ (ES). The ES included an assessment of the likely significant impacts of the proposed scheme on water resources. Further information is presented in a Specialist Technical Report (STR): Assessment of Water Resource Impacts².

The Crossrail Act received Royal Assent in July 2008 and provides deemed planning permission to construct and operate Crossrail subject to various conditions and Protective Provisions set out within the Schedules of the Act. Following Royal Assent, the Department for Transport made an Order to appoint Cross London Rail Links (CLRL) as the Nominated Undertaker for the Crossrail works. The Order transfers the powers to gain the necessary consents and build the railway to CLRL. London Underground Ltd has also been appointed as Nominated Undertaker for certain works at Tottenham Court Road and Bond Street stations. For certain parts of the Crossrail infrastructure, CLRL is entering into agreements with others to take forward the construction works. These include Network Rail (in relation to the On Network sections of the route), Canary Wharf Group Contractors (Crossrail Ltd) (in relation to Isle of Dogs Station) and Berkeley Homes (in relation to Woolwich Station).

1.3 Purpose and Objectives

The Nominated Undertaker is required to comply with the Crossrail Environmental Minimum Requirements (EMR) in designing, and constructing Crossrail. The EMR set out environmental control measures that have been developed in consultation with Local Planning Authorities and other statutory bodies and comprise: General Principles, the Crossrail Construction Code, the Environmental Memorandum, the Planning and Heritage Memorandum, and the Register of Undertakings and Assurances.

¹ The Environmental Statement for Crossrail comprises the main Environmental Statement (volumes 1-9) and its Addendum submitted with the Crossrail Bill in February 2005, four Supplementary ESs (May 2005, January and November 2006 and May 2007) and four Additional Provision ESs (January, May and November 2006 and May 2007)

² Technical Report: Assessment of Water Resource Impacts, (February 2005). Mott MacDonald.

Section 7.1.2 of the Construction Code requires the Nominated Undertaker to, “...prepare a strategy for handling water resources issues in consultation with the Environment Agency...based on accepted industry practice. The process for agreeing the strategy will include liaison and consultation with key stakeholders.”

1.3.1 Purpose of the Water Resources Strategy

- To fulfil the requirement of the Construction Code to prepare a strategy for handling water resources.
- To set out the environmental management and regulatory regime with respect to water resources and clarify the roles and remits of the Nominated Undertaker and key stakeholders³ particularly in view of the disapplication of certain water resources legislation by the Crossrail Act.
- To provide an overview of the water resources issues identified in the ES and the how the arrangements and controls for managing these issues are being met during detailed design and construction of Crossrail.
- To ensure an integrated approach to water resources management for Crossrail.

1.3.2 Scope

The Water Resources Strategy covers the principal groundwater, surface water and flood risk issues identified as relevant to the Crossrail project, during detailed design, and construction.

The issues highlighted in this Strategy will be addressed in more detailed, site specific water management plans contained within EMPs for each construction site

³ More detail on the key stakeholders is provided in **Section 3**

2 Environmental Management and Regulatory Regime and Links to Consenting Process

The following section details various documents and systems that fall within the environmental management and regulatory framework for the Crossrail project and will help to ensure the consideration and protection of water resources throughout design and construction.

2.1 Regulatory Regime

The Crossrail Act received Royal Assent in July 2008 and provides the powers for the construction and operation of Crossrail. The Crossrail Act disapplies a number of existing legislative requirements, including the requirements for certain environmental consents. In place, Schedule 17 of the Act sets out the requirement for 'Protective Provisions'.

2.1.1 Disapplied Legislation

Table 2.1 lists key water resources legislation and related consents that are not applicable to the Crossrail project, which are covered by Schedule 17 Part 3 (see **Section 2.12 and 3.1 – 3.3**).

Table 2.1: Environmental consents relating to the water environment that are not applicable to Crossrail

Consent	Legislation
Licence for works in tidal waters	Coast Protection Act 1949
River Thames Works Licence	Port of London Act 1968
Ground water abstraction licence	Water Resources Act 1991
Licence to construct impounding works to rivers	Water Resources Act 1991 (as amended by the Water Act 2003)
Consent for works in, over, under or adjacent to main rivers	Water Resources Act 1991
Works affecting flow / structures in watercourses or navigation	Land Drainage Act 1991
Consent for depositing structures in or under tidal waters.	Food and Environment Protection Act 1985

Of particular relevance for water resources management, is that disapplied legislation includes the requirement for a licence from the Environment Agency to abstract water (from surface or groundwater sources) under Section 24 of the Water Resources Act 1991.

The construction of Crossrail will require some temporary abstraction for de-watering purposes that would normally be licensed. The requirement for an abstraction licence has been disapplied by paragraph 15 of Schedule 14 to the Act. This is because the Protective Provisions in Part 3 of Schedule 17 ensure that Environment Agency approval must be obtained for any specified

work done under the powers of the Crossrail Act likely to affect any surface or ground water resources (see **Section 3.1.1** for more detail).

Under Section 48A of the Water Resources Act, an abstraction could not normally be licensed that would result in derogation of an existing licensed abstraction, and abstractors are liable to prosecution if they fail to comply with the conditions of their licence thereby leading to derogation. However, it is accepted that abstractions required for Crossrail, for de-watering purposes may lead to derogation of existing licensed groundwater abstractors. Clause 55 of the Bill allows this but provides in consequence a right to compensation for an existing licensed abstractor who suffers loss or damage in consequence. The Environment Agency will consider the rights of existing abstraction licence holders when determining Schedule 17 consents for de-watering.

2.1.2 Consents and Approvals Required

The following environmental consents and approvals will be required for Crossrail:

- **Consents set out in Schedule 17 to the Crossrail Act (known as the ‘Protective Provisions’)**. Schedule 17 consents relate to three regulators, The Environment Agency, British Waterways and Port of London Authority. Further information regarding each of these organisations is provided in **Section 3** below. Schedule 17 consents required under the Crossrail Act will be applied for by the Nominated Undertaker.
- **Environmental consents in accordance with existing legislation that have not been disapplied by the Crossrail Act**. Schedule 2 of the Crossrail Act specifically addresses the discharge of water. It states that the Nominated Undertaker may use any watercourse for the drainage of water in connection with the construction or maintenance of the works authorised by the Act, although the Nominated Undertaker shall take such steps as are reasonably practicable to secure that any water discharged into a watercourse is as free as may be practicable from gravel, soil or other solid substance or oil or matter in suspension. However paragraph 8 (6) does not authorise the doing of anything prohibited by section 85(1), (2) or (3) of the Water Resources Act 1991. Fisheries byelaw consent (removing fish from rivers, streams, lakes, ponds) under Salmon and Freshwater Fisheries Act 1975 has also not been disapplied.
- **Other approvals that have been agreed with regulatory authorities as part of the project’s Undertakings and Assurances**. For example, the agreement between the Secretary of State for Transport and the Environment Agency in February 2008, covering the specific concerns of the Environment Agency (see **Section 3.1.3** for more detail).
- Consents will also be required from the relevant Statutory Undertaker for discharges to the sewerage system. Schedule 2 of the Crossrail Act states that the Nominated Undertaker may use any public sewer or drain for the drainage of water in connection with the construction or maintenance of the works. However it also states that the Nominated Undertaker shall not discharge any water into a public sewer or drain except with the consent of the person to whom it belongs; and such consent may be given subject to such terms and conditions as that person may reasonably impose but shall not be unreasonably withheld. Furthermore. The Nominated Undertaker shall not make any opening into any public sewer or drain except in accordance with plans approved by the person to whom the sewer or drain belongs.

2.2 Crossrail Environmental Requirements

In addition to the many controls provided through existing legislation and the Crossrail Act, there are a number of other controls applicable to the project that will support the protection of water resources. They are described below.

2.2.1 Environmental Memorandum

Within the EMR, Section 4.10 of the Environmental Memorandum sets out in further detail, the principles by which future environmental decisions will be taken with regard to water resources:

Wherever reasonably practicable, interference with surface water features and existing drainage patterns including important subterranean flows to wetland will be avoided.

Where surface features or existing drainage patterns must be interfered with, so far as is reasonably practicable:

- a) *necessary works will be positioned, designed and constructed to minimise impacts in terms of flow, minimise or manage flood risk, dewatering, water quality, erosion and/or sedimentation, resulting in adverse impacts on palaeoenvironmental, archaeological, ecological or landscape resources.*
- b) *continuity of surface flows will be maintained to mitigate environmental impacts, by means of stream diversions, creation of natural banks and features and where unavoidable, culverts.*
- c) *mitigation of ecological impacts will be provided for and consideration will also be given to enhance nature conservation benefits resulting from drainage works.*
- d) *compensation for loss of flood storage capacity will be provided on an equivalent basis within the limits of the land which can be acquired under the Crossrail Act.*

The use of sustainable drainage principles will be investigated and implemented in preference to other forms of drainage, where this is reasonably practicable and agreed by the relevant statutory undertaker.

2.2.2 Construction Code

Section 7 of the Construction Code sets out the measures to be undertaken to protect water resources during the construction of Crossrail.

2.2.3 Generic Documentation

The Water Strategy forms one of a number of generic documents that are intended to provide a common framework for dealing with environmental issues across the project. The following are of relevance to the Water Resources Strategy:

- **Generic Land Activities Contamination Report:** this report sets out how sites within 250m of the Crossrail route alignment identified as being a potential source of contamination, will be considered. For sites classified as high or medium risk with more complex issues (Category One), Phase 1 Assessment Reports will be produced and site specific intrusive investigations will be undertaken as part of the construction planning process. The report identifies Category One worksites where surface or groundwater receptors are at risk of pollution from contaminated land. For low risk sites (Category Two) the generic provisions detailed within the report will apply.
- **Generic Archaeological Written Scheme of Investigation:** this will consider archaeology in relation to the water environment.

- **General Ecological Management Plan:** this sets out general ecological measures to be implemented across the Crossrail project, including aquatic ecology issues.

2.2.4 Environmental Management Plans

As required by Section 2.4 of the Construction Code, Environmental Management Plans (EMPs) for each worksite set out how the project will deliver the environmental requirements and how environmental issues that arise will be handled to help ensure compliance with relevant legislation. Section 7.1.3 includes a requirement for water management plans that list specific receptors in the water environment and take account of relevant Environment Agency Pollution Prevention Guides (PPGs) and CIRIA guidelines to set out how potential impacts on the receptors will be avoided or mitigated. Water Management Plans take account of the requirements of the Environmental Memorandum and the Construction Code.

Section 5 of the Environmental Memorandum identifies particular Crossrail worksites as being environmentally sensitive. For each of these sites, the EMP contains more detail focusing on mitigation, compensation and monitoring requirements and opportunities for enhancement in relation to the identified environmental topics as outlined in Table 5.1 of the Environmental Memorandum.

These sites were identified through consultation with statutory agencies and are sites where a significant impact is predicted or where there are particular environmental concerns. The worksites that have been identified as being environmentally sensitive due to water resources issues are set out in **Table 2.2** below.

Table 2.2: Environmentally Sensitive Worksites identified for Water Resources

Location	Consultees
Horton Brook/Land South of Grand Union Canal	Natural England, Environment Agency
Stockley Ponds	GLA Biodiversity Unit, Environment Agency
Isle of Dogs	GLA Biodiversity Unit, Environment Agency, British Waterways
Pudding Mill Lane	GLA Biodiversity Unit, Environment Agency, British Waterways
Limmo Peninsula (including Instone Wharf)	Environment Agency, Port of London Authority
Belvedere (River Thames and access road)	Environment Agency, Port of London Authority

Source: Annexe 3: Crossrail Environmental Memorandum Table 5.1

The Construction Code requires the production of contingency plans for major incidents, which will be included in the EMPs for each worksite. These contingency plans include measures in response to incidents such as contaminants entering a watercourse, sewer or drain. The contingency plans will be informed by Environment Agency pollution incident response planning guidance.

As required by the Construction Code, all EMPs will be discussed with relevant qualifying local planning authorities. In addition, for sensitive sites, the key consultees set out in **Table 2.2** above will also be consulted.

2.3 Environmental Management System

The requirements for an Environmental Management System (EMS) are set out in Section 2.2 of the Construction Code and Section 3.5 and Appendix 1 of the Environmental Memorandum. As Nominated Undertakers, both Cross London Rail Links and London Underground have developed Environmental Management Systems which are consistent with the principles of BS EN ISO 14001 for the project and which comply with the requirements of the Construction Code and Environmental Memorandum. The purpose of the EMS is to help ensure compliance with environmental legislation, environmental provisions in the Crossrail Act, the Environmental Policy of the Nominated Undertaker, and the Environmental Minimum Requirements.

2.3.1 Environmental management during construction

The main construction contractors will be required to have an EMS which is consistent with the principles of BS EN ISO 14001. The contractors EMS will support and comply with the Nominated Undertaker's EMS.

The contracts awarded for Crossrail enabling and main construction works will include a requirement on the contractor to comply with the relevant Environmental Management Plan (including the Water Management Plan) for each worksite. Contractors will also be required to comply with all relevant environmental legislation and to take account of published standards, accepted industry practice, national guidelines and codes of practice appropriate to Crossrail. For the duration of the contract the Nominated Undertaker will monitor the environmental performance of the contractor through site inspections and audits.

The contractor will operate an induction scheme to ensure all employees are aware of their environmental responsibilities, to identify training needs for personnel and to provide appropriate training. The training will include toolbox talks for site operatives to maintain an appropriate level of awareness of environmental issues.

3 Crossrail Key stakeholders

Key stakeholders for the purpose of this report, include those who either have a regulatory role or own or operate assets that will be affected by the construction of Crossrail.

The principal regulator is the Environment Agency but there are specific worksites where the British Waterways Board and the Port of London Authority also act as regulators.

Thames Water is the water supply and sewerage undertaker over the majority of the route and as such is a major stakeholder. Other water companies such as South East Water, Three Valleys Water, Essex and Suffolk Water and Anglian Water Services are considered as minor stakeholders.

Further information on the key stakeholders and their remits is set out in the following section.

3.1 Environment Agency

3.1.1 Schedule 17 Consents

Part 3 of Schedule 17 of the Crossrail Act sets out where consents are required from the Environment Agency with respect to water resources.

Consents are required for any specified works likely to:

- a) Affect any drainage work or the volumetric rate of flow of water in or flowing to or from any drainage work;
- b) Affect the flow, purity or quality of water in any watercourse or other surface waters or groundwater;
- c) Cause obstruction to the free passage of fish or damage to any fishery; or
- d) Affect the conservation, distribution or use of water resources;”

In the Environment Agency’s consultation with CLRL over applications being made under Schedule 17 (Part 3), the Environment Agency will also have regard to its wider recreational and environmental responsibilities.

The Environment Agency is also responsible for issuing consents to modify cross drainage structures under the surface railways, for any construction (principally tunnelling and portals) within 16 m of any of the Thames tideway flood defences and 8 m of any other main or ordinary watercourse.

The Environment Agency’s approval under Part 3 of Schedule 17 will be sought for abstractions for dewatering. As part of the consent application process the Nominated Undertaker will seek to reach agreements with existing abstraction licence holders who may be affected by any dewatering activities on the Crossrail project. The Environment Agency will give consideration to the rights of existing abstractors when determining applications under the Protective Provisions.

The Environment Agency’s approval under Part 3 of Schedule 17 will also be sought for works on the flood plain that affect flood storage.

3.1.2 Other Consents

The requirement for consent to discharge to controlled waters under the Water Resources Act 1991/Groundwater Regulations has not been disapplied by the Crossrail Act. The Environment Agency will therefore continue to be responsible for issuing consents for discharge activities.

However, the Environment Agency has agreed that where discharges represent a low environmental risk, they could be dealt with via Schedule 17 Part 3 consent or an agreed, local pollution control/monitoring plan. The decision whether to apply for a discharge consent under the Water Resources Act will depend on the potential risk to the environment as assessed by the Nominated Undertaker and agreed by the Environment Agency, and the duration of the discharge. Furthermore, in some cases the duration of the discharge would be shorter than the time required for completion of the consent application and determination process. In these cases, or where risk is assessed to be low, discussions will take place with the Environment Agency well in advance of the point at which an application would need to be submitted, to seek an agreed approach and terms.

In addition to planned discharges, there may be occasions where there are minor, unexpected discharges due, for example, to heavy rainfall events or as a result of the emergency use of water for fire control during construction.

The Nominated Undertaker will work with the Environment Agency to ensure a consistent, agreed approach to dealing with unexpected discharges.

3.1.3 Requirements of Agreement between Environment Agency and Secretary of State for Transport

The Environment Agency petitioned on various aspects of the Crossrail Bill and in order to address specific concerns an Agreement was negotiated and signed by the Secretary of State for Transport and the Environment Agency on 4th February 2008. The agreement sets out the requirement and arrangements for, approvals relating to the following issues:

- Thames Tidal Flood Risk at portals, shafts and stations;
- Flood protection at Pudding Mill Lane during construction in the River Lea;
- Survey, assessment and monitoring of drainage works structures in relation to settlement;
- Methodology for emergency dredging;
- Flood compensation storage at the Isle of Dogs.

Further details are provided in Section 4.

3.1.3.1 Consultation

In accordance with the terms of the above Agreement, the Nominated Undertaker will consult the Environment Agency as far in advance of the submissions as set out above as is reasonably practicable and appropriate in the circumstances of each case. The Nominated Undertaker will make available, and update from time to time, a proposed programme with respect to the making of requests for approval from the Environment Agency. Regular liaison meetings are held to meet these requirements.

In undertaking consultation, the Nominated Undertaker will have regard to the Environment Agency's wider environmental and recreational responsibilities.

3.1.4 Arrangements under Schedule 7 to the Crossrail Act 2008

Schedule 7 to the Crossrail Act sets out the arrangements relating to Planning Conditions. The Environment Agency is a statutory consultee for any submission under Schedule 7 which is

relevant to matters set out in paragraph 27 (1) of Schedule 7⁴. Subject to the approval of Local Planning Authorities, the nominated undertaker will, when making submissions under Schedule 7, distribute copies directly to the Environment Agency. In other cases, the relevant planning authority will undertake consultation directly with the Environment Agency as provided for in Schedule 7, paragraph 27(1).

3.2 British Waterways Board

Under Schedule 17 (Part 5) of the Crossrail Act, consents are required from the British Waterways Board (BWB) for work sites beside or in the Grand Union Canal, West India Dock North, Lea Navigation and City Mill River. In addition, consents are required for tunnelling beneath the Regent's Canal and for works in the docks in the Isle of Dogs and Royal Docks.

Discharges to 'inland freshwaters' must be authorised by the Environment Agency, under the Water Resources Act 1991. However, in certain cases (for example at the Isle of Dogs) the British Waterways Board are the site owners and hence their consent will also be required for temporary discharges to a canal.

3.2.1 Requirements of Agreement between BWB and Secretary of State for Transport

An agreement between BWB and the Secretary of State for Transport was signed in October 2008 that regulates the powers of the Crossrail Act in relation to property owned by BWB.

The Agreement sets out a number of requirements. Those of relevance to this Strategy are that:

- The Nominated Undertaker is required to use its best endeavours to avoid adversely affecting the structure of BWB's waterways;
- The Nominated Undertaker is required to avoid adversely affecting the operation of BWB's waterways and any associated maintenance equipment so far as is reasonably practicable

There are also further site specific agreements that set out requirements and undertakings in relation to the River Lea, Grand Union Canal, Limehouse Basin, West India Dock, City Mill River and Pudding Mill Lane.

3.2.1.1 Consultation

In accordance with the terms of the above Agreement, the Nominated Undertaker will consult BWB as far in advance of submission of plans under Paragraph 3 of Part 5 of Schedule 17 of the Act as is reasonably practicable in the circumstances of each case.

3.3 Port of London Authority

Under Schedule 17 (Part 6) consents will be required from the Port of London Authority at the following locations to enable dredging, gravel removal and geotechnical investigations to be undertaken.

- Limmo Peninsula shaft and Instone Wharf;
- Victoria Dock Portal and Connaught Tunnel;

⁴ (a) the conservation of the natural beauty or amenity of inland or coastal waters or land associated with such waters;

(b) the conservation of flora or fauna which are dependent on an aquatic environment;

(c) the use of such waters or land for recreational purposes.

- North Woolwich Portal and Thames Tunnel.

The Port of London Authority will also be consulted on dredging the Thames Estuary and its tributaries. The consultation will include monitoring and maintenance requirements.

Licences from the Port of London Authority to moor or operate barges will be required at Instone Wharf and Manor Wharf and for operation in the Thames Estuary.

3.4 Thames Water Utilities Ltd

Part 2 of Schedule 17 sets out the Protective Provisions for water supply and sewerage undertakers (amongst other utility companies) including the general principle that any apparatus (including mains, pipes, sewers, drains, outfalls, manholes, ventilating shafts and pumps) is not to be moved until replacement apparatus has been provided and is in operation.

Thames Water Utilities Ltd is the water supply and sewerage undertaker along most of the Crossrail route including all the major station, portal, shaft and tunnel construction sites. Other water companies including Three Valleys Water, Essex and Suffolk Water, South East Water and Anglian Water have a water supply only role in parts of the surface rail system route where no planned dewatering activities will be taking place and hence no impacts on groundwater sources are anticipated.

It is expected that water companies will have several interfaces in relation to water resource impacts during the design and construction of Crossrail. These are described further below.

- The relevant water company will be requested to provide a supply of water to construction sites during construction.
- Permits or consents will be required from Thames Water, as the sewerage undertaker, for temporary to surface drains or combined sewers to receive general construction site run-off and drainage (including from tunnelling operations at a number of sites) and discharges from dewatering activities. The EMR requires that site drainage, including surface run-off and dewatering effluents will be discharged to sewers where reasonably practicable. Consequently it is anticipated that a large number of permits will be issued to use the sewerage system for site drainage. Thames Water has stated it will monitor construction site drainage to their assets and will need access to the sites to undertake this monitoring. This requirement has been incorporated into the Construction Code. Where there is an increase in the area of hardstanding, peak flow rates of surface water drainage to sewers may increase. Although Sustainable Drainage Systems (SuDS) principles are unlikely to be appropriate in heavily built up areas, the drainage design will aim, where reasonably practicable, to avoid an increase in key flow rates to the combined sewer system and as part of the construction planning process, the Nominated Undertaker will seek to ensure as far as reasonably practicable the provision of sufficient on-site water storage/attenuation facilities.
- The Nominated Undertaker will work with Thames Water to ensure a consistent, agreed approach to dealing with unexpected discharges.
- It is anticipated that, in the event of loss of an existing groundwater supply as a result of dewatering for Crossrail, Thames Water will be requested to supply supplementary water to the abstraction licence owner as compensation. To facilitate this, Thames Water will be supplied with a list of abstractions that could be affected and the potential additional demand that they could face as a result.
- Prior to any dewatering taking place, Thames Water will be consulted about the need to monitor existing groundwater sources during the dewatering process. This will enable the Nominated Undertaker to monitor drawdown and groundwater quality to determine if

any adverse impacts occur. Although impacts are considered unlikely, a programme of monitoring of both water quality and groundwater levels may be required at certain sources where the alignment passes near to or across the inner or outer groundwater source protection zone (SPZ)⁵ or equivalent time of travel zone.

- Permits/consents will be required from Thames Water for permanent discharges of runoff into the sewer system at tunnel and portal drainage pump stations, station and shaft structures, train washing and servicing depot facilities and any track drains that connect to the Thames Water network.

3.5 Well Owners

An assessment of the effect of Crossrail de-watering activities on existing groundwater abstractions from the deep Chalk aquifer has been undertaken by Mott MacDonald⁶ (see **Section 4.1.3**). The assessment was based on simulating the drawdown as a result of dewatering activities using the London Basin Groundwater Model (a model used by Thames Water to manage groundwater resources within the London Basin). As a result, 21 abstraction licence holders have been identified as likely to incur an additional drawdown of 2m or more as a result of Crossrail dewatering of the deep Chalk aquifer. However, it is not anticipated that this will result in derogation in the majority of cases.

Consultation with well owners was undertaken in 2005 and again following an update of the London Basin Groundwater Model in 2008. Where appropriate, consultation continues.

⁵ As defined by the Environment Agency for groundwater sources such as boreholes used for public water supply; to reflect the risk of contamination from any activities that might cause pollution in the area. The closer the activity, the greater the risk. Maps have been produced showing three zones of risk around each groundwater source (inner, outer and total catchment).

⁶ Mitigation for Well Owners, CR-PN-PRW-CN-RT-00001, Rev. 4.0

4 Water Resources Issues

The following water resources issues have been identified through the initial EIA process as requiring consideration prior to and during detailed design, consenting and construction of Crossrail.

4.1 Groundwater

4.1.1 Overview

The geology encountered along the Crossrail Line 1 alignment between Royal Oak, Pudding Mill Lane and Plumstead Portals is shown in **Figure 4.1**. The generalised geological succession along the Crossrail route is summarised in **Table 4.1** along with a summary of the typical nature of each of the strata.

Table 4.1 Geological succession along the Crossrail route

Period	Series	Deposits	Typical Characteristics
Quaternary	Holocene	Made Ground	Highly variable in composition and thickness. Normally a mixture of locally derived geology and remnants of human industrial activity.
		Alluvium	Predominantly clay with layers of sand and peat.
	Pleistocene	Langley Silt	Formerly known as Brickearth. Sandy or clayey silt.
		River Terrace Deposits	Predominantly sand and/or gravel.
Palaeogene	Eocene	London Clay Formation	Dark blue or brown clay.
		Harwich Formation	Highly variable in composition and thickness and encountered as sandy clay, fine sand or flint pebble gravel.
	Palaeocene	Lambeth Group	Upper portion (Woolwich and Reading formations) comprises predominantly clays with layers of fine sand, shells and limestones. Lower portion (Upnor Formation) comprises clayey silty sands with layers of flint gravel and clay.
		Thanet Sand Formation	Grey fine sand
Cretaceous	Upper Cretaceous	Chalk Group	Weak limestone with flint nodules

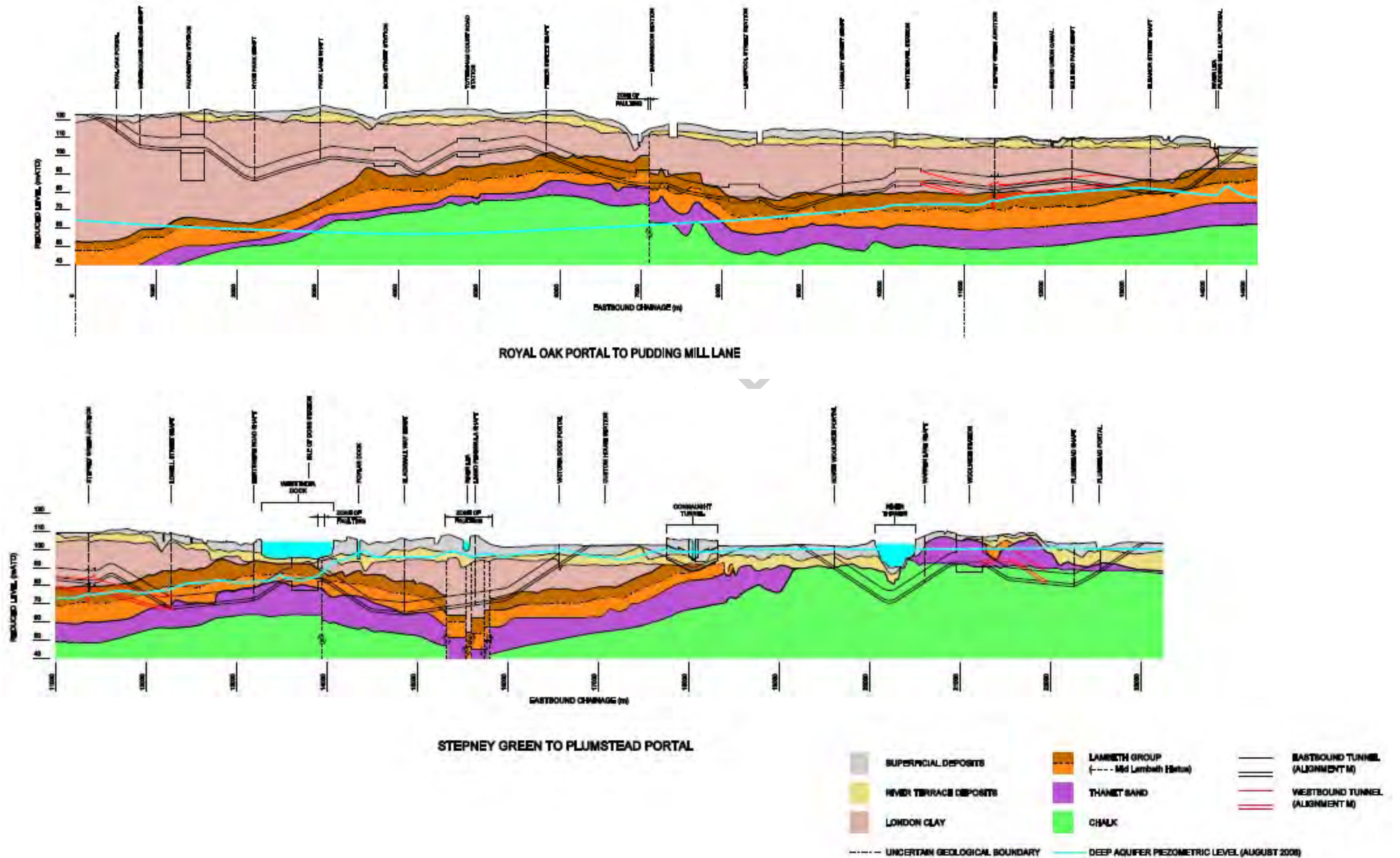
A geological long section for the whole of the central tunnelled section is shown in **Figure 4.1**.

The hydrogeological regime consists of a deep aquifer and a variable shallow aquifer. The deep aquifer comprises the Chalk and the basal sands (a historic and collective term for the Thanet Sand Formation and the Upnor Formation of the Lambeth Group). The shallow aquifer comprises the River Terrace Deposits. In central London the two aquifers are separated by an aquiclude consisting of the low permeability units of the Lambeth Group and the overlying London Clay Formation. The London Clay and Lambeth Group thin east of Stepney Green due to uplift and erosion which allows the two aquifers to become increasingly connected. East of the Connaught Tunnel the aquiclude is completely removed resulting in one continuous aquifer. The Crossrail Route crosses the River Thames at Woolwich where the Chalk is encountered directly beneath the River Terrace Deposits. Tidal effects can be detected in the groundwater for significant distances from the river. The actual distance depends on both the geology and the geomorphology.

Localised shallow perched water tables may be present above low permeability layers within the superficial deposits. Additionally sand and gravel layers within the Lambeth Group and the discontinuous Harwich Formation can be water bearing. Where these deposits are laterally extensive, the higher permeabilities may lead to substantial flows into excavations.

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Figure 4.1: Geology of the central section of the Crossrail route



4.1.2 De-watering

Dewatering from the deep aquifer will only be required where deep excavation is proposed in the Chalk, Thanet Sand Formation or Upnor Formation. De-watering of the deep Chalk aquifer will therefore be required during construction of the Lowell Street, Hertsmere Road, Blackwall Way, Limmo, Warren Lane and Eleanor Street Shafts, the Isle of Dogs and Woolwich Stations and the Thames Tunnel portals at North Woolwich and Plumstead.

In particular, Limmo shaft is a tunnel boring machine launch chamber for tunnel drives towards both Farringdon and Victoria Dock Portal. Owing to the size and depth of the shaft required at Limmo, significant dewatering of the deep aquifer will be necessary at this worksite.

The route from Paddington to Stepney Green and then to Pudding Mill Lane is constructed predominantly in the low permeability London Clay and Lambeth Group. Localised and limited de-watering may be required at Stepney Green and Eleanor Street shafts to stabilise the granular units of the Lambeth Group and the Harwich Formation.

All structures along the route between Stepney Green and Plumstead Portal will require de-watering because:

- a) A combination of uplift and erosion results in the deep aquifer being encountered much closer to the ground surface; and
- b) East of Connaught Tunnel the aquiclude is missing completely. It is currently proposed that dewatering for the three portals (Victoria Dock, North Woolwich and Plumstead) will be localised and confined to the River Terrace Deposits.

Table 4.2 shows the anticipated de-watering requirements across the route.

Table 4.2 Dewatering requirements

Location	Base of structure (mATD)	Geology	Chalk Group groundwater levels (mATD)	Conclusion	Dewatering of deep aquifer required?
Farringdon		London Clay and Lambeth Group		Limited dewatering of the Lambeth Group	No
Liverpool St Station	71.3 at Blomfield Box with connecting adit at 64	London Clay and Lambeth Group	67 (2006) 75 assumed by 2010.	Tunnels constructed in London Clay and Lambeth Group with minimal risk of high water pressures from deep aquifer	Direct de-watering of Thanet Sands possible. Assume 5l/s.
Stepney Green Shaft	79 and 71.5	Sand layer at base of London Clay with thickness 5.7-1.3m.	77 (2006) Middle Aquifer (sand layer) – water level.	Temporary dewatering of sand layer would be required unless groundwater can be controlled by grouting. Possibly some depressurisation of Thanet Sands or dewatering from the deep aquifer if under-drainage can be implemented.	Possibly to around 68 mATD
Eleanor Street Shaft	72	Base London Clay 80.8 Base Lambeth Group 62.7	77 (2007)	Shaft approx 8-10m above top of Thanet Sands, risk of high groundwater pressures from deep aquifer.	Yes, to approx 70 mATD

Location	Base of structure (mATD)	Geology	Chalk Group groundwater levels (mATD)	Conclusion	Dewatering of deep aquifer required?
Pudding Mill Lane Portal	91.5 (u/s base slab)	Top London Clay 101.95 Top Lambeth Group 89.15 Top Thanet Sands 75.28	85 (2007)	Base shaft in upper part of Lambeth Group. Further site investigations required to confirm if dewatering required although the current data suggests that only a small water level reduction would be required.	No
Lowell St Shaft	62	Base London Clay 88 Base Lambeth Group 71	77 (2007)	Top of shaft box in Lambeth Group, base in Thanet Sands, Chalk Group water levels above base.	Yes to approx 60 mATD
Hertsmere Road Shaft	72	Top Lambeth Group 92.5 Top Thanet Sands 79 Top Chalk Group 64	77 (2007)	Base of structure in Thanet Sands, Chalk Group water levels above base.	Yes, to approx 68 mATD
Isle of Dogs Station	65.3	Base Lambeth Group 74.3 – 81 Base Thanet Sands 61-65.5	90 (2007)	Base of station box would be in Thanet Sand Formation and Lambeth Group in the east.	Yes to approx 60-65 mATD
Blackwall Way Vent Shaft	55	Base London Clay 84.1 Top Thanet Sands 67 Top of Chalk Group 44	90-95 (2003)	Base of shaft within Thanet Sands level. Risk of base heave and seepage due to high water levels.	Yes to approx 61 mATD
Limmo Peninsula Vent Shaft	64	Base London Clay 65 and 58	95 (2007)	Base of shaft close to base of Lambeth Group. Top of Thanet Sands may be no more than 17m below excavation level. Risk of base heave or seepage due to high water levels.	Yes to approx 61 mATD
North Woolwich Portal	Track level approx 82.5 or 85	Superficial deposits overlying Chalk Group	100 (2007)	Base of structure uncertain, however high groundwater levels make it likely that some limited dewatering would be required inside the side walls	Yes some during construction of base slab

Location	Base of structure (mATD)	Geology	Chalk Group groundwater levels (mATD)	Conclusion	Dewatering of deep aquifer required?
Woolwich Station	90	Superficial deposits overlying Lambeth Group (may not be present), Thanet Sands and Chalk Group.	100-105 (2003)	Groundwater levels well above base of station but some dewatering will possibly be required within station box. Risk of base heave or seepage.	Yes to approx 88 mATD
Plumstead Portal	90	Thanet Sands sub crop below River Terrace Deposits	100 to 105 (2003)	Portal constructed within deep aquifer, below groundwater level. Would only be minor and short term before construction of the base slab between the diaphragm walls.	Yes, some during construction of base slab.

Notes:

Groundwater levels based on Crossrail ground investigations data where available.

Actual levels could be different at time of construction.

4.1.3 Effects of de-watering activities on existing well owners

An assessment of the effect of dewatering (based on current designs) on groundwater levels in the deep Chalk aquifer has been undertaken⁷, using the London Basin Groundwater Model. This has focused on the tunnelled route section from Westbourne Grove to Pudding Mill Land and from Stepney Green to Plumstead Portal.

A worst case scenario was simulated using the model, assuming that dewatering will begin at all sites simultaneously and at the same rate, so that the greatest effect would occur after approximately 6 months when maximum dewatering will be taking place at all sites. However, as early starts are planned at some sites it is possible that the total maximum dewatering rate will be lower and hence the predicted effects are considered conservative.

It has been assumed that a drawdown of less than 2 m at an existing abstraction borehole is insignificant, given the changes in water levels that have occurred historically and the normal design practice of setting well casing to the base of the Thanet Sand Formation and setting pumps with a large margin of headroom below current dynamic water levels. These considerations result in a very low likelihood of a pump running dry or having a significant reduction in output if an additional drawdown of less than 2 m is imposed.

Details of all licensed groundwater abstractions or protected rights within the modelled 2m or greater drawdown contour have been obtained from the Environment Agency and Local Authorities, and the potential for derogation considered. There are 21 abstractions within the 2m drawdown contour derived from the simulations and it is anticipated that the majority of the abstraction licence holders will not experience derogation as a result of Crossrail dewatering.

Monitoring of groundwater levels during the period of dewatering will be undertaken at appropriate locations to verify that the modelled impact of Crossrail dewatering on drawdown is

⁷ Mitigation For Well Owners, CR-PN-PRW-CN-RT-00001, Rev.4.0

comparable with the observed situation. This will then confirm the predicted drawdown for each of the abstraction boreholes within the 2m drawdown contour and the likelihood of derogation and need for mitigation. Consultation with the well owners to confirm whether derogation could occur will also be undertaken.

As dewatering could additionally result in adverse effects on groundwater quality, various water quality parameters will also be monitored during the period of dewatering.

If groundwater monitoring identifies that abstractors are likely to experience a loss of supply due to Crossrail dewatering, as a result of drawdown or changes in water quality (which affect their ability to use the water for the required purpose) appropriate mitigation measures will be implemented, including the provision of alternative supplies.

4.1.4 Risk of groundwater pollution

The construction of Crossrail is unlikely to result in groundwater pollution as appropriate mitigation measures will be designed and implemented to minimise or avoid the risk. The Construction Code specifies avoiding the use of materials that could pollute groundwater, including special consideration of the use of substances contained within List I and II of the Groundwater Regulations 1998. However, where this is not practicable, contractors will be required to implement good site practices to avoid spills which result in contamination of the shallow aquifer.

The vertical alignment of the bored tunnels passes through both the upper and lower aquifers. Within the Lambeth Group strata, seams of saturated ground or perched water may be encountered which may be directly connected to the aquifers. The Thames Tunnel bores pass through the Upper and Lower Chalk below the lower aquifer. Additional intrusion into the Chalk will arise because of dewatering for construction of stations, shafts and portals to the eastern section of the Central Route. However, the proximity of these locations to the River Thames will lessen the impact.

Careful selection and monitoring of fluids used in the shaft sinking and tunnelling process will help ensure the risk of direct contamination of the deep aquifer is minimal, thereby protecting the quality of existing groundwater abstractions from the deep aquifer. The fluid additives used in the tunnelling process are typically foams and polymers, classed as biodegradable and non-hazardous. The design of shaft structure foundations and the tunnel linings and the specification for the tunnelling process will ensure the risk of connectivity between the upper and lower aquifers is low.

Following erection of the pre-cast concrete tunnel lining behind the tunnel boring machine (TBM) the annulus between the cut ground and the extrados of the lining will be filled with a cementitious grout to seal off any risk of connection between aquifers.

Where the route alignment passes through groundwater source protection zones (SPZ), further site investigation and appropriate foundation designs will avoid the permanent works creating potential pollution pathways between the shallow and deep aquifers. This mainly affects areas where the surface rail passes through the SPZ for Thames Water's ELRED sources and South East Water's Maidenhead source.

The Nominated Undertaker will ensure the adoption of good practice measures as well as those specified in the Construction Code by making their implementation a condition of the contract for construction. Contractors will be audited and approved by CLRL to ensure they incorporate the measures specified where appropriate.

4.2 Surface Water

4.2.1 Overview

The western section of the Crossrail route utilises the existing Great Western over-ground track from Maidenhead to Royal Oak Portal; just west of Paddington Station. This section of the route crosses a number of surface water courses including the River Thames, River Brent, River Crane, Fray's River, River Colne and Maidenhead Ditch. From the point where the route heads underground through central London, there are very few surface water courses (many of London's rivers have become subsurface culverts or sewers that have been incorporated into Thames Water's sewerage network). However, the Grand Union Canal which runs roughly adjacent to the Crossrail route from Slough to Hanwell stations, also closely follows the route from Royal Oak Portal to Paddington Station.

The Thames Estuary is the main surface watercourse within the central route area (to the East of central London). As the route splits to the east of Whitechapel Station, the north east section passes beneath Regents Canal and the River Lea before surfacing at Pudding Mill Portal where the route then crosses the Bow Back Rivers System (which includes City Mill River, Pudding Mill River, Bow Back River and Waterworks River between Bow Portal and Stratford Station), and the main rivers Roding, Rom and Ingrebourne (which are all tributaries of the Thames Estuary). The underground south-east section also passes beneath Regents Canal and the River Lea (Limehouse Cut) and then surfaces temporarily at West India Dock North by the Isle of Dogs Station and finally at Victoria Dock portal (but passes under Royal Albert Dock through Connaught Tunnel and the Thames Estuary through the Thames tunnel). In addition, Great Breach Dyke, Butts Canal, Horse Head Dyke and Corinthian Dyke form part of a network of pumped surface drains crosscut by ditches and sewers, known as the Marsh Dykes, located between a point east of Plumstead station and Slade Green Station to the south of the Thames.

Impacts on all watercourses within 500m of the route alignment and 1000m of stations have been assessed as part of the EIA.

4.2.2 Risk of surface water pollution

Potential sources of pollution to surface water features across the route include direct spills/leaks of contaminants, drainage/run-off from worksites, and discharges from de-watering of contaminated groundwater.

Schedule 2 of the Crossrail Act sets out specific provisions with respect to discharges and states that the Nominated Undertaker may use any watercourse for the drainage of water in connection with the construction or maintenance of the works; and may make connections with the watercourse. However, it also specifies that the Nominated Undertaker shall take such steps as are reasonably practicable to secure that any water discharged to a watercourse is as free as may be practicable from gravel, soil or other solid substance or oil or matter in suspension.

The Construction Code specifies measures that should be taken to control the risk of pollution to surface waters. These include the application of industry standard guidance such as the Environment Agency's Pollution Prevention Guidance Note (PPG) 5 (23 as was): Works and maintenance in or near water and PPG13: Vehicle washing and cleaning. Measures also include the protection of erodible earthwork surfaces, instructions for the storage of contaminating substances on site and the use of drip trays or impermeable surfaces during refuelling, oiling and greasing.

The Nominated Undertaker will ensure the adoption of the measures specified in the Construction Code by making their implementation a condition of the contract for construction.

Contractors will be audited and approved by the Nominated Undertaker to ensure they incorporate the measures specified in the Construction Code where appropriate.

De-watering effluent is expected to be discharged to a watercourse from the Lowell Street, Hertsmere Road, Isle of Dogs, Connaught Tunnel and Pudding Mill Lane Portal worksites. The Crossrail Act does not disapply the Water Resources Act 1991 which requires that any discharge to a surface water course must be consented by the Environment Agency (Schedule 2 of the Act does not authorise anything prohibited by the Water Resources Act with respect to discharges). The Environment Agency will issue discharge consents with conditions that serve to regulate the quality of the discharge and thereby prevent unacceptable levels of pollution. In cases where dewatering effluent will be discharged to water bodies owned by BW, consent from BW will also be required.

4.3 Flood Risk

4.3.1 Risk of groundwater flooding

The ES describes how some of the longer station boxes or piled ramps could act as a partial barrier to groundwater flow in the shallow aquifer and potentially increase the risk of localised groundwater flooding in the basements of buildings due to a build up of groundwater. Further information is presented in the Assessment of Water Impacts Technical Report (2005). Taking into account the calculations presented in Appendix E of that Technical Report as well as subsequent design developments, significant increases (0.5 – 1.0m) in groundwater level in the Upper aquifer are only expected at Victoria Dock and North Woolwich portals. However these increases should be mitigated by the existing Highway drainage.

Groundwater level monitoring in the shallow aquifer is being undertaken as part of geotechnical investigations. Water level changes will be monitored in standpipes and additional drainage provided if it is considered to be necessary.

4.3.2 Flood risk to Crossrail tunnels

Some sections of Crossrail pass through the defended, current floodplain of the tidal River Thames, with the potential risk of flooding of the tunnels from the River Thames and the River Lea in the event of failure of the flood defences (the overtopping or breaching of the embankments or failure of the Thames Barrier). Flood water entering the tunnels would put the infrastructure and operation of Crossrail at risk and may threaten connected London Underground tunnels and the safety of people using Crossrail and the Underground network.

In accordance with the Agreement with the Environment Agency, a risk analysis has been undertaken to determine the extent to which construction of Victoria Dock Portal and the Thames Tunnel would exacerbate the extent of flooding and risks from a flood event should there be a failure of the Thames tidal defences and to identify any mitigation measures that will be necessary.

As per the Agreement, the Nominated Undertaker will design shafts and stations within the Zone 2 Thames Tidal Floodplain so that water level entry points are above design flood levels within the defended, current floodplain. Proposed water entry levels and design flood levels will be submitted to the Environment Agency for approval.

Consultation is currently underway and will continue with the Environment Agency and London Underground to determine the risk of flooding via the Crossrail tunnel network.

4.3.3 Flood risk at other sites

Flood Risk Assessments are presented in Appendix H to Specialist Technical Report, Report 1E0321-G0E00-00006 for several cross drainage structures. These concluded that in all cases there would be no significant risk of additional afflux under design flood conditions, although in the cases of Gidea Park Stabling Sidings and at West Drayton some streamlining could be needed to reduce entry and exit losses. Since all these structures involve work in watercourses, and consents from the Environment Agency are required under Schedule 17 to the Act before construction begins. Where required, evidence that the final design does not cause significant upstream flooding will be provided as part of the consent application.

Clause 6 of the Environment Agency Agreement describes how the recommendations of the formal Flood Risk Assessment (FRA) for Pudding Mill Lane portal will be implemented subject to any approved revision of the FRA. The Nominated Undertaker will provide temporary flood protection measures along the Bow River upstream of the portal works.

4.4 Flood Storage Compensation

Clause 9 of the Environment Agency Agreement describes the arrangements for providing 100% flood storage compensation for the permanent loss of dock area where the Isle of Dogs Station extends above the waterline in the North Dock (using reasonable endeavours). Studies have concluded that this could be provided by some re-grading of the inter-tidal zone along the River Lea around the Limmo and Instone Wharf sites. Alternative options include a financial contribution for flood compensation works to be undertaken by the Environment Agency. Flood storage compensation will be provided within two years of the Isle of Dogs station being open for operational use.

A second area of lost flood storage may occur at West Drayton. The detailed design of the cross drainage structure for the Frays River and associated embankments will allow this loss to be quantified. Preliminary investigations indicated that there was a suitable area of land for re-grading to provide storage compensation. The consent for work on this river will address flood storage compensation.

4.5 Barging (requirements for wharfing and navigation)

All barging operations on the tidal Thames are under the control of the Port of London Authority (PLA). It is anticipated that barge movements and moorings in the North Dock at the Isle of Dogs are at risk of being restricted by construction of the Isle of Dogs Station. However, assurances have been made to the users of the docks, including BWB, regarding these navigation issues, for example that construction barges within the dock are moved to prevent obstruction from Friday evening to Sunday evening.

Barging to remove excavated material has been proposed at Instone Wharf and at Manor Wharf. At Instone Wharf, a conveyor will transfer the excavated material from the bored tunnel operations at Limmo Peninsular shaft. Here, the material will be loaded directly onto barges or ships for transfer by river to its destination. It is also proposed that excavated material from the Central Stations and shafts construction, east of Paddington, will be transported to Instone Wharf and transported in the same way. As such, Instone Wharf will require some upgrade work and limited dredging. The PLA has been consulted regarding this.

Manor Wharf will be refurbished and used for the transfer of excavated material from the bored tunnels for the Thames Tunnel crossings. Again the PLA have been consulted and have provided advice on the likely upgrade work required.

4.6 Dredging

The potential requirement for dredging operations has been identified at Instone Wharf, Manor Wharf and in the City Mill River.

In accordance with the Agreement with BWB, in the event that works at City Mill River alter the route of the navigational channel, the Nominated Undertaker will dredge the river to provide a navigable depth on completion of the works of no less than 1.8m.

Dredging may result in adverse water quality effects if contaminated sediments are mobilised (unless contaminants remain in the solid phase or the water is already contaminated). Mitigation measures to minimise any effects include avoiding dredging during the ecologically sensitive period between June and August which should prevent damage to juvenile fish.

Dredging plans will be approved by the PLA and consents to undertake dredging will be required from both the Environment Agency and PLA.

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