Report of the Thames Tunnel Commission October 2011

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LONDON BOROUGH OF RICHMOND UPON THAMES

TOWER HAMLETS

Southwark Council

THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA

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1 EXECUTIVE SUMMARY

- The Thames Tunnel Commission (herein referred to as the Commission) recognises that the scale of sewage discharges into the Thames Tideway is unacceptable. Even with the improvements to the sewage treatment works (STWs) and the Lee Tunnel in place, the estimated 18 million cubic metres of annual stormwater and sewage overflows and the annual number of spills from certain Combined Sewer Overflows (CSOs) would result in adverse water quality that will intensify with increases in the population projected and with possible adverse effects due to climate change.
- The ten worst CSOs are responsible for nearly 80% of the total load discharged. If these polluting loads were removed then the remaining CSOs would not have a significant effect on dissolved oxygen in the River Thames. Under current plans, a proposed 22km long tunnel will collect spills from these and 7 more CSOs at a cost for each overflow that might allow for individual treatment works to be built at each.
- There is a need to address current planning and funding arrangements for water and wastewater systems, as under these it is easier to construct large, costly, inflexible and environmentally impacting infrastructure systems, like the tunnel, than it is to provide green infrastructure alternatives that deliver many benefits to society and that are adaptable to a changing climate.
- While the Commission accepts the need to take into account both aesthetic and health impacts, the benefits compared with the costs of connecting the proposed number of CSOs to a full length tunnel needs to be re-assessed.
- It is crucially important that the Environment Agency's methodology for determining whether a CSO has unacceptable adverse environmental impacts should be supported by a scientifically robust evidence base informed by adequate monitoring, validated computer models and measures which can be precisely calculated. Given the lack of scientific knowledge behind these models and limited data, uncertainties in this assessment process should be clearly identified and linked to the costs and benefits of remediating each CSO so that informed decisions can be made.
- The Commission recommends that a wide ranging cost-benefit study, including the full range of potential benefits, be undertaken to investigate the potential and feasibility of connecting certain less frequent discharging CSOs to green infrastructure source control measures as an alternative to connection to the full length tunnel. Greater attention should be given to an assessment of the disproportionate costs incurred in cleaning up the River Thames to achieve an unreasonable standard of cleanliness where salmonid fisheries are supported.
- The Commission regrets that the alternative options to a full length tunnel have never been adequately tested, especially where such alternatives can deliver more than the mono-benefit of CSO spill reduction that the tunnel will provide. These options include reducing flows by separation, by green infrastructure, by the construction of local detached sewage treatment works, by the construction of distributed storage and by the enhancement of the existing sewerage network, thereby allowing a partial tunnel solution at a lower cost or even a non-tunnel solution.
- Professor Chris Binnie and Professor Colin Green have produced proposals for alternative solutions that appear to offer much better value for money than the single tunnel solution. The Commission urges Defra, the Environment Agency and Thames Water to give careful consideration to these alternative proposals.

- The Commission also urges consideration of complimentary green infrastructure solutions in the medium to long term to alleviate stormwater runoff volumes before they enter the sewerage system and to address surface floodwater challenges, particularly in the context of emerging national and European legislation and policy such as "The Natural Choice: Securing the Value of Nature", that promote principles of economic and environmental sustainability and integrated water management approaches.
- The Commission raises serious concerns about the escalating costs of the Thames Tunnel and the impact this will have on customers, pushing a significant proportion of Thames Water bill payers into water poverty.
- The underlying principles of national and European legislation and policy emerging in the last five years are economic and environmental sustainability and an integrated approach to water management. This should lie at the heart of the approach to reducing stormwater and sewage discharges into the Thames Tideway.
- The National Policy Statement (NPS) on Waste Water should not pre-empt the role of the planning process to determine whether the Thames Tunnel meets the criteria for major waste water developments. The Commission supports the EFRA Committee's recommendation that the NPS should be simply a generic document and not make reference to specific schemes.
- Over the past 10-15 years, the feasibility of SuDS as a substantial part of the solution to the problem of urban water management has changed drastically. Other cities around the world provide the evidence that the new technologies are operational and reliable and that rapid implementation of SuDS and GI – say in 10 to 20 years – is realistic.
- **The Commission strongly recommends that the 2007 Ministerial request of Thames Water to pursue a full-length storage tunnel be reconsidered, so that the full range of 'best technical knowledge' options available to manage stormwater are evaluated with equal consideration as the tunnel in meeting compliance with the Urban Waste Water Treatment Directive. The Commission also encourages Defra to inform the EU proceedings for the need for an environmental and economic reassessment to ensure that not only stormwater overflow issues are addressed but also flooding and wider societal benefits, and that the options pursued do not entail excessive cost for the benefits accrued in today's economic climate.**

2 INTRODUCTION

2.1 How did the Thames Tunnel became the preferred option?

2.1.1 Much of London's sewerage infrastructure consists of combined systems, meaning a single sewer conveys both foul sewage and rainwater runoff to a sewage treatment works for treatment. The current sewer system is subject to significant flows from surface drainage, which has intensified in the last decades because of increasing amounts of impermeable surfaces that accompany development and aggravate stormwater runoff, as well as population growth and intensified weather events. In particular, the increase in hard surfaces, such as roofs and roads, has reduced the capacity of the land to absorb rainwater. Instead, it only takes a few millimetres of rainfall to surge into the combined sewerage system. When this occurs, it is normal practice to discharge the overflows of stormwater and sewage directly to a watercourse—or, in London's case, into the River Thames. This is called a combined sewer overflow (CSO) event.

2.1.2 In 2000, the Thames Tideway Strategic Study (TTSS) Group was established, under the independent chairmanship of Professor Chris Binnie, with representatives from the key UK government agencies involved in urban waste water management: the Environment Agency (EA), the Department for Environment, Food, and Rural Affairs (Defra), the Greater London Authority (GLA), and Thames Water (TW). The Water Services Regulation Authority (Ofwat) maintained an observer status. The objectives of the TTSS were to assess the impact of intermittent discharges of storm sewage on the Thames Tideway, to identify objectives for improvements, and to explore potential solutions.

2.1.3 Following four years of analyses, the TTSS recommended its preferred solution: a large diameter storage and transfer tunnel to be delivered within 15 years known as the Thames Tideway Tunnel. A total of 36 combined sewage overflows (CSOs) were identified by the Environment Agency as being unsatisfactory, of which 34 discharged into the tidal Thames and two into the River Lee. The remaining 21 CSOs were found by the EA not to require any action.

2.1.4 The largest unsatisfactory CSO discharging into the River Lee was to be addressed by a 7 kilometre long, 7.2 metre diameter storage tunnel, referred to as the Lee Tunnel, from Abbey Mills Pumping Stations to Beckton Sewage Treatment Works, while a local improvement solution was adequate for the other CSO. Following completion of the improvements to the sewage treatment works and the Lee Tunnel by 2015, both underway now, spillages of combined stormwater and sewage to the tidal Thames in a typical year are estimated to be reduced from 39 million cubic metres to some 18 million cubic metres, at a total cost of £1.3bn.

2.1.5 The Thames Tunnel was to address the remaining spillages and criteria developed by the TTSS:

- To reduce the adverse environmental impacts on the river ecosystems and fish species;
- To reduce the unacceptable aesthetic issues, and;
- To reduce the elevated health risks for recreational users of the tidal Thames.

At the time of the TTSS recommendation, estimated cost of the Thames Tunnel was £1.7billion.

2.1.6 In 2005, Ofwat commissioned a report by Jacobs Babtie to review the work and reports of the TTSS. Published in February 2006, it suggested a proposal that provided less benefits at a lower cost: two shorter tunnels in the east and west, a new treatment facility near Heathwall Pumping Station in central London, and a screening plant and enhanced primary treatment plant at Abbey Mills in east London, as well as in-river skimmers, sewage treatment upgrades, and re-oxygenation measures. The Babtie report also did not fully agree with the criteria set

out by the TTSS, including the dissolved oxygen targets for the environmental impacts, and suggested that sustainable drainage systems (SuDS) should be implemented over the medium to long-term where appropriate.

2.1.7 The TTSS and Babtie reports and options were then considered by a working group set up by Defra in December 2005. The work of this group was initially to consider whether a partial solution, coherent to the wider Thames Tideway problem, could be delivered in time to protect the 2012 Olympic and Paralympic Games against the risk of significant aesthetic pollution from CSOs. This work led to the then Minister of State for Climate Change and the Environment [Ian Pearson] writing to Thames Water in July 2006 to ask it to provide a detailed assessment and costs for two options: option 1 being a full-length and continuous tunnel controlling unsatisfactory CSOs in the Beckton and Crossness catchments; and option 2 being two separate tunnels as proposed in the Jacobs Babtie report.

2.1.8 In December 2006, Thames Water delivered its assessment in the Thames Tideway Tunnel and Treatment Summary Report, 'Tackling London's Sewer Overflows'. It concluded that Option 1 variants achieved a higher proportion of the objectives defined by the TTSS and that the only variant of Option 1 that could realistically offer any potential for the desired early-phased delivery for the 2012 Olympics was a full-length (30 kilometre), 7.2-meter diameter tunnel from Abbey Mills and West London joining at Beckton—known as Option 1c (see Map 1)

2.1.9 This report informed the 'Regulatory Impact Assessment, 2007' for sewage collection and treatment for London, published by Defra in March 2007. Specifically, the assessment rejected the solution in the Jacobs Babtie report because it did not meet the criteria set by the TTSS and the Environment Agency (EA), and because it was considered not to meet the requirements of the Urban Waste Water Treatment Directive. Specifically the proposal was rejected for not dealing with overflows from 18 unsatisfactory CSOs and because, according to computer modeling results, the expected improvement of dissolved oxygen concentrations did not meet the required standards.

2.2 Developments since the 2007 Ministerial request for the Thames Tunnel

2.2.1 In April 2007, the Minister of State for Climate Change and the Environment stated, in a letter to the Chief Executive of Thames Water, that: "A full-length storage tunnel with additional secondary treatment at Beckton sewage treatment works…is needed." Subsequently, the Minister requested that Thames Water make provision for the design, construction, and maintenance of the scheme. As a result, Option 1c from the TTSS report became the baseline tunnel option considered by the London Tideway Tunnel programme and has remained as such since.

2.2.2 Following this instruction, Thames Water has refined the full-length storage tunnel scheme by examining three alternative tunnel alignments: the River Thames route, the Rotherhithe route, and the Abbey Mills route. All three contribute towards achieving the EA water quality standards and the TTSS criteria, and satisfying the interpreted requirements of the Directive, but the Abbey Mills route offers the lowest cost and least adverse environmental and community impacts, so is now the preferred route. Site selection consultation was conducted in 2009.

2.2.3 The recommended full-length storage tunnel (Abbey Mills route) is now estimated to cost £3.588 billion and has the shortest implementation time to facilitate target objectives in 2020. Thames Water's Needs Report concludes that compared to other tunnel alternatives, the full-length storage tunnel approach on the Abbey Mills route is the most cost effective solution which meets the Directive requirements and the environmental objectives set by the TTSS. In an article in the New Civil Engineer magazine of June this year, however, Martin Baggs, Thames Water's Chief Executive Officer, revealed that the £3.6bn price tag is an indicative 2008 price,

used to benchmark options, and that it will inevitably increase at outturn once the project risk and financing cost is added in.

2.2.4 In March 2010, the then Secretary of State for Environment, Food and Rural Affairs, Hilary Benn, set out the case for the Thames Tunnel as a project of national significance, which, if not implemented, could cause reputational risk to the UK. The succeeding Secretary of State, Caroline Spelman, issued a written ministerial statement in September 2010 confirming the Coalition Government's support for the construction and wrote that: "I am also minded that development consent for the project should be dealt with under the regime for nationally significant infrastructure projects established by the Planning Act 2009. I consider that this project with its unique scale and complexity, is of national significance and, therefore, appropriate for this regime."

2.2.5 In 2010 Thames Water opened a new £250million desalination plant in East Beckton designed to provide water to 1 million of the Capital's population during times of drought and peak demand. The Commission received evidence from Professor Colin Green making an economic case that, instead of desalination, storm water could have been collected by source control measures, such as rainwater harvesting around the City, saving the need for such an energy intensive plant. (See: http://www.lbhf.gov.uk/Directory/News/ttc.asp) This is an example of the propensity to use large infrastructural solutions rather than dispersed and localised approaches as is done in many other parts of the world. In London this would remove significant amounts of stormwater and reduce demand for the sewer tunnel.

2.2.6 Thames Water's phase one consultation process was conducted from September 2010 to January 2011. The phase two consultation process is due to begin in November 2011. Thames Water expect to submit planning applications in the summer of 2012.

2.2.7 Between 2007 and 2011, several key legislative and policy statements related to water management have emerged both in the EU and the UK that should also inform the Thames Tunnel implementation decisions. In the EU, these policy documents include the EU Biodiversity Strategy, the April 2009 EC White Paper, 'Adapting to Climate Change', and the Water Framework Directive Guidance Documents on Common Implementation Strategy. In the UK, these documents include the UK Government White Paper, 'The Natural Choice: Securing the value of nature', and the UK National Ecosystem Assessment.

2.2.8 In the EU Biodiversity Strategy, relevant policy includes Target 2, which says that, by 2020, ecosystems and their services are to be maintained and enhanced by establishing green infrastructure and by restoring at least 15 percent of degraded ecosystems. Specifically:

- Action 5: Improve knowledge of ecosystems and their services;
- Action 6: Set priorities to restore and promote the use of green infrastructure;
- Action 7: Ensure no net loss of biodiversity and ecosystem services.

Action 6 goes on to commit the European Commission to develop a Green Infrastructure Strategy by 2012 to promote the deployment of green infrastructure projects and the maintenance of ecosystem services, for example, through better targeted use of EU funding streams and Public Private Partnerships. By 2014, Member States, with the assistance of the Commission, are charged with developing a strategic framework to set priorities for ecosystem restoration at sub-national, national and EU levels. On 12th October 2011, the Minister, Richard Benyon launched the 'Green Infrastructure Partnership', saying: "There are areas where there isn't enough green space to face the challenges of climate change – increased flooding and overheating and there are areas where lack of green space is associated with deprivation and poor health."

2.2.9 In the EC White Paper, 'Adapting to Climate Change: Towards a European framework for action', under the water management section there is a commitment to "explore possible ways of improving policies and developing measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming."

2.2.10 In the Water Framework Directive Common Implementation Strategy, Guidance Document No. 24 says (under Principle 7: Favouring robust adaptation measures) that: "If investments are being planned for infrastructure with long life spans it is prudent to favour measures that are resilient to a wide range of plausible climate conditions … these measures should also work with natural processes and realise multiple benefits (e.g., for flood risk management, drought management, nature conservation, navigation and recreation)." In Principle 8: Maximising cross-sectoral benefits and minimising negative effects across sectors, it says that "measures taken to improve water status through waste water treatment or reuse, artificial recharge of aquifers, inter-basin transfers and so forth, imply higher energy consumption and greenhouse gas emissions."

2.2.11 The UK Government Natural Environment White Paper, 'The Natural Choice; Securing the value of nature' (June 2011), lays out a vision to 2060 for biodiversity, water management, green infrastructure, air quality and ecosystem services. Green infrastructure is expected to deliver reduced pollution and greater resilience to climate change. The paper outlines 10 'catchment level partnerships' between businesses, citizens and interest groups and encourages local nature partnerships working at the strategic landscape scale. The White Paper calls for more coherent and large scale approaches to protect fragmented, fragile ecosystems; citing a need to restore nature in our cities, towns and rivers and recognising the tension in water management between increased demand and reduced flows in summer.

2.2.12 The 'UK National Ecosystem Assessment: Understanding nature's value to society' (June 2011) notes that ecosystems have changed markedly over the past 60 years, pressures are increasing, and the natural world is consistently undervalued. It cautions that decisions made now will have far reaching consequences and that a more integrated, holistic approach is needed to deliver sustainable development. The recently published 'Manual for Cities: Ecosystem Services in Urban Management' provides clear guidance and evidence for taking a multi-functional and multi-value approach to natural and green spaces in urban areas, connecting urban planning and design with ecosystems and water management in an integrated way.

2.3 The Thames Tunnel Commission

2.3.1 The Thames Tunnel Commission was launched on 4 July 2011, informed by the EFRA Committee's response to Defra's draft National Policy Statement on Waste Water, which highlighted the lack of information available to the Committee on alternative options to the Thames Tunnel:

"The absence of a detailed evidence base makes it hard to assess whether the draft NPS's conclusions on the potential for SuDs (sustainable drainage systems) to contribute to reducing waste water are either over or under-stated. We recommend that Defra revises the National Policy Statement (NPS) to set out in detail the basis of its assessment for the potential of alternative approaches to mitigate the need for new infrastructure, such as the increased use of sustainable drainage systems and water efficiency measures to reduce the production of waste water."

In paragraph 64 of the report, the Committee further notes that:

"Witnesses also had reservations as to the adequacy of the draft NPS's sections on alternatives to constructing new infrastructure. London Councils were concerned that the draft NPS did not

contain "particular advice" on alternatives to the London schemes such as reducing demand, diverting surface water from sewage systems or decentralisation of waste water treatment infrastructure. It argued that, since previously rejected alternatives to the Thames Tunnel had now had their cost assessments revised, it was inappropriate to restrict the IPC's consideration of "plausible alternatives" [121]. The Minister conceded that there could be a "bit more" information included on the need for specific projects which would help the IPC further [123]."

2.3.2 The concerns of the EFRA Committee, and those who submitted evidence to the Committee's inquiry into the NPS, made clear the need for an independent review of the various options for dealing with London's waste water, within the wider context of water management across the Capital. Five London boroughs (Hammersmith and Fulham, Kensington and Chelsea, Richmond, Southwark and Tower Hamlets) came together to sponsor an independent Commission to carry out this review.

2.3.3 The aim and purpose of the Thames Tunnel Commission was fourfold:

- Review the findings of previous studies relating to the Thames Tunnel and reassess the assumptions made in those studies in the light of subsequent research and more up-to-date scientific knowledge;
- Examine the recent responses of other world cities to the problems of pollution, flooding and potential water shortages;
- Consider evidence from stakeholders, experts in the field and other interested parties;
- Reassess the options for addressing EU Directive 91/271/EC in the light of developing international perspectives on waste water management and in the light of the recent EU White Paper on Adaptation and Surface Water Management.

2.3.4 The Commission met regularly, over a three month period, to review the existing analyses of waste water management in London, within the context of current and emerging environmental legislation, policy and procedures (see Annex B). To that end the Commission studied practices and approaches used abroad as well as new development in urban drainage, waste water collection and treatment, sustainable urban design and redevelopment. A total of 40 organisations and individuals submitted written evidence to the Commission (see Annex C) and, over three days, a total of 25 individuals, representing 12 of those organisations (see Annex D), were called to give further oral evidence to the Commission.

2.3.5 This report presents the findings and recommendations of the Commission on the basis of the evidence received. The membership of the Commission and members of the Secretariat are listed at Annex A.

3. SUMMARY OF EVIDENCE RECEIVED

3.1 Interpreting compliance requirements & other driving factors for the Thames Tunnel

3.1.1 The need for the Thames Tunnel arises, in large part, from the objective of the United Kingdom to address infraction proceedings, taken against the UK by the European Commission for being in breach of the Urban Waste Water Treatment Directive (91/271/EEC). In the opinion of the European Commission, waste water collecting systems in London are being allowed to spill untreated waste waters from combined sewer overflows too frequently and in excessive quantities into the River Thames.

3.1.2 Passed in 1991, the Urban Waste Water Treatment Directive was the prevailing regulatory framework at the time the Thames Tideway Strategy Study evaluated London's options to address stormwater and sewage overflow. The Directive concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. Transposed into English law in 1994, Annex 1 of the Directive has guided the requirements for collecting systems:

"The design, construction and maintenance of collecting systems shall be undertaken in accordance with the best technical knowledge not entailing excessive costs, notably regarding: volume and characteristics of urban waste water, prevention of leaks, and the limitation of pollution of receiving waters due to storm water overflows."

The Directive is silent as regards the number of permissible overflows per year. That is for the Member State to consider when assessing the appropriate measures to limit pollution.

3.1.3 There was a general view that the three key EU Directives in this area: the Water Framework Directive, the Flooding Directive and the Urban Waste Water Treatment Directive are all complementary and reinforcing but that the fundamental one has to be the Water Framework Directive in that it sets out the criteria for establishing good ecological status for European rivers. It was acknowledged that there has always been a problem in determining what good ecological status means for an open urban and tidal river, and that this is still being debated but that the Water Framework Directive seeks to establish this and, as such, should be the primary driver of water management in relation to our urban rivers. The Urban Waste Water Treatment Directive and the Flooding Directive should "ride on the back of the Framework Directive", according to Defra.

3.1.4 The infraction proceedings, relating to the Urban Waste Water Treatment Directive (UWWTD), are clearly driving Defra's focus on a single tunnel solution. The Government is of the opinion that the European Commission's timetable for compliance with the Directive is such that SuDS can play a very minimal part in delivery. Although there does not appear to be a clear deadline set by the EC for compliance with the UWWTD, the Commission was unable to clarify what scope there might be for a partial SuDS solution being proposed over a longer period of time. The Government is reliant on the TTSS report of 2006 and Appendix E in the 2010 consultation documents in determining that green solutions will be difficult to implement in meeting the requirements of the UWWTD. The Commission found no evidence of any dialogue with the European Commission on the acceptability of other solutions for the presumed infraction of the UWWTD, nor on the long term sustainability of solutions, nor on the ways to best integrate the plans for meeting UWWTD, the Water Framework Directive and the Flood Directive.

3.1.5 Raj Bhatia provided written evidence that, as part of the 'Drain London' initiative, Thames Water has proposed SuDS retrofit measures in London, including detention basins, green roofs, pocket street infiltration and permeable paving, many of which, over the medium to long-term,

provide solutions associated with response to the UWWTD by reducing stormwater entering the sewage system, obviating the necessity for a tunnel. In an early study, Thames Water are now working in partnership with local authorities to consider using SuDS to manage flood risk in the Counters Creek sewer catchment area.

3.1.6 To a significant extent, flood management is unhelpfully seen as a separate issue to water supply and waste water treatment, requiring different and often disconnected solutions. The same is true for the issue of waste water treatment. Developments in waste water treatment technology can be of significant influence on the location of Sewage Treatment Works (STWs), on the preferred mix of black water and storm water, on the tolerable hydraulic loading and its variability, on the usability of the effluent and much else. In contrast with many major cities around the world, an integrated master plan for the drainage, flood risk management, water management, water quality management and water supply of Metropolitan London is lacking, as is the integration of these water issues with policies on urban planning, social and economic development, public health and well-being.

3.2 Evaluating the criteria used to validate the Thames Tunnel and determine connections

3.2.1 The TTSS criteria set to evaluate tunnel options were threefold:

- To reduce the adverse environmental impacts on the river ecosystems and fish species;
- To reduce the unacceptable aesthetic issues, and;
- To reduce the elevated health risks for recreational users of the tidal Thames.

3.2.2 According to the TTSS report ,"there are no statutory ecological objectives to apply" and "since it is generally recognised that fish are the most sensitive indicator of ecological quality, the decision was taken to devise standards that are protective of relevant fish species." (16) (S 4: Protection of Ecology: paras 2 and 3). A large number of fish are, however, already present: 125 different species of fish have been caught in the Thames Estuary between Fulham and Tilbury since 1964. Since 1990, 13 new species have been recorded in the River Thames, including seahorses, after earlier investment in sewerage infrastructure to improve river quality.

3.2.3 The ecological standards devised by the TTSS Group were much more ambitious, with the aim of turning the Thames into a sustainable fishery for salmon, smelt and other sensitive species (9) (S 5.12 – 5.15). There seems to be no limit to the budget that can be spent to sustain the Thames as a fishery for sensitive fish. UWWTD and UK Regulations do not legislate for it, however, and the Commission's view is that this aim is expensive and unrealistic.

3.2.4 The Wandsworth Society questions the rationale for the proposed tunnel, believing it will have a relatively limited effect on the quality of water in the tideway at a huge environmental, social and financial cost. The Society goes on to cite several key studies, including Jacobs Babtie, which states that the STW upgrades would prevent most fish kills. Evidence from the EA to the Commission provided little scientific and credible information about the relative amounts of oxygen and bacteriological pollution arising from the CSO spills, STW inputs (from both storm tank overflows and final effluents), background diffuse runoff from roads and other surfaces in the City and coming from upstream into the river reach above Mogden. It is possible that even with the proposed tunnel, pollution from these myriad of other sources will still compromise the quality of the river water.

3.2.5 The water in the River Thames is used for a large number of functions, in addition to the ecological functions that it serves and it is the conviction of the Commission that the water could be used even more intensively. Water quality requirements for these other functions were never elaborated on. That makes the focus of the water quality standards rather limited,

definitely in relation to the long term solutions being sought.

3.2.6 The Commission heard evidence that SuDS can mitigate most of the pollutants picked up by stormwater, whereas the tunnel, while addressing the acute pollution problems, will not help to address the cumulative and long term polluting problems that introducing stormwater into the sewerage system can cause. Nor will it help with addressing flooding risk in the City.

3.2.7 One expert noted that UK policy on source control for these micropollutants does appear to espouse the introduction of sustainable drainage systems but that the implementation of such solutions is piecemeal, i.e. there is a problem in extrapolating the strategic objectives into outcomes implemented on the ground.

3.2.8 Some expert witnesses questioned the extent to which the aesthetic criteria were of relevance to the terms of the UWWTD, which refers to environmental damage. The scientific value of monitoring the aesthetic criteria was also questioned. It was pointed out, for example, that aesthetic monitoring of pollution (much of which has been hearsay) cannot identify which CSO is responsible for the discharge as the Thames is a very turbid flow of water and the tide will carry pollutants and detritus for some miles up and down stream.

3.2.9 Reference was also made to the 'Bromley Case', in which the Advocate General's opinion on what the 'best technical knowledge not entailing excessive cost' actually means was given. In simple terms, his legal opinion was that the costs of fixing the problem is compared to the harm that will continue if it is not fixed.

3.2.10 Lambeth Council's evidence recognises that due to both population growth and required development there will be increased pressure on existing infrastructure and that there will ultimately be the need for a major civil engineering project to accommodate such growth in London. However, the Council says the Thames Tideway Tunnel should consider taking a more holistic approach and be accompanied by complimentary 'softer' measures to address flooding.

3.2.11 It was widely agreed that pollution in the River Thames has vastly improved over the past thirty years – the Port of London Authority (quoting the Environment Agency) boasted that it is the cleanest metropolitan estuary in Europe - but that the current levels of sewage going into the river are unacceptable.

3.2.12 The Commission concludes that indeed there is an urgent need to address the problem of the CSO discharges. A long term sustainable solution is required, addressing the CSO problem from the wider context of problems, challenges and opportunities in relation to London's urban water management and taking into account the need for adaptation to external developments such as climate change, shortages of natural resources (e.g. energy nutrients, water), developments in technology and demography, in asset values, funding systems and in governance practices. At the same time, seeking to maximise the opportunities to provide new green infrastructure and better places to live in line with the Mayor's aspirations for London to be the greenest City in Europe. Stormwater is a key resource that can be utilised to keep London green; without this, green areas will need to be watered with expensive and wasteful tap water.

3.3 Questioning decisions for connections and verifying models with data collection

3.3.1 In her evidence, the Chairman of the Stop the Shaft group, Sian Baxter, referred to Environment Agency monitoring that suggests that 98.7% of discharges come from 18 CSOs, and so questioned whether any other outflows need to be addressed. The same monitoring data shows that five CSOs contribute some 70% of the discharge. The value for money aspect of connecting marginally polluting CSOs to the Tunnel was raised as was the quality and accuracy of the EA and TW monitoring of individual CSO discharges. The Commission was surprised

by the fact that decisions on such a significant investment as the construction of the Thames Tunnel were based on computer modeling results that had a weak scientific base and could not be verified due to the lack of knowledge and monitoring data. The efficacy of the modeling could not, however, be assessed in detail by the Commission as modeling reports and results were not provided in evidence, despite repeated requests. Due to the lack of scientific rigour in the analyses, the somewhat arbitrary categorisation of some of the lower level polluting CSOs was brought into question, as a less than scientific method of selecting for connection.

3.3.2 On the basis of the monitoring of individual CSO discharges there was an argument presented by some witnesses that the lesser to mid-polluting CSOs could be tackled by SuDS and/or local treatment. It was also revealed that Thames Water has been conducting more accurate monitoring, as to polluting loads, at the nine pumped CSOs. This data has not been released but it is being used to validate the modeling and this process is still ongoing. There was criticism of the fact that this level of monitoring is not being conducted across all the CSOs that might be connected to the tunnel.

3.3.3 The Environment Agency (EA) has 20 years of monitoring data on dissolved oxygen levels in the Thames, which was not provided in evidence and which, it argued, is better water quality data than anywhere else in the country. The EA, in its evidence, pointed to London's clay soil and the lack of large areas of land as problems in introducing SuDS as the solution to reduce storm water run off and CSO volumes and frequencies. These assumptions were never tested. One of the witnesses showed ample evidence of the availability of land throughout London – except for the city centre – while others pointed at water storage opportunities on roofs, in basements, under roads and elsewhere. Appendix E in the 2010 consultation document demonstrated that in many parts of London, there are many opportunities to retrofit SuDS and illustrated how this might be done.

3.3.4 The Agency also stated that the west to east interceptor sewers are running at close to full capacity at certain times, even in dry weather flow. This is, however, a good reason to implement SuDS in order to retain storm water locally, rather than drain it without delay into the sewer system and this will also help manage flood risks. Dealing with over capacity sewers in times of dry weather also requires control of inputs nearer to source and the Commission were surprised that no consideration had been given to providing new dispersed STWs to reduce the foul flows going into the main drainage network, in common with the approach being taken in many other parts of the world.

3.3.5 Enlarging the capacity of the interceptors, e.g. by building the tunnel, would require a further extension of the hydraulic capacity of the connected STWs, as they will be dealing with a larger volume of water at a higher flow rate. It is unclear how this extension is included in planning and budgeting.

3.4 Estimating costs/benefits and the impact on Thames Water bill payers

3.4.1 The approximate estimate of the preferred Option 1c in December 2006, without a detailed scheme design, was £2.16 billion. The current preferred design is a shorter tunnel than Option 1c but its cost is now projected to be £3.6 billion, although this is a figure that was used by Thames Water in 2008 to benchmark and is expected to rise. Thames Water customers would be paying for the scheme.

3.4.2 In its evidence, Ofwat expressed its desire to achieve the best value for money secured for customers, given the solution as it stands. Ofwat recognises the enormity of the project, even in relation to Thames Water, which is the biggest water company in the UK. The regulatory body also recognises that the impact on customer bills will be relatively large – a £60 to £65 increase in annual bills, which currently average £319.

3.4.3 Ofwat expressed concerns as to the increased cost associated with the tunnel, pointing out that the £2.23billion estimate in 2006 was for the whole scheme: the Thames Tunnel, the Lee Tunnel and the Beckton sewage treatment works upgrade, meaning that the current estimate for those works is now £4.5 billion - broadly double the 2006 estimate. In evidence, Ofwat noted that the cost benefit analysis was marginal in 2006 so can only have got worse.

3.4.4 The Consumer Council for Water (CCW), in its oral evidence to the Commission, called for a new, environmental audit of the river, followed by a completely fresh cost-benefit analysis of the whole tunnel proposal. The CCW was clear that any such analysis should take account of the fact that the Thames will never be bathing water and that the river is always going to have high turbidity due to tidal action. This should also establish what the relative sources of the pollutants entering the river are: CSOs; diffuse inputs; from upstream; STW.

3.4.5 CCW also noted that an estimated cost of £3.6 billion for the tunnel works out at something like £120 million per kilometre, including all the superstructure and connections, so every kilometre that is dug west of the core Central London area, is going to increase the cost at something like that level. The Consumer Council's view is that building a small self-contained local sewage treatment works in West London could be an option that significantly reduces the length and cost of the tunnel. The £80 million sewage treatment works at Reading, was cited as an example of the potential cost savings.

3.4.6 Councillor Ravi Govindia, Leader of Wandsworth Council, believes it is in the interest of Thames Water's customers that a ceiling is placed on the maximum costs so they can be clear on the effect it will have on their future water sewerage charges.

3.4.7 The Commission noted that maximising benefits for society was never the main objective of the project. Alternatives were never studied from the perspective of synergies or collateral benefits – actual or potential – but rather as a mono-functional solution to a single problem.

3.5 Understanding the benefits and implementation hurdles of green infrastructure alternatives

3.5.1 The Milwaukee Metropolitan Sewerage District's Executive Director, Kevin Shafer, recommends that the Thames Tunnel Commission, if financially feasible, strive to move forward with multiple approaches simultaneously. In the City's practical experience, multiple approaches are more likely to provide synergistic benefits than single solutions. Simply put, green infrastructure supplements grey infrastructure and helps it work more efficiently. Mr. Shafer writes, "I know this through both computer modeling and practical experience."

3.5.2 Water Commissioner, Howard Neukrug, of the Philadelphia Water Department believes that expansions of traditional sewage overflow control systems is not the sustainable approach to developing water quality solutions for the future. Yesterday's sewer systems were not designed to handle today's challenge and the ever expanding regulatory system, nor, more importantly, are they equipped to mimic the natural storm water management principles essential for true ecosystem restoration. A green approach to storm water control as an alternative to traditional approaches brings with it significant and measureable improvements in the urban environment, including biodiversity, reductions in green house gas emissions, reductions in heat stress-related illness and mortality, reductions in electrical and fuel usage, improvements in aquatic and terrestrial ecosystems, reductions in crime and associated water quality enhancements.

3.5.3 Defra accepts the need for sustainable drainage systems but does not accept that these can alleviate the need for the Thames Tunnel solution, as currently proposed. Ofwat has constantly questioned the value for money of the tunnel proposal, as is its role, and commissioned the Jacobs Babtie study in order to explore more cost effective options. The regulator accepted

the Government's decision in 2007, however, that the tunnel was the only adequate solution. In evidence to the Commission, however, Ofwat noted that there was a feeling within the organisation that, with a change of government there might be an opportunity to look at it again.

3.5.4 The former Chairman of the TTSS Group, Professor Chris Binnie, gave evidence that the main technical review of SuDS, that informed the strategic study, was the Binnie, Black and Veach report, conducted in 2002. In his evidence, Professor Binnie accepted that the £12,000 invested in this study was a miniscule proportion of the £5million invested in the whole strategic study.

3.5.5 The Greater London Authority (GLA) , while expressing support for the tunnel, accepts the need to extend its existing green infrastructure projects and to implement related planning policies contained within the London Plan. The GLA recognises the need for a mixed economy solution of both grey and green infrastructure and is open to proposals for speeding up the introduction of SuDS solutions.

3.5.6 While the Government's changes to the permitted development rights, in 2010, were recognised as a step forwards on implementing green infrastructure, the relaxation of some of the other controls over rainwater discharge, with local authorities no longer having the power to enforce SuDS for rear extensions or rear patios, for example, was seen by the GLA as a step backwards.

3.5.7 Thames Water are also developing strategic sewer flood alleviation schemes, such as Counters Creek in Hammersmith and Fulham, to address peak demand and stop sewer flooding in homes. The Thames Tunnel team is also responsible for the work on the Counters Creek strategic sewer but there are two separate aims driving the two schemes: one is stopping the discharges to the river, the other one is stopping flooding in homes. Across London there are activities delivering flood risk management schemes, based on surface water management plans, by Drain London and Thames Water's regulatory compliance under DG5. There is no interconnectedness between these and the tunnel. Customers and property tax payers will have to pay additional costs over and above those required for the tunnel of several million pounds for flood risk reduction. An integrated approach to storm and water management, as taken elsewhere in the world, would deliver greater benefits and at less cost.

3.5.8 At Beckton sewage treatment works, Thames Water is increasing the treatment capacity from 17 cubic metres a second up to 27 , another 10 cubic metres a second of treatment capacity. This will enable treatment of more flow in wet weather. Other improvements to treatment works are also ongoing. In evidence, the company stated that they now have stringent suspended solids limits: the ammonia standard is reduced as is the Biochemical Oxygen Demand (BOD). All of the secondary treatment parameters are being improved. Thames Water did not rule out the possible construction of a new sewage works.

3.5.9 Thames Water views SuDS as the right thing to do for new development, and a means of future-proofing whatever solution is chosen to reduce CSO discharge. The company does not believe, however, that retro-fitting SuDS would reduce the number of CSO discharges to a point that complies with the current legislation. They are also concerned that their customers do not become a default funding mechanism for schemes that might be more appropriately funded by local council tax payers. As far as the Commission was able to establish neither was ever tested and verified by research and analysis. Nor were these issues ever the subject of a debate on the water management strategy with the relevant parties such as Thames Water, the GLA, the Environment Agency and the London Boroughs.

3.5.10 Ofwat referred to the problems of siting new sewage treatment works, due to planning requirements and the objections of local residents. A new works in Brighton took some 10 years to be granted planning permission. Ofwat would encourage the water companies to fund SuDS, where it is cost beneficial.

3.5.11 The Commission was told that that such subsidy schemes for disconnecting roofs and paved surfaces from combined sewer systems are operational and successful in many cities abroad.

3.5.12 Professor Bryan Ellis noted some of the problems in maintaining SuDS in UK cities, where so many different authorities and companies are responsible for maintaining infrastructure, e.g. porous pavements may be regularly dug up by different utilities and telecommunications companies. He pointed to practice in Japan as a means of overcoming these problems, where they have co-ordinated approaches for five years in the introduction of infrastructure.

3.5.13 Professor Ellis was critical of the lack of a proper planning review for the introduction of SuDS. It is his belief that this should have developed from the Thames Tideway Strategic Study but did not, due to the fact that the remit of the original contractors employed to do the modeling work was concerned with looking at spillage, frequencies and rates and volumes related to the CSOs. They were not required, specifically, to address the issue of pluvial flooding (by heavy rainfall) in contrast to river flooding. SuDS is seen as desirable by all but its implementation appears to have been relegated to some future time due to perceived problems in introducing and maintaining such systems. Professor Ellis would like to see better liaison between the London Boroughs and Thames Water, to improve co-operation and collaboration in the introduction of SuDS. He referred to one successful collaborative study, being funded by Thames Water, for which a rain garden has been constructed in Islington. It is the first time that a rain garden has been monitored in London to identify how much water it is taking out of the sewerage system. It is a very small rain garden, a 30 metre square of roof surface, but early monitoring results had shown that at that date it had taken out all the rainfall.

3.5.14 Professor Ellis argues that the current approach of the Environment Agency needs modification, and he believes that the Environment Agency have recognised this. In discussions with Birmingham City Council the Agency has recognised that its surface water maps are only just the first broad screening, and that the Council should not rely upon these as firm indications of flooding distributions and depths within their area. Identifying the problem is the first part of the modeling, the second part is finding the solution. A modeling approach is available, which looks at what the appropriate types of SuDS are that could be used to address the problem, and where they could be located.

3.5.15 The model is a procedure which allows the scanning of a site or development or subcatchment, to identify, for example, where flat roofs are, where car parks are, etc. It can eliminate roofs with more than 3 degrees as being unsuitable for green technologies and then in combination with groundwater maps it can identify where attenuation storage can be provided. The model identifies what particular kinds of SuDS are appropriate and where they can be located in the catchment. The model is rerun with the SuDS inserted to see what the benefits are in terms of flow reduction.

3.5.16 Professor Ellis did not believe that the public would be unaccepting of SuDS schemes, e.g. the flooding of parks, as some have suggested. He pointed out that the flood meadows in London are always operational and that people accepted them in the past. The main problem that he sees with SuDS is ensuring that these are maintained over time in the private sector. Over a 20 or 30 year timescale, it was Professor Ellis's belief that sufficient alternative drainage infrastructure could be put into place to control as much as 90% of events. He suggested that legislation should require that at least the first 10 to 15 millimetres of rainwater run-off should be contained or retained on site or within a development and not released. It was his view that

this would be a considerable start and would not need a lot of retrofitting. It would require the necessary governance and funding streams though to make it work.

3.5.17 Cllr Stephen Greenhalgh noted the different governance structures of British and US cities as one of the reasons why the US is so far ahead in introducing SuDS. Chicago has a clear accountable technical officer responsible for water quality and environmental issues at a strategic level. The Commissioner for Water Quality and Environmental Issues is responsible for introducing SuDS programmes across the city.

4. INVESTIGATION OF ALTERNATIVE SOLUTIONS

4.1 Green infrastructure options

4.1.1 Green infrastructure (GI), also referred to as low impact development (LID) or sustainable drainage systems (SuDS), are practices that can be used to address stormwater problems at source by restoring some of the natural hydrologic functions of urbanised areas. It can also encompass limited development in sensitive headwater regions and groundwater recharge areas but, more recently, the attention has focused at the city, neighbourhood and site-level scale with the capture and retention of rainfall, infiltration of runoff, and the trapping and absorption of pollution through decentralised, engineered stormwater controls. Engineered systems most commonly being used in U.S. and Australian urban areas include green roofs, rain gardens, rain barrels and cisterns, vegetated swales, pocket wetlands, and permeable pavements. Green infrastructure also encourages narrower street widths, greening the urban environment, and parking lots bordered by drainage swales. With up to 70% of the total impervious cover in U.S. urban areas attributable to transportation-related surfaces, and a majority of that cover directly connected to storm drain systems and along waterways, such surfaces can often produce the first runoff during storm events.

4.1.2 In contrast to conventional centralised controls, the benefits of green infrastructure are that it is decentralised, is adaptable and offers flexibility and site-specific solutions that can be tailored to both newly developed land or retrofitted into existing areas. Facilities can be installed on and in private as well as on/in public land. Even in 100% paved areas, green infrastructure can be applied to provide local water supplies, reduce and retain stormwater runoff, e.g by a combination of green roofs, rain tanks and underground infiltration facilities. GI can be used on individual sites or individual neighbourhoods to address localised stormwater or CSO problems, or incorporated into a more widespread municipal stormwater management programme. Other major benefits include stormwater volume control, pollutant removal, water conservation and a host of other ancillary benefits, discussed in more detail below.

Stormwater volume control

4.1.3 Traditional stormwater management focuses on flow rates from larger storms. This approach overlooks the importance of volume control from storms. It is increasingly clear from mounting evidence, however, that reducing the amount of urban runoff is the most effective stormwater pollution control. Reducing runoff volumes decreases the overall volume entering combined sewer systems, reducing the number and size of overflows. Effective practices for providing volume reduction benefits include green roofs, permeable pavements, infiltration swales and crates, bioretention, trees, and water harvesting practices.

Pollutant removal

4.1.4 Not only does green infrastructure decrease pollutant loads by reducing runoff volumes, there is a growing body of work indicating that green infrastructure practices are effective at removing pollutants from stormwater directly. Using natural processes, green infrastructure filters pollutants or biologically or chemically degrades them, which is especially advantageous to separate sewer systems that do not provide additional treatment before discharging stormwater. Effective practices include open areas and buffer zones around urban streams and rivers to provide treatment and management of overland flow before it reaches the waterway.

Water conservation

4.1.5 Communities across the globe must find ways to respond to water supply shortfalls. Water conservation can help alleviate these threats by allowing communities to maximise their existing and planned water supply sources and prevent the need for costly expansion of water

treatment, storage and transmission facilities. Green infrastructure practices, such as rainwater harvesting techniques help capture and conserve water. Harvested stormwater can be used for low end domestic purposes such as irrigating gardens, toilet flushing and laundry washing. Downspout disconnections, rain gardens, porous pavements, curbless parking lots, and narrower roads can also help replenish and sustain groundwater.

Heat stress reduction

4.1.6 Evaporation helps alleviate heat stress. Retained stormwater can be used for maximising evaporation during hot dry spells. Water can be used for direct evaporative cooling from wetted pavements and roofs or for indirect evaporative cooling by plant evaporation. Reduction of heat stress reduces energy demand for air conditioning.

Ancillary benefits

4.1.7 Green infrastructure is also attractive because it can be used to achieve multiple ecological environmental, social and economic goals, measured by some as shorter hospital stays, reduced instances of childhood obesity, reduced crime (perceived and actual), increased community interaction, air and noise quality benefits, and the list continues. Whereas funds spent on conventional stormwater management can only be used for water infrastructure. The Thames Tunnel is a mono-functional device in terms that it can only be used for the storage and conveyance of wastewater. Whatever the motivation is for evaluating green infrastructure and its various options, best management practices across the literature find that land uses tend to dictate the best green infrastructure measure fit, as well as costs, storage capacities, and treatment abilities. Most benefits translate into quality of life and economic value such as higher property values.

4.2 Evidence from the US

4.2.1 Mitigating CSOs is costly. A 2000 'Clean Watersheds Needs Survey' estimated that $56 billion (2005 dollars) in capital investment was needed for U.S. CSO control. Separating combined sewer lines and building deep storage reservoirs or tunnels are the two most common grey infrastructure methods of CSO control. The costs for separating combined sewers, disconnecting stormwater inlets from the combined sewer systems, and directing them to a newly installed separate storm sewer system range from $2.6 million to $3.2 million for each mile of combined sewer to be separated. Deep storage systems, built to hold the excess surge of combined sewer wastewater during wet weather events, take years to build and are costly.

4.2.2 Yet, more recent data is being gathered on how green infrastructure strategies reduce stormwater costs— competitively. The U.S. Environmental Protection Agency summarised 17 case studies of developments applying green infrastructure techniques in December 2007, concluding that "in most cases, [green infrastructure] practices were shown to be both fiscally and environmentally beneficial" with total capital costs savings ranging from 15% to 80%, with a few exceptions.

4.2.3 In New York City, where the Department of Environmental Protection (DEP) found that the biggest remaining challenge to water quality standards are CSOs, the city decided in its Sustainable Stormwater Management Plan to pursue a hybrid grey-green approach. Since 2005, the city has spent more than $1.5 billion on CSO reduction including infrastructure improvements and CSO storage facility upgrades. But according to the September 2010 NYC Green Infrastructure Plan report, these types of CSO reduction projects are very expensive and do not provide the sustainability benefits that New Yorkers have come to expect from multibillion dollar public fund investments. New York's DEP modeling efforts demonstrated that the use of green infrastructure in combination with other strategies would not only be more effective at controlling CSOs, as compared to grey strategies alone, but would also

provide the additional benefits of cooling the city, reducing energy costs, and increasing property values—and the study found that green infrastructure could be more cost effective than certain large infrastructure projects, such as CSO deep storage tunnels (Gunderson/DEP). The costs for each strategy were also calculated on a unit cost basis. Based on the cost per cubic metre of CSO reduction for each respective alternative, the grey strategy is estimated to be the more expensive option ($0.62 per gallon for the grey strategy versus $0.45 per gallon for the green option). In particular, the costs of building green in new developments is less than a centralised CSO approach or conventional stormwater management programmes and may provide an opportunity to further decrease the economic costs.

4.2.4 Studies in Maryland and Illinois show that new residential developments using green infrastructure stormwater controls saved $3,500 to $4,500 per quarter- to half-acre lot. Cost savings for these developments include averted costs for less conventional stormwater infrastructure and paving, and lower site preparation costs. Adding to the cost savings, developments using green infrastructure normally yield more lots for sale and higher sales prices because of the premium buyers place on vegetation and conservation development.

4.2.5 In urban areas, green infrastructure will be most cost effective when it is incorporated as part of an overall redevelopment effort or when large improvements to infrastructure are required. In these instances, the costs of green infrastructure are minimised relative to the scope and costs of the overall project, as in the case of the earlier New York example.

4.2.6 Although green infrastructure has been shown to reduce stormwater runoff and combined sewer overflows and improve water quality, its value as an alternative is only as good as it can be implemented—and measured. U.S. cities have incorporated green infrastructure into stormwater management programs because of direct efforts to encourage alternative stormwater approaches. But the approach is benefitting from policy prescriptions being put into place over the last 5-10 years, ranging from incorporating green infrastructure into long-term control strategies for CSOs (some cities are even creating stormwater utilities similar in function to water and wastewater utilities to allow for the assessment and collection of a user fee dedicated to stormwater management programs) to dedicated funding for stormwater management that rewards green design to providing incentives for residential and commercial use of green infrastructure. As just one example, beginning in 2006, Portland, Oregon provided up to a 25% discount in its stormwater utility fee for properties with on-site stormwater management.

4.3 Delivering multiple benefits from using Sustainable Drainage Systems (SuDS) and Water Sensitive Urban Design (WSUD)

4.3.1 Value creation is the key to modern urban planning and within this, water management, which should be integrated into the wide range of societal functions and is no longer the province of the water system specialist alone. Managing water in today's modern city requires a co-creative approach between policy makers, professionals and citizens and the use of source control measures (known as SuDS in the UK) is now standard practice throughout most of the world. The out-of-sight, out-of-mind approach especially to drainage and wastewater, where drains and sewers convey the water away, identified in the 2004 NAO report[1] is no longer tenable given recent knowledge advances that see all forms of water in the urban environment as potential resources and a means of providing opportunities to enhance urban living at low cost. For example, the 'Greening for Growth' project in Victoria in London[2] seeks to embed the natural environment in the creation of a sustainable and climate-resilient 126ha business area. Without surface water management, providing irrigation for the green areas and also controlling flooding of Victoria station using 25ha of green roofs that deal with 80,000m3 of rain water annually, the scheme would not be able to be delivered.

4.3.2 Alternatives for the management of stormwater nearer to source have been considered during the formulation of the TTT scheme. The first of these was a study by Black and Veatch for the 2005 scheme review. This reported that there were some grounds for considering the use of SuDS in certain areas.

4.3.3 The most comprehensive assessment of SuDS viability was carried out in 2009. This was presented in the consultation of 2010 as Appendix E[3]. The specification for this study, as for those earlier, was to determine the cost and effectiveness of the use of SuDS in reducing or eliminating overflows into the River. No wider considerations, such as flood risk reductions or quality of urban life were to be considered in the study.

4.3.4 Due to the time and resources available for the study only a limited range of SuDS could be considered for retrofitting and only 3 of the sewer catchments in the TTT area could be studied. The three example areas were located in the west of the catchment, south of the River Thames; the subcatchments contributing to the West Putney, Putney Bridge and Frogmore (Buckhold Road) CSOs. Frogmore (Buckhold Road) comprises 454ha mixed use urban area; West Putney and Putney Bridge catchments are 425ha and 142ha respectively. This study showed it was relatively straightforward to disconnect significant amounts, easily some 40% of the paved areas in the catchments examined.

4.3.5 Computer modelling by CH2M Hill showed particularly promising results for the potential disconnection in the Putney Bridge and Frogmore subcatchments. For the typical year, the 50% removal option results in reduced numbers of CSO events, maximum flow rates and total overflow volume. For Frogmore (which is the best case), for example, the number of events is reduced from 29 to 10 (-66%), and the total overflow volume from 94,500 m3 down to 21,400 m3 (-77%). The number of events producing over 1000 m3 is also significantly reduced at all three CSOs. The impact of removing the first 5mm of rainfall (via storage in blue/green roofs etc.) has little impact on the large storms considered here. However, a greater depth of 50mm would have been sufficient to contain each of the rainfall events in the typical year.

4.3.6 The study showed that disconnecting 50% of the impermeable area from the entire catchment areas would reduce the total overflow volume by 54%; reducing the number of CSO spills in a typical year to 3 (a reduction of 90%) for one of the major CSO catchments. This would require the disconnection of some 10,327ha of connected hard surfaces such as roofs, drives, car parks, roads and pavements. This is not an inconsiderable amount (equivalent to approximately 15,000 football pitches) but compared to the totality of unpaved area in the catchment it must be feasible.

4.3.7 A more constant hydraulic loading and a more constant quality of the influent of STW improve the treatment efficiency; long periods of heavy hydraulic loading require extra capacity of the sludge settlers to avoid sludge overflows. Such prolonged periods of heavy hydraulic loading would result from the emptying of the Tunnel after it was filled by a storm.

4.3.8 Ultimately these scenarios were further refined to reflect opportunities likely to be cost-effective and acceptable to relevant stakeholders, although no modeling of these options was undertaken. In this context the existence of large areas of low to medium-rise municipal housing blocks, often flat-roofed and set in extensive grassed grounds, was seen to provide an

1 *NAO (2004) Out of sight - not out of mind. HC 161 Session 2003-2004: 16 January.*

2 *Landscape Institute (2011) Local Green Infrastructure.*

3 *Ashley, R, Stovin, V, Moore, S, Hurley, L, Lewis, L and Saul, A, 2009, London Tideway Tunnels Programme Thames Tunnel Project Needs Report - Potential source control and SUDS applications: Land use and retrofit options 29th July 2009 [http://www.thamestunnelconsultation.co.uk/consultation-documents.aspx]*

excellent and cost-effective opportunity for retrofitting SuDS. Whilst not providing a complete solution to all of the CSO spills, SuDS were shown to be effective enough at making significant reductions such that the residual spills at certain CSOs could be managed locally and/or a reduced length of tunnel could be employed much as is being done in Philadelphia, Boston and a number of other cities. London is unusual in that it seems to go for a mono-solution – the Thames Tideway Tunnel but the best solution is not likely to be a mono-solution - it will need a multi-faceted, multi-strand approach.

4.3.9 There are many difficulties in implementing SuDS approaches in London. These include legal and regulatory problems in regard to transfer of 'ownership' of the redirected stormwater from Thames Water (TW) to myriad property and landowners and road and highway operators. Many of these stakeholders do not have the experience and hence the capacity to take on this responsibility and would need to be assisted by TW to develop this capacity – as an alternative, TW could develop a new business that can provide installation and maintenance of installed facilities. TW concluded from the 2009 study that the costs were high and that it would take a long time and be too disruptive to effect the SuDS option. No attempt was made to include the wider benefits of using SuDS.

4.3.10 Nonetheless urban redevelopment in general provides a significant opportunity to incrementally implement an, arguably, more sustainable and adaptable philosophy of green infrastructure to manage surface water and this will happen inevitably in London. It is desirable to consider redevelopment as 'new build' and to apply far more stringent SuDS principles than 'like-for-like' surface runoff control. The scale of redevelopment is such that in many urban areas such an approach could transform the drainage characteristics of some 10% of urban core areas over a period as short as 10 years and, on average in North-Western Europe, in a period of 50 years time about 80% - 90% of the urban area will have undergone substantial redevelopment activities.

4.3.11 SuDS are the better answer to the effect of climate change. It is expected that London will suffer more frequently from more intensive rainstorms, more droughts and more heat stress. Green infrastructure helps to cope with all three and is flexible over the period of several decades, while the Tunnel, once installed, lacks flexibility. In addition GI has a smaller carbon impact both during construction and in continuing operation.

4.3.12 Since these studies were undertaken a lot more work has been forthcoming looking at the multi-functional value of managing stormwater using green infrastructure (GI) and SuDS. In the USA and now in the UK, new tools have been developed showing that the added economic value of using GI instead of new sewers can be prodigious – some $3bn in Philadelphia for example. Such added value is highly significant given the current economic climate and could be very valuable to the local communities across London.

4.3.13 Given the latest ideas about multi-functional and multi-value GI used in conjunction with surface water management now emerging, there is the opportunity to both improve the quality of the water in the River Thames, and by using GI to manage the stormwater closer to source, simultaneously add greening to the local area at potentially lower cost than that of connecting some of the local CSOs into the new Thames Tunnel. The source control study already undertaken for the Thames Tideway Tunnel (TTT) has shown that stormwater disconnection is feasible and that the main impediment to its use is cost compared with the narrowly defined range of benefits. The Thames Water study however failed to include the known added value of the other potential benefits of using source control instead of the end of pipe storage tunnel option.

4.3.14 It is argued extensively in the TTT documents that many of the sewers in London are, effectively, running almost full in dry weather and, as a consequence, need to be increased in

size or capacity, creating additional storage this way. It is contended that further population growth will exacerbate this problem. Yet, there seems to be no attempt to consider the use of dispersed wastewater treatment plants or retrofit in peripheral catchment areas. Globally the use of decentralised wastewater facilities has grown, acknowledging their inherent flexibility and hence resilience compared with large end-of-pipe plants. In addition, decentralised facilities also reduce pumping costs. Local resource (nutrient) and energy recovery (closing the urban water, nutrients and energy cycle together) from the wastewater at these plants is seen to be a future opportunity and one that avoids the need for long distance conveyance in expensive upsized sewers.

4.3.15 TW should be setting more ambitious goals and objectives for urban drainage, water management and water supply for the short, medium and long term that focus on the opportunities rather than the threats. The Commission proposes that a new and more wide ranging cost-benefit study be undertaken to investigate the potential multi-functional value and feasibility of retrofitting mainly GI source control measures as an alternative to connecting certain of the CSOs to the tunnel and also to consider the options for decentralised wastewater treatment to tackle the overloaded sewers. The added benefits should include making London more climate resilient, integration with flood risk management measures, the Mayor's drive for additional green infrastructure via land use planning and, not least, providing green jobs and devolved responsibilities to communities under the 'Big Society' initiative.

4.3.16 This study would require access to Thames Water's computational models of the sewer network, especially to verify the effects of any proposed source control and decentralisation on the highly complex and interconnected sewer network in London as well as on the emissions of the CSOs and the STWs. The study would need to be conducted by experienced, independent and competent consultants and would need to meet the very tight timetable for responding to the impending 2nd stage Tideway Tunnel consultation. It was a disappointment to the Commission that despite numerous requests, access was not provided to the reports about the validation and results from the computer models used in the most recent analyses.

5. RECOMMENDATIONS

5.1 Planning issues

5.1.1 The Planning Act 2008 introduced a new system for issuing planning consent for large , nationally significant projects to avoid the delays that occurred in determining applications such as the Sizewell B nuclear power station and Heathrow Terminal 5. The Infrastructure Planning Commission (IPC) was established to make decisions on such projects, known as Nationally Significant Infrastructure Projects (NSIPs) guided by National Policy Statements (NPS) which clarify the issues which the IPC should take into account when considering planning applications. The provisions of the Localism Bill, at present before parliament, abolishes the IPC and decisions will now be taken by the relevant Secretary of State, with advice from a new Major Infrastructure Planning Unit.

5.1.2 A draft NPS was published on Waste Water by Defra in November 2010. For planning applications covered by this, NPS decisions will be made jointly by the Secretary of State for Environment, Food and Rural Affairs and the Secretary of State for Communities and Local Government. However, the Thames Tunnel project does not currently meet the definitions in the Planning Act for a waste water NSIP, since the Act applies to the construction or alteration of waste water treatment plants with a capacity to serve a population of more than 500,000. While the tunnel meets the population criteria, it is not a sewage treatment works. The government proposes to amend the Planning Act so that large scale storage and transfer schemes are brought within the planning regime for Nationally Significant Infrastructure Projects. The House of Commons Environment, Food and Rural Affairs (EFRA) Committee has endorsed this course of action.

5.1.3 The Draft NPS on Waste Water not only sets out Government policy on the national need for waste water infrastructure, identifying specific criteria for proving any project's needs, but also sets out, in Chapters 3 and 4, material in support of the needs case for the two London NSIPs, one of which is the Thames Tunnel, that the Government has already assessed as meeting these needs.

5.1.4 In the European context an NPS on Waste Water only is exceptional; many countries have moved to integrated plans for surface water, groundwater, waste water and water quality and water resources planning.

5.1.5 The EFRA Committee has recommended that the draft NPS be revised to produce a purely generic document by removing Chapters 3 and 4 on the replacement of the Deephams Sewage Treatment Works and the Thames Tunnel. Defra may wish to provide material in an annex exemplifying points made in the NPS by reference to specific schemes, but it should be made clear that it does not constitute information to which decision makers must have regard when considering project applications. **We believe this recommendation is of fundamental importance and give it our full support. The National Policy Statement should not include the Thames Tunnel as a specific scheme. The Statement should be a purely generic document.**

5.1.6 The draft NPS appears to be pre-empting discussion of key issues to be determined through the planning procedures. It is for the planning process and not the National Policy Statement to determine whether the Thames Tunnel meets the criteria for major waste water developments. The draft framework document has rightly been criticised for its failure adequately to consider alternative measures which might meet national needs for waste water in place of constructing new infrastructure. **We would expect the Secretaries of State, advised by the Major Infrastructure Planning Unit, to demand a rigorous analysis of all alternative means of developing the project while still delivering what is**

required by European and national legislation within an acceptable timescale. The original government decision of 2007 has been overtaken by alarming increases in costs as well as by developments in sustainable drainage practice. Assumptions made then that only a full length tunnel could deliver the required reduction in sewage discharges into the Tideway need to be robustly challenged if public value for money is to be assured.

5.1.7 The draft NPS document considers decentralisation of waste water treatment infrastructure in one paragraph (2.413). It dismisses a decentralised approach to waste water treatment as most appropriate for smaller, dispersed rural communities. Such an assessment reveals a lack of interest or understanding of global initiatives in looking at appropriate alternatives for closing the cycle of water, nutrients and energy and reducing the environmental footprint of cities. Scientific evidence is clear that adaptability in the long run will be reduced by centralising the treatment infrastructure.

5.1.8 The document states that it is the Government's policy to encourage the use of SuDS wherever possible, and that this policy was strengthened in The Flood and Water Management Act 2010. Appendix E of the Needs report, titled 'Potential source control and SuDS applications', concludes that, in the catchments which comprised the study area, it was technically feasible to retrofit stormwater disconnection measures using SuDS, which could potentially be effective at reducing the CSO spills into the River Thames. However, spill events were likely to remain above 10 events per typical year even in areas where the strategy is most practical. We recognise the significant impediments to the utilisation of SuDS in the short to medium term, but many of our witnesses at the evidence hearings are convinced that in the long term SuDs should be widely adopted in London. It is important to plan now where SuDS should be expected to contribute to the reduction of stormwater discharges. **We have recommended, in paragraph 4.3.15, that a wide ranging cost-benefit study should be undertaken to investigate the potential multi-functional value and feasibility of retrofitting mainly GI source control measures as an alternative to connecting certain CSOs to the tunnel.** The EFRA committee has recommended that Defra should undertake within 12 months a full assessment of the potential national impact of the widespread adoption of SuDs. **We recommend that, whatever might be the response from government to the EFRA Committee's recommendation for a national assessment, the cost-benefit study we call for should provide an in-depth analysis for the Beckton and Crossness catchments.**

5.2 The case for the tunnel

5.2.1 The Thames Tideway Tunnel appears to have a number of advantages over other options for drastically reducing the quantity of sewage discharges into the River Thames.

- The project would be the sole responsibility of Thames Water as undertaker to deliver. Any hybrid solution which relied in part on Sustainable Drainage Systems would make accountability for a failure to meet the required environmental standards harder to apportion.
- The entire cost of the Thames Tideway Tunnel might be funded by shareholders and, therefore, ultimately by customers of Thames Water. At a time of tight constraints on public expenditure this has obvious merits for government. There might, however, be concern on the part of shareholders at the scale, complexity and risks of the Thames Tideway Project. The Floods and Water Management Act 2010 includes, in section 35, provision for large infrastructure projects to be delivered by third party infrastructure providers, where the size or complexity of a project threatens, or is likely to threaten, the undertaker's ability to provide services for its customers. The Thames

Tunnel project characteristics suggest that this might be a candidate to be delivered using this approach. We understand that Thames Water, Defra, Infrastructure UK and Ofwat are currently considering the possible structure of an infrastructure provider for the delivery of the Thames Tunnel.

- The tunnel could possibly be delivered by 2020, although the Commission notes that there are doubts about the feasibility of this projection, with a reasonable expectation that it would meet the requirements of the Urban Waste Water Treatment Directive at least for the short term: a claim that the Commission could not verify.
- The Thames Tideway Tunnel is a stand-alone solution which does not depend on other ancilliary measures to achieve compliance with environmental regulatory requirements.
- Any solution which relies exclusively or largely on retrofitting SuDS, disconnection, and the separation of stormwater from sewerage systems would take longer to implement.
- The Thames Tideway Tunnel would provide the most efficient solution to enhancing underground storage capacity over a wide range of catchments within 10-20 years.

5.2.2 If the options for the medium to long term solutions to the problem of unacceptable discharges into the Thames Tideway could fairly be represented as simply a choice between a Tideway Tunnel or Sustainable Drainage Systems and other green infrastructure measures then the case for the tunnel would be convincing. **However the better solutions in the medium to long term will inevitably embrace a range of strategies, from source control or SuDS, to separation, storage and the enhancement of the existing sewage network and STWs.**

5.3 The case for a mixed solution

5.3.1 There is widespread agreement that SuDS have an essential role to play and this is acknowledged by Thames Water, the Environment Agency and all other proponents of the tunnel. However because SuDS is not the whole answer it is too readily assumed that the only solution available is the one which delivers on its own the required compliance with environmental regulations, including the Urban Waste Water Treatment Directive.

5.3.2 Yet the tunnel cannot provide the solution to a number of the discharge issues. Some of the historic discharges have been, and continue to be, not from Combined Sewer Overflows but from Sewage Treatment Works. Thames Water's publication of July 2011 "*Why Does London need the Thames Tunnel?*" quotes a case study of heavy rainfall during the first weekend of June 2011 causing 250,000 cubic metres of sewage to be discharged from CSOs and at least 230,000 cubic metres of sewage from the Mogden Sewage Treatment Works at Isleworth. The tunnel would have done nothing to reduce the discharges from the Mogden Sewage Treatment Works.

5.3.3 The Thames Water publication, "*Why Does London need the Thames Tunnel?*", states that the Thames Tunnel needs to control or intercept 34 of the CSOs that discharge to the River Thames through central London. At the time of writing, Thames Water's most recent proposals allow for 16 of these 34 CSOs to be dealt with by adaptations of the existing sewer network, allowing for indirect interception by the tunnel, while the 35th will be controlled by the Lee Tunnel and the 36th has already been addressed by a local scheme. The methods of adapting these CSOs include the construction of new overflow weirs off the interceptor sewers, controlling flows and the enhancement of the capacity of Sewage Treatment Works (STWs). 18 CSOs are to be directly intercepted by the Thames Tunnel at an individual cost equivalent to

some £200m each.

5.3.4 We were told by the Environment Agency that the existing network is running at near full capacity in certain parts of the sewerage network, even in dry weather. The fact that certain CSOs discharge after just 2mm of rain is frequently cited as justification for the full tunnel. Each CSO presents separate issues and it is essential to demonstrate in each case that only connection to the tunnel can provide the required control at an acceptable price and within the required timescale.

5.3.5 The proposed Thames Tideway Tunnel Project is predicted to reduce the annual volume of storm sewage discharges into the Thames by 93%, of which over half will be achieved by the work already in progress on the Lee Tunnel and the upgrading of the five STWs. The cost of constructing the 7 km Lee Tunnel (£635m) and upgrading the five STWs (£675m) is expected to amount to some £1.3billion. It is evident, therefore, that the next stage of the Thames Tideway Tunnel Project, the construction of the full length tunnel of 23 kilometres, at a cost of approximately £3.6 billion, appears to offer less value for money. It is expected to reduce storm sewer discharges, which before the commencement of the Thames Tideway Tunnel Project amounted to 39 million cubic metres, from 18 million cubic metres to 2.6 million cubic metres. After the tunnel is complete there will still be periodic discharges from the Sewage Treatment Works and approximately 2.6 million cubic metres discharged annually from CSOs. The annual number of CSO discharges would fall from an average of 60 a year to four or less.

5.3.6 We were told by Thames Water that if the extended works at Mogden had been in place there would have been five occasions over the previous 13 years when an overflow would have been made from Mogden STW, with a total estimated volume of some 3.3 million cubic metres. As this sewage treatment works discharges into the western reaches of the Tideway, its overflows might have potentially more adverse impacts than overflows of untreated sewage from the other sewage treatment works sited downstream.

5.3.7 The Environment Agency has assessed 10 CSOs using limited accuracy computer models as being unsatisfactory in terms of dissolved oxygen standards. The largest discharges from these 10 CSOs are attributed to Abbey Mills Pumping Station which will be addressed by the Lee Tunnel. All of these ten CSOs are also considered unsatisfactory in terms of aesthetic standards and seven are considered unsatisfactory in terms of health standards. These ten CSOs are Abbey Mills P/S, Greenwich P/S, Deptford , Hammersmith P/S, Falcon Brook P/S, Heathwall P/S, Western P/S, Lots Road P/S, Ranelagh and Acton. Nine are to be connected to the Thames Tunnel and one to the Lee Tunnel [see Map 2]. We accept that the discharge from these ten CSOs, considered unsatisfactory by the Environment Agency, must be addressed, though we note that Professor Chris Binnie, who was chairman of the Thames Tideway Strategy Steering Group from 2000 to 2006 has suggested, in his recent Review of the Tunnel, that there might be no absolute need to deal with the dissolved oxygen impacts from Greenwich P/S and Deptford. His Review can be found at: http://www.lbhf.gov.uk/Directory/News/ttc.asp. We refer further to Professor Binnie's Review at paragraph 5.3.24 .

5.3.8 These ten CSOs (including Abbey Mills Pumping Station) account for nearly 80% of the total load discharged from all the CSOs. In its paper, *'An Assessment of the Frequency of Operation and Environmental Impact of the Tideway CSOs'*, The Environment Agency states that if these loads were removed , there would not be a significant effect on dissolved oxygen from the remaining CSOs.

5.3.9 35 of the 36 unsatisfactory CSOs are designated by the Environment Agency as having unacceptable aesthetic impacts and 16 are designated as having unacceptable health standards [see Map 3]. Only one CSO is deemed unsatisfactory for health impacts alone. This is Holloway CSO which is not to be connected to the Tunnel but to be controlled by diversions and gate

modifications that direct CSO overflows to the Northern Low Level 1 sewer.

5.3.10 The criteria for assessing the effect of CSO discharges on aesthetic quality is less straight forward than that for assessing the impact on dissolved oxygen. The Environment Agency's methodology takes into account location, ease of access to the public and the number of people in the vicinity, as well as frequency and size of discharges.

5.3.11 While we accept the need to take into account both aesthetic and health impacts, as well as dissolved oxygen impacts, we are not persuaded that the determination of which CSOs fail for aesthetic standards conducted by the Environment Agency stands up to rigorous review. Ten CSOs have been deemed to pass the Environment Agency's own assessment for dissolved oxygen impacts, aesthetic quality or health impact yet have been assigned to Category 2 (discharges that have an adverse environmental effect) rather than Category 3 (discharges that do not have an environmental effect). These are Shad Thames P/S, Earl P/S, Church St, Queen Street, Smith St, KSP, Grosvenor, Savoy St, Norfolk St, Essex St [see Map 4]. All of these CSOs except Earl P/S are to be adapted by control within the network rather than by direct interception by the tunnel.

5.3.12 The justification for overriding the evidence has been given to us as 'based on visual observation made by Thames Water, Environment Agency and due to public complaints received'. This calls into question the scientific rigour and validity of the whole assessment exercise conducted by the Environment Agency which scores and ranks each CSO on accepted criteria, only for visual observations and public complaints ultimately to determine if a CSO is assessed to be satisfactory or unsatisfactory.

5.3.13 Two of the 18 CSOs which are to be directly intercepted are designated unsatisfactory because they are considered to have failed to meet aesthetic standards only (Regent Street and Earl P/S).

5.3.14 In summary there are a total of 36 CSOs assessed as unsatisfactory. Of the 18 CSOs to be intercepted by the Thames Tunnel, 6 are deemed to be unsatisfactory for dissolved oxygen, aesthetic and health standards, 2 for dissolved oxygen and aesthetic standards, 8 for health and aesthetic standards and 2 for aesthetic standards. Abbey Mills P/S, which is to be controlled by the Lee Tunnel,was deemed unsatisfactory because of dissolved oxygen and aesthetic standards. Of the 17 CSOs which are to be controlled within the network and by a local scheme 1 CSO was considered unsatisfactory because of dissolved oxygen, health and aesthetic standards, 3 CSOs were considered unsatisfactory on aesthetic and health standards, 12 on aesthetic standards only and one on health standards only.

5.3.15 **It is crucially important that there is full confidence in the methodology for these assessments. The cost implications of these designations are far reaching and it is therefore essential that the pragmatic approach adopted for determining whether a CSO has adverse environmental impacts is replaced by ample monitoring of results, a decent data analysis – including the use of validated models - and a measure which can be precisely calculated. This should then be linked to an uncertainty assessment linked to clear estimates of costs and benefits.**

5.3.16 The health standards should be reviewed by the Chief Medical Officer to determine whether these appropriately reflect the association between CSO spills and elevated health risk. While no CSO is to be intercepted to meet health standards alone, eight are to be intercepted to meet both health and aesthetic standards and two are to be intercepted to meet aesthetic standards alone. While this may lead to desirable improvements to the quality of the Tideway, the concept of Best Technical Knowledge Not Entailing Excessive Cost (BTKNEEC), which is stipulated in the Urban Waste Water Treatment Directive, might suggest a more cost effective solution to meet the health and aesthetic objectives than the connection of these ten CSOs to a full length tunnel. Some of the options might include source control measures by SuDS and

disconnection of paved area and/or end of pipe measures such as the use of screens, skimmers and UV disinfection.

5.3.17 We note that 17 of the 36 unsatisfactory CSOs have proved capable of resolution by implementing local solutions, such as the construction of new overflow weirs. We would expect a detailed review to be undertaken of what other incremental improvements could be made to the drainage and sewer network with a particular focus on the less frequent discharging CSOs which are to be connected to the Tunnel. These include Stamford Brook and North West Relief. It would be most instructive to commission a specific study for such infrequent dischargers to determine what measures might be expected to lead to an almost total elimination of discharges in future.

5.3.18 Any appraisal of the possible solutions to the problem of unacceptable discharges into the Thames Tideway must determine priorities. The Thames Tideway Tunnel Project commissioned first the construction of the Lee Tunnel, at a cost of £635 million, and the extensions to the Sewage Treatment Works (Mogden £140 million, Crossness £220 million, Beckton, £190 million, Riverside £85 million and Long Reach £40 million).

5.3.19 The Lee Tunnel will remove the worst offending CSO at Abbey Mills. Any alternative to a full length tunnel must, as a first priority, reduce or eliminate the discharges from the remaining nine CSOs which impact most seriously on water quality (see paragraph 5.3.7). From West to East these are Acton, Hammersmith P/S, Falcon Brooks P/S, Lots Road, Ranelagh, Western P/S, Heathwall P/S, Deptford and Greenwich P/S.

5.3.20 The next priority should be to reduce or eliminate the discharges from the remaining ten CSOs for which to date no local solution has been found. From West to East these are West Putney, Putney Bridge, Frogmore, S W Relief, Clapham, Brixton, Regent Street, Fleet, NE Relief and Earl P/S.

5.3.21 Of the nine CSOs which impact most seriously on water quality in the first priority category, seven are in the western reaches of the Tideway, from Acton to Heathwall. Another four CSOs of the second priority are in this western reach of the Tideway. The Jacobs Babtie review of 2006, appointed by Ofwat to review the Thames Tideway Project, recommended that a partial tunnel solution (Option H), investigated but rejected by the Thames Tideway Strategic Study, should be adopted in place of a full length tunnel. A 9km long, 7.2 m diameter western storage tunnel was recommended to be built from Hammersmith to Heathwell Pumping Station. The Babtie review also recommended a range of measures to complement the partial solution, including separation, SuDS, storage, and real time control.

5.3.22 We regret that the approach of a range of measures was not adopted. The Jacobs Babtie proposal was rejected as non-compliant with the Urban Waste Water Treatment Directive. The full length tunnel is now promoted as the only solution which can provide adequate storage and, therefore, prevent non-compliant discharges. **The alternative options of reducing flows by separation, by green infrastructure, by the construction of local detached sewage treatment works, by the construction of distributed storage, and by the enhancement of the existing sewage network, thereby allowing a partial tunnel solution at a lower cost or even a non-tunnel solution, have never been adequately tested.**

5.3.23 We recognise the practical difficulties of finding a suitable site for one or more new local detached sewage in the Beckton or Crossness catchments and such an option would inevitably prove controversial. However there are smaller footprint plants installed successfully elsewhere in urban settings. If a site could be identified near the river, the by-products such as screenings and sludge might be removed from the site by river transport.

5.3.24 We have noted with interest the recent Review of the Tunnel produced by Professor Chris Binnie, who chaired the Thames Tideway Strategy Group from 2000 to 2006. He now believes that the Western Tunnel, connecting with Acton and extending to Heathwall, should be revisited in the light of the improvements to be delivered by the Lee Tunnel and the upgrading of the Sewage Treatment Works. He also suggests that present estimates of projected dry weather flows are overestimated, and that some of the environmental standards are in certain respects inappropriate. His full review can be found at: http://www.lbhf.gov.uk/Directory/News/ttc.asp

5.3.25 We welcome this contribution to the debate on the case for a full length tunnel and agree that there must be a rigorous re-appraisal of the cost-benefits of the preferred scheme.

5.3.26 Due to the focus on the full length tunnel, precious time has been lost to retrofit SuDS and disconnect paved surfaces from the combined sewer system in order to reduce the total CSO volume.

5.3.27 Due to the substantial budget required for the construction of the full length tunnel hardly any budget can be made available over the next decades for the implementation of other components of a mixed solution, such as for flood risk reduction, without spending considerably more money.

5.3.28 **There has been no public information about the energy and carbon impact of the tunnel. Defra told us that they expected Ofwat to require this only at the next asset management planning 5 year review in 2014. We believe that there needs to be an assessment made of the environmental impact of the tunnel, in comparison with alternative solutions, before any decision is taken on its construction.**

5.3.29 **We believe that there needs to be a new joint governance structure in the Capital to successfully develop and deliver an integrated, long term approach to addressing London's drainage and urban water management needs. This should bring together Thames Water, the Environment Agency, Defra, the GLA and the London boroughs and other key groups such as CC Water.**

5.4 The infraction proceedings

5.4.1 Annex 1 of the UWWTD states that the design, construction and maintenance of collecting systems shall be undertaken in accordance with the best technical knowledge not entailing excessive costs (BTKNEEC). The BTKNEEC provision seeks to ensure that the best possible technical knowledge is used to prevent environmental damage being caused from wastewater discharges, up to the point where an increase in the level of technology leads to an excessive cost compared to the lower level of technology. In other words, the cost of a scheme using 'best technical knowledge' becomes excessive if a less costly, lower technology-based scheme is equally compliant with the UWWTD.

5.4.2 In Defra's regulatory impact assessment for sewage collection and treatment for London in March 2007, it states that:

"The Directive recognises that overflows will occur, as it is not possible to construct collecting systems and treatment plants so as to treat all waste water during situations such as unusually heavy rainfall. It therefore requires member states to decide on measures to limit pollution from storm water overflows. It is considered there is some flexibility in terms of the measures we can consider and apply to limit pollution from storm water overflows."

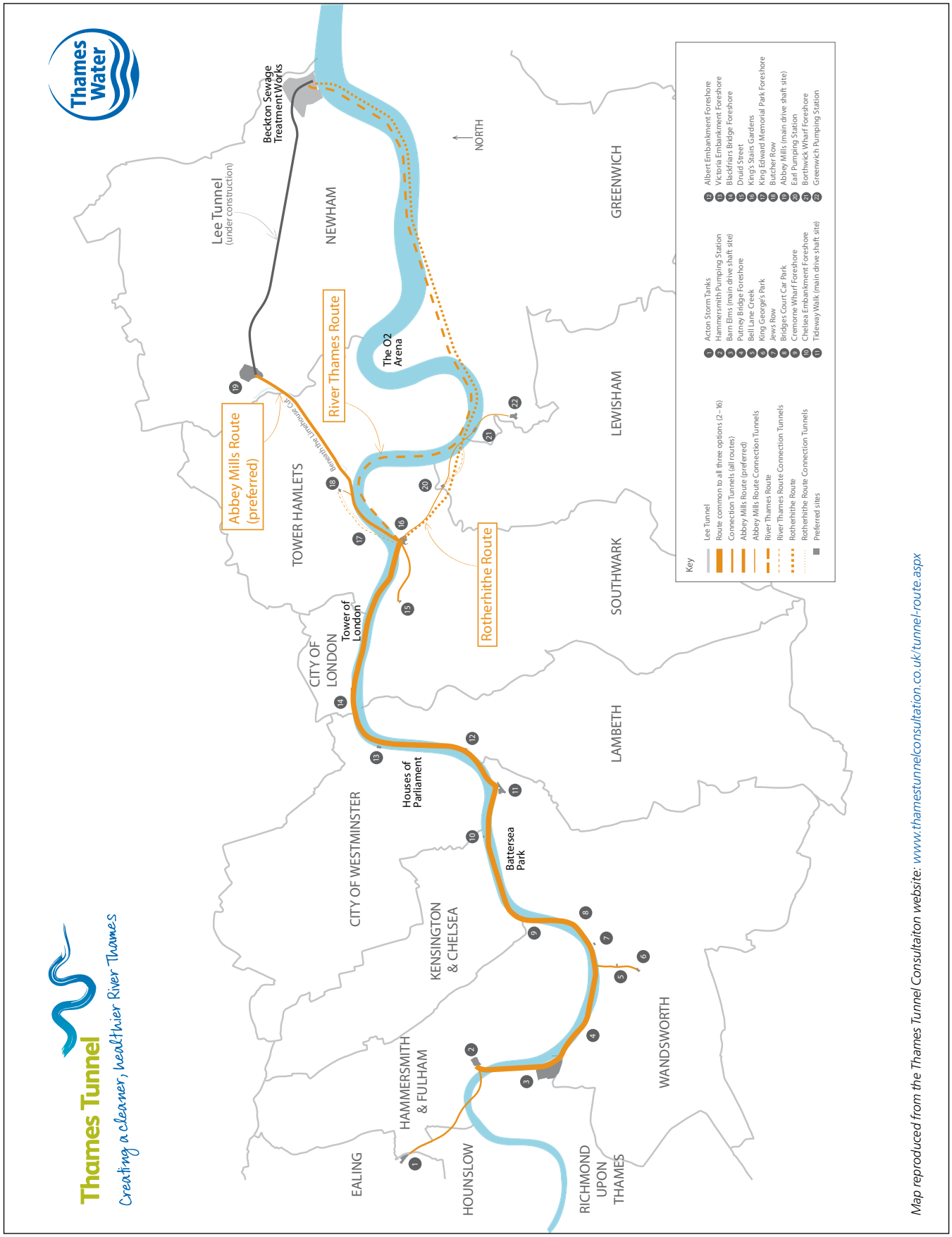
5.4.3 Given these two conditions, the Commission finds, as many of the other testimony provided to the Commission also supports, that the UK's implementation of the Urban Waste Treatment Directive 1991/271/EEC and the Water Framework Directive have been interpreted in a

restrictive way. It is the Commission's understanding that the EU Directive requires pollution to be reduced, not eliminated, and that it is up to member states to determine prescribed limits for the ecological health of rivers. In the case of the ecological standards, the TTSS may have set the standards too high in the early 2000's to deliver a scheme today that does 'not entail excessive cost'—another important component to interpreting the EU Directive. The Commission also finds that aside from the rising cost consideration of the full-length tunnel, there is a need to examine whether green infrastructure technology may alleviate the conditions that cause and exacerbate CSOs.

- **Therefore, the Commission recommends that the 2007 Ministerial request of Thames Water to pursue a full-length storage tunnel be reconsidered, so that the full range of 'best technical knowledge' options available to manage stormwater are evaluated with equal consideration as the tunnel in meeting compliance with the Urban Waste Water Treatment Directive. The Commission also encourages Defra to inform the EU proceedings for the need for an environmental and economic reassessment to ensure that not only stormwater overflow issues are addressed but also flooding and wider societal benefits, and that the options pursued do not entail excessive cost for the benefits accrued in today's economic climate.**

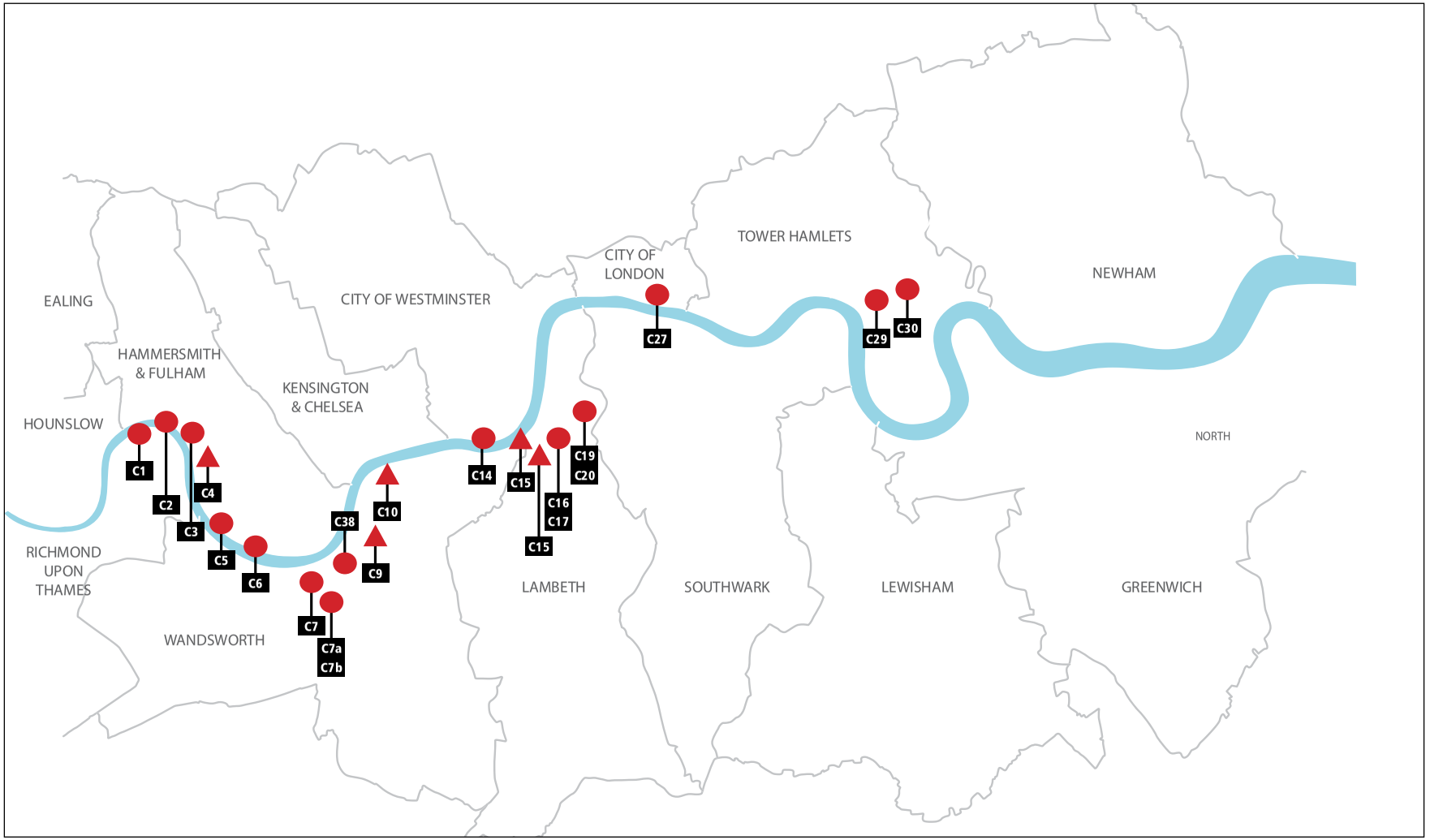
MAPS

1 Preferred Abbey Mills route



Map reproduced from the Thames Tunnel Consultaiton website: www.thamestunnelconsultation.co.uk/tunnel-route.aspx

2 Unsatisfactory CSOs for dissolved oxygen



Legend

- ▲ Combined sewer overflow (CSO)-Pumping Station to be intercepted
- ● Combined sewer overflow (CSO)-Gravity to be intercepted

- C1 Acton Storm
- C2 Stamford Brook
- C3 North West Storm Relief
- C4 Hammersmith PS
- C5 West Bridge
- C6 Putney Bridge
- C7a Frogmore Bell Lane
- C7b Frogmore Buckhold Road
- C8 Jews Row
- C10 Lots Road
- C14 Ranelagh
- C15 Western PS
- C16 Heathwall
- C17 South West Storm
- C19 Clapham
- C20 Brixton
- C27 Fleet Main
- C20 North East Storm Relief

4 CSOs placed in Category 2

APPENDIX A

Members of the Thames Tunnel Commission

Chairman – The Earl of Selborne GBE FRS

Lord Selborne has sat in the House of Lords since 1972. He chairs the Foundation for Science and Technology and is a former Chairman of the Lords Select Committee on Science and Technology. He is the current Chairman of the Partners Board of Living with Environmental Change and has been President of the Royal Geographical Society and Chancellor of the University of Southampton.

Commission Member – Professor Richard Ashley

Professor Ashley is Professor of Urban Water at Sheffield University and a Chartered Civil and Environmental Engineer. He is recognised internationally for his work on computer modeling of the performance of sewer systems. He holds research posts at Lulea technical university in Sweden; the University of Bradford and UNESCO IHE Delft, Netherlands, and was a member of the DTI team that undertook the Foresight studies into future flood risks in the UK, an adviser to the inquiry into Water Management in the UK in 2006, the Pitt review of the UK floods of 2007. He has many years experience in sustainability assessment and now works on several EU projects on flood resilience and adaptation to climate change. He also advises OECD on water infrastructure, works with Australian and US partners on water sensitive urban design and flood risk worldwide.

Commission Member – Henry Henderson, Natural Resources Defense Council

Henry Henderson is the director of NRDC's Midwest office, which opened in Chicago in 2007. Before joining NRDC, Henry served as a partner in the Chicago-based environmental consulting firm Policy Solutions Ltd. Henry was the founding commissioner for the City of Chicago's Department of Environment from 1992 to 1998. As commissioner, he developed an environmental mission for the city, which included the development of the Chicago Brownfield Initiative, a natural resources rehabilitation initiative, the city's energy policies and utility regulations, and Chicago's clean air initiative to improve regional air quality while promoting economic development. Henry served as the Illinois assistant attorney general from 1985 to 1987. Over the past 10 years he has taught environmental law and policy at the University of Chicago, the University of Illinois and Kent College of Law.

Commission Member – Dr Jean Venables CBE

Jean Venables is a Chartered Civil Engineer and Chartered Environmentalist with an MSc in Public Health Engineering and a long involvement in water and wastewater engineering, water pollution control, water resources issues and flood risk management. From 1994 to 2003, she was Chairman of the Thames Region Flood Defence Committee. She initiated the Thames Estuary 2100 project and was an expert advisor to the project team. In 2006 she was appointed and remains Chief Executive of the Association of Drainage Authorities. In 2008/09, Jean was President of the Institution of Civil Engineers (ICE) and is now a member of the ICE Water Panel and Chairman of the ICE Professional Conduct Committee.

Commission member - Dr.ir. Frans H.M. van de Ven, Deltares and Delft University

Frans van de Ven is leader of the Urban Land & Water Management team at Deltares, the Dutch independent institute for delta technology, and he is associate professor of Urban Water Management at the Faculty of Civil Engineering and Geosciences at Delft University of Technology. He holds a PhD in Hydrology and is leading research worldwide on limiting the environmental footprint of cities and making them climate resilient and subsidence-free. This

includes research on improved concepts for urban water management and better methods for urban drainage design and water quality control.

Secretariat

Peter Smith	London Borough of Hammersmith and Fulham
Alex Kennaugh	Natural Resources Defense Council
Tom Conniffe	London Borough of Hammersmith and Fulham
Dr Louise Walker	EcoFutures Ltd

The members of the Commission express their deep gratitude to the above for all the assistance they have given in producing this report.

APPENDIX B

Bibliography

Thames Tunnel Studies and Reports

The Main Thames Tideway Tunnel documentation:

- Thames Tideway Strategic Study – Steering Group Executive Summary (Thames Water, February 2005)
- Thames Tideway Strategic Study – Supplementary Report to Government (Thames Water, November 2005)
- Thames Tideway Strategic Study Independent Review – Phase 1 Final Report (OFWAT/ Jacobs Babtie, February 2006)
- TTSS Summary Report: Tackling London's Sewer Overflows (Thames Water, December 2006)
  - An assessment and valuation of environmental benefits (Eftec, December 2006)
  - An assessment and valuation of environmental and social impacts and market benefits (Entec, December 2006)
  - Tideway Tunnel Cost Benefit Analysis (NERA, December 2006)
- Regulatory Impact Assessment, Sewage Collection and Treatment for London (Defra, March 2007)
- Site Selection background papers (Thames Water, May 2009)
- Project Overview (Thames Water, Summer 2010)

Technical Studies:

- Tideway – Refinement of Option A (Faber Maunsell, August 2004)
- Connections – CFD Modelling (Thames Water R&T, November 2004)
- Land & Planning Reports (Cascade, 2004)
- Budget Costs phases 5 to 7 (EC Harris, 2004)

- Renewable Energy Options (National Energy Foundation, October 2004)
- Pumping Study (KSB, December 2004)
- Tideway Storm Event Sampling (Thames Water R&T, December 2004)
- Tideway Investigation (Halcrow)
- Hydraulic, O&M and H&S Study (WS Atkins)
- Underground Works Study (Faber Maunsell)
- Settlement & Ground Movement Study (GCG)
- Treatment Study (Binnie, Black & Veatch)
- Pumping Study (KSB)
- Power (McLellan)
- Screening (Thomson RPM)
- Litter Disposal Paper (Thames Water Engineering)
- Control System (Thames Water Engineering)
- River Quality Study (Environment Agency)
- Thames Tideway Strategy; Sustainable Urban Drainage Systems (SUDS) Study (Binnie, Black & Veatch, November 2002)
- Thames Tideway Strategy; Land, Planning and Environment Strategic Review (Land Use Consultants & Cascade Consulting, 2002)
- Construction Cost Estimates (EC Harris)
- Derivation of Budget Capital Costs (Thames Water Engineering)
- Derivation of Budget Operational Costs (Thames Water Engineering)

The following complementary studies were also commissioned:

- Fish Trial (Environment Agency)
- SCITTER (Thames Water Engineering and R&T, July 2003)
- Flow Monitoring (Thames Water Engineering)
- Catchment Modelling (Thames Water Engineering)
- Literature Search (Thames Water R&T)
- Legislation (Thames Water Legal Department)

Other supporting documents:

- CSO Interception Review (Environment Agency, April 2004)
- Interim/Smaller Scale Measures to Alleviate the Environmental Damage Caused by the CSO Discharges (Environment Agency, September 2004)
- Key risks considered in developing a solution for London's combined sewer overflows (Environment Agency June 2004)
- Use of Tetra Deep-Bed Filtration for Treatment of Wet Weather Overflows (Slack D,

Fleming H, Hart J – Severn Trent Services, undated)

- Investigating and modelling the development of septic sewage in filled sewers (Robert Bachmann, Adrian J Saul, Robert Edyvean – Sheffield University, 2004)

International Studies and Reports

1. 'The Chicago Green Alley Handbook' (City of Chicago)
2. 'A Guide to Stormwater Best Management Practices: Chicago's Water Agenda' (City of Chicago, 2003)
3. Rooftops to Rivers: Green strategies for controlling stormwater and combined sewer overflows (Kloss&Calarusse, Natural Resources Defense Council, June 2006)
4. London: Garden City? Investigating the changing anatomy of London's private gardens and the scale of their loss (London Wildlife Trust/GLA, 2010)
5. Changing Course: Delivering a sustainable future for the water industry in England and Wales' (Severn Trent Water, April 2010)
6. The Economics of Ecosystems and Biodiversity: Mainstreaming the economics of nature; A synthesis of the approach, conclusions and recommendations of TEEB (TEEB, 2010)
7. The Economics of Ecosystems and Biodiversity: A quick guide to TEEB for local and regional policy makers (TEEB, 2010)
8. Economical CSO Management, Gunderson et al (Stormwater, May 2011)
9. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions: 'Our life insurance, our natural capital: an EU biodiversity strategy to 2020' (Brussels, May 2011)
10. City of Philadelphia: 'Green City, Clean Waters' http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan
11. New York City's Green Infrastructure Plan and Surface Water Management Plan.

APPENDIX C

The following organisations and individuals (listed in alphabetical order) responded, in writing, to the Commission's open call for evidence, issued in July 2011.

Lord Berkeley, Chairman of the Rail Freight Group

Mr Raj Bhatia B Arch RIBA, Dip TP

Professor Chris Binnie MA, DIC, Hon DEng, FREng, FICE, FCIWEM.

City of Philadelphia

Consumer Council for Water

Comer Brothers

Professor J. Bryan Ellis, Middlesex University

Environment Agency

Greater London Authority

Justine Greening MP's Working Group

Mr WAH Hamilton

Simon Hughes MP

Mr Graham King

London Borough of Greenwich

London Borough of Hammersmith & Fulham

London Borough of Lambeth

London Borough of Richmond

London Borough of Tower Hamlets

London Borough of Wandsworth

London Forum of Amenity and Civic Societies

Lloyds Emerging Risks Team

Milwaukee Metreopolitan Sewerage District

Ofwat

Mr David Percival MICE

Peterborough Road and Area Residents Association

Port of London Authority

The Putney Society

Save King Edward Memorial Park

Save Kings Stairs Gardens Action Group

Save Your Riverside Action Group

Smart Sponge Products Ltd

Stop the Shaft

Ms Jennifer Slaney

Mr Graham Taylor, Bermondsey and Rotherhithe Environment Group

Mr & Mrs Taylor

Thames Bank

Thames Water

Wandsworth Society

Westminster City Council

Wildfowl and Wetlands Trust

APPENDIX D

Oral Evidence Hearings

Oral evidence was heard over three days (on 17 & 18 August and 8 September) from the following organisations and their named representatives (in order of appearance):

Thames Water:

RICHARD AYLARD, External Affairs Director

PHIL STRIDE, Head of London Tideway Tunnels

MIKE GERRARD, Managing Director, Thames Tunnel Project

HOWARD BRETT, Waste Water Policy and Strategy Manager

DAVID CRAWFORD, Assistant Integration and Modelling Lead

Consumer Council for Water:

DAVID BLAND, Chairman, South East

ANDREW WHETNALL, Member, South East

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APPENDIX E

List of Abbreviations

The following abbreviations have been used in this report:

BOD	- Biochemical Oxygen Demand
BTKNEEC	- Best Technical Knowledge Not Entailing Excessive Cost
CCW	- Consumer Council for Water
CSO	- Combined Sewer Overflow
Defra	- Department of Environment, Food and Rural Affairs
DEP	- Department for Environmental Protection
EA	- Environment Agency
EC	- European Commission
EFRA	- Environment, Food and Rural Affairs
EU	- European Union
GI	- Green Infrastructure
GLA	- Greater London Authority
ICE	- Institution of Civil Engineers
IPC	- Infrastructure Planning Commission
LID	- Low Impact Development
NAO	- National Audit Office
NPS	- National Policy Statement (on Waste Water)
NSIP	- Nationally Significant Infrastructure Project
Ofwat	- Office of Water Services
P/S	- Pumping Station
STW	- Sewage Treatment Works
SuDS	- Sustainable Drainage Systems (formerly: SUDS - Sustainable Urban Drainage Systems)
TTSS	- Thames Tideway Strategic Study
TTT	- Thames Tideway Tunnel
TW	- Thames Water
UWWTD	- Urban Waster Water Treatment Directive
WSUD	- Water Sensitive Urban Design

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