Safety and Sustainability Panel

Date: **15 July 2014**

Item 6: **Structures and Tunnels Investment Portfolio – Managing Safety Risks**

This paper will be considered in public

1 Summary

1.1 The purpose of this paper is to describe the risk assessment approach used by Surface Transport Asset Management to evaluate the safety, functionality and environmental risks associated with Surface assets. This follows a request from Finance and Policy Committee members in March 2014 when considering project authority for the Surface Transport Structures and Tunnels Investment Portfolio (STIP) implementation. The paper describes the risk scores for the STIP and explains why they will have different levels of risk following completion of works. The paper also describes the interim measures in place for these assets to ensure safety is maintained prior to the completion of works.

2 Recommendation

2.1 **The Panel is asked to note this paper.**

3 Background

3.1 There are over 1,800 structures on the Transport for London Road Network (TLRN), including 475 bridges and footbridges, 676 retaining walls and 281 subways. There are also 12 major road tunnels, including Blackwall, Rotherhithe and Limehouse. In 2010/11, a major study was undertaken to determine the interventions and investment needed to reduce the risk profile held against these structures and reverse the impact of decades of under-investment that preceded TfL's ownership.

3.2 Investment has been secured for the highest priority structures, including Hammersmith Flyover, Upper Holloway Bridge, Ardleigh Green Railway Bridge, Highbury Corner Bridge and Fore Street Tunnel. Up to £500m has been allocated in the TfL business plan to bring these structures into a state of good repair – this is referred to as Structures and Tunnels Investment Portfolio (STIP). Appendix 1 includes a map of the structure locations and a table with a picture and brief description of each.

4 Risk Based Prioritisation

Description of risk based approach

4.1 A risk based Value Management approach is used to prioritise all capital works on Surface Transport assets. The approach is used to assess the level of risk an

asset poses to the delivery of TfL goals and objectives. For example, the risk a bridge poses to the delivery of the Surface Outcome of Reliable Roads takes account of:

(a) **Event** – determines the specific event, say a component failure, which is a risk to Reliable Roads. The event is determined through an analysis of inspection data which is used to grade bridges and their components into condition categories that range from Very Good to Very Poor. Appendix 2 shows the number of structures in each of the condition categories.

(b) **Likelihood** of the event – the condition, component type, material and other influencing factors, such as vehicle restrictions, are used to assess the likelihood that the event will happen. Therefore, as the condition of a bridge/component deteriorates the likelihood that the event will occur increases.

(c) **Consequence** of the event – the impact on road journey reliability if the event occurs, this takes account of the type of event (e.g. minor fault, local failure or major component failure), safety impacts of the event, traffic volume, congestion and diversions caused by restricting or closing the bridge, length of time required to undertake the repair and the costs.

4.2 Together, the likelihood and consequence are used to evaluate the risk the event poses to the reliability of our roads. Appendix 3 shows the risk categories and matrix used to asses an event. This approach is consistent across asset types, enabling the risks associated with one asset type, say a bridge, to be directly compared with the risks on other assets types, such as carriageway, lighting, drainage, traffic signals and bus infrastructure.

4.3 The risk score is divided by the cost of the works to produce a Value for Money score, in accordance with the Office of Government Commerce (OCG) guidance on Management of Value.

4.4 The 2012/13 and 2013/14 Assurance Reviews of Surface Transport's asset renewal capital programmes cited this approach as industry best practice.

Risk scores for STIP

4.5 The risk scores for STIP are shown in Appendix 4 – it shows safety, functionality, environment and total risk scores for each asset, both pre and post intervention. The post intervention risk is referred to as the Residual Risk. The figures show that STIP will have a major impact on risk reduction – reducing the total risk across this portfolio of structures from £42.1m to £1.97m per annum.

4.6 One asset, Blackwall Tunnel, has a noticeably higher residual risk after the works – the annual risk reduces from £3.3m to £1.2m. This residual risk is due to the high consequences (length of traffic diversion and congestion caused) associated with tunnel restrictions and closures. The planned works will deliver considerably lower likelihoods, for example of asset faults and failures. To further reduce the likelihood would require the installation of multiple back-up systems for key mechanical and electrical equipment – this has a poor benefits/cost ratio as the costs are disproportionally higher than the benefits achieved. More impactful solutions, such as the construction of Silverton Tunnel, are required to reduce the consequence side of the equation.

4.7 Explanations for other lesser residual risks are provided in Appendix 4.

5 Managing Safety

5.1 The structures in the portfolio will be brought to a state of good repair over the next ten years. In the interim, as with all TfL owned assets, safety and functionality risks will be managed through the well established regime of inspection, monitoring, routine maintenance and interim measures.

5.2 TfL adheres to the national code of practice for bridge and tunnel inspections – for example, on bridges a General Inspection every two years and a Principal Inspection every six years. Further to this, and as recommended by the national code of practice, TfL developed a Risk Based Inspection (RBI) process for Principal Inspections. This enables the frequency of Principal Inspections to be varied from 2 to 12 years based on a range of factors. TfL's RBI approach is now being adopted by other UK highway authorities.

5.3 Appendix 5 describes the interim measures for the STIP assets to ensure risks are suitably managed until the works are delivered.

List of appendices to this report:

Appendix 1: STIP Structures
Appendix 2: Bridges by Condition Category
Appendix 3: AMD Risk Categories and Matrix
Appendix 4: STIP Risk Scores
Appendix 5: STIP Interim Measures

List of Background Papers:

None

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Appendix 1: STIP Structures

Figure 1 shows the locations of the STIP structures and Tables 1 and 2 provide a brief description of each structure and the planned works.

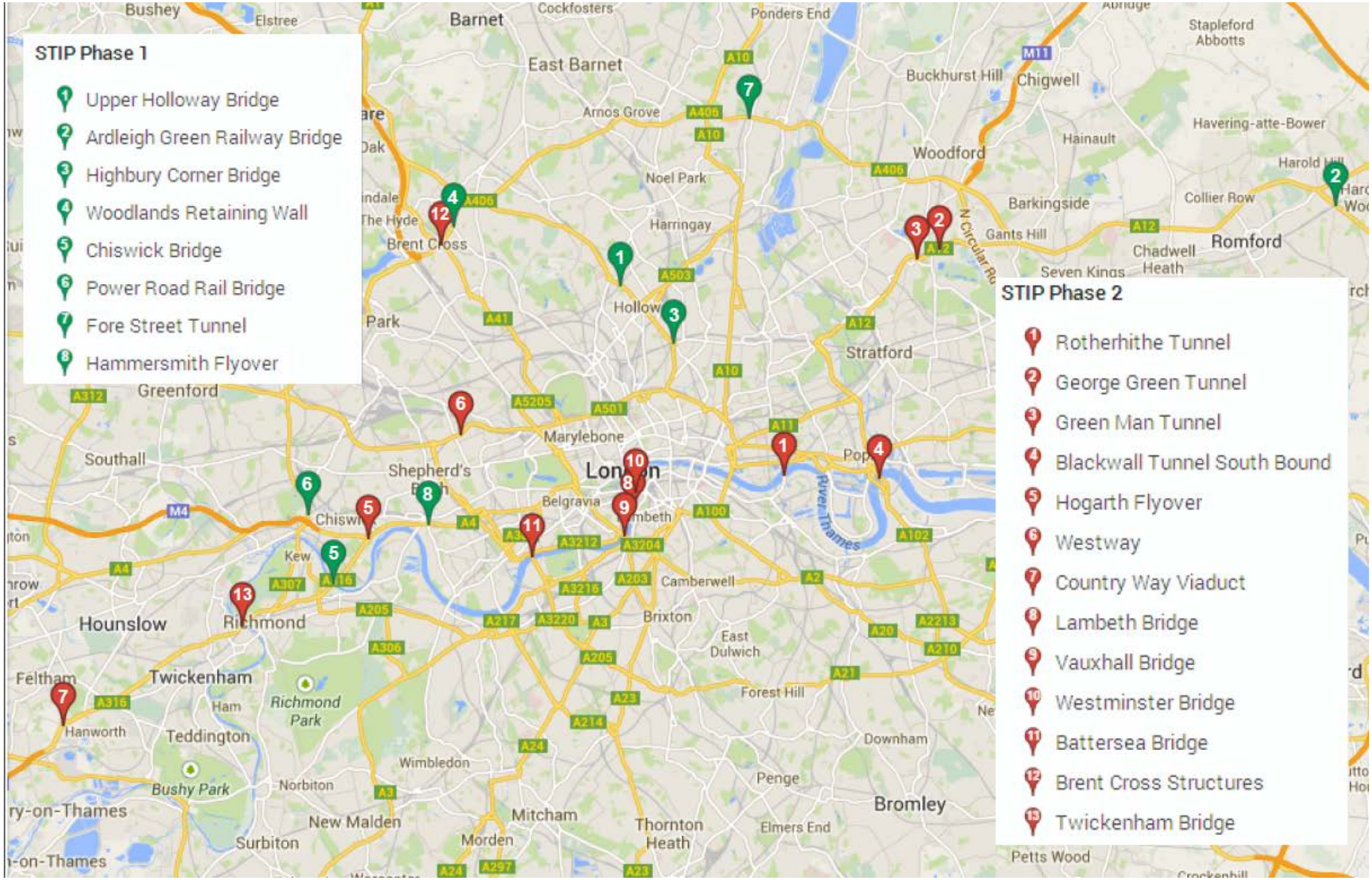
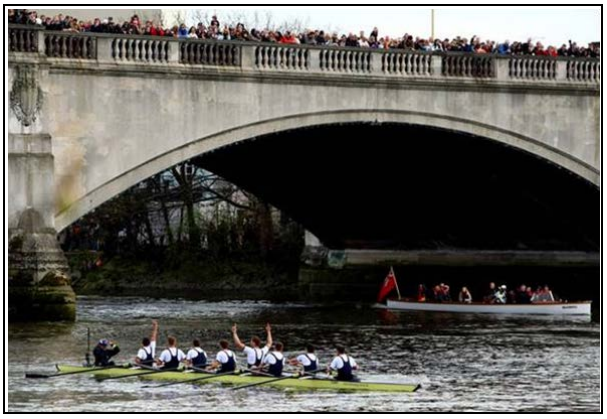


Table 1: STIP Phase 1 Structures

Structure Name	Description and planned works
1. Upper Holloway Bridge 	A road-over-rail single span bridge built circa 1868. It carries the A1 Holloway Road, comprising two traffic lanes and two bus lanes, over a section of the London Overground. The bridge is adjacent to Upper Holloway Station. The structure has deteriorated rapidly in the last 10 years and cannot be economically repaired. A full replacement is required to avoid future restrictions and closures.
2. Ardleigh Green 	A road-over-rail three span bridge carrying the four lanes of the A127 over busy railway lines. The bridge deck is riveted steel beams and concrete jack arches. The abutments are mass brickwork and the intermediate supports are riveted steel trestles. A footway, integral to the bridge, is on the east side and a separate footbridge provides pedestrian access on the west side. The whole bridge will be replaced.
3. Highbury Corner Bridge 	A road-over-rail bridge constructed circa 1930, it crosses the London Overground railway, supports the highway, and hosts commercial and residential buildings. The section of the bridge supporting the A1 highway, approx. 40m × 23m, is owned and managed by TfL, highlighted opposite in red. This section is in a poor state of repair and vehicles carrying heavy loads are restricted. The planned works are a full bridge replacement.

4. A406 Woodlands Retaining Wall 	The wall is located east of the Brent Cross interchange, on the south side of the A406 North Circular Road. It retains the gardens of properties backing onto the A406. It is approximately 200m long and made up of 55 mass concrete panels of differing lengths and heights. There are a number of services running in the vicinity of the wall, including gas and electricity. Temporary propping has been installed to prevent collapse in the short term. The whole wall will be replaced.
5. Chiswick Bridge 	Constructed in 1933, it is a five span reinforced concrete arch bridge carrying the A316 over the River Thames. It is Grade II* listed and suffering from deterioration of the deck, supports and parapets. The previous capacity assessment (in 1999) indicated minimal reserve, meaning restrictions may be necessary if further deterioration occurred (which is now the case). A major refurbishment of the bridge is planned.
6. Power Road Rail Bridge 	A three span road-over-rail bridge built circa 1922. It carries the A406 North Circular Road (Gunnersbury Avenue) over two Network Rail lines, shown opposite. The construction form is a reinforced concrete beam and slab deck supported on reinforced concrete abutments and piers. The deck is in a very poor condition and will be replaced.

7. Fore Street Tunnel 	The Tunnel was constructed by the Highways Agency and opened to traffic in 1998. It is 361m long and carries 60,000 vehicles a day in two dual carriageway bores along the A406 North Circular Road, under Fore Street Junction and Silver Street Network Rail Station. Planned works include structural repairs to address water ingress, renewal of mechanical and electrical equipment, wet and dry wells, Emergency Distribution Panels (EDP's) and associated cables, and upgrading the lighting to LEDs.
8. Hammersmith Flyover 	The Flyover is an early example of segmental post tensioned construction, being essentially held together by high tensile steel cables which run through the structure from end to end. Monitoring identified a substantial increase in the rate of deterioration (breaking of wires) in the main cables. Major strengthening and refurbishment work are on-going to bring the structure back to full capacity.

Table 2: STIP Phase 2 Structures

Structure Name	Description and planned works
1. A101 Rotherhithe Tunnel 	A single bore, bi-directional tunnel, approximately 1125m long, carrying the A101 and a pedestrian footway under the River Thames. The structure comprises cast iron segments faced with mass concrete and decorative tiles. The structure was constructed c1908 and parts of it are Grade II listed. Planned works include replacing fire mains, replacing flood gates, renewing pump stations, upgrading detection systems and ventilation, upgrading lighting to LEDs and structural repairs.
2. A12 George Green Tunnel 	A 295m long twin cell, cut and cover structure constructed from secant piles and a reinforced concrete top and bottom slabs. Each bore carries a two lane carriageway. The structure was built c1999. Planned works include upgrading lighting to LEDs, installing detection systems and wayfinding signs, and renewing safety systems and equipment.

3. A12 Green Man Tunnel 	A 297m long twin cell, cut and cover structure constructed from secant piles and a reinforced concrete top and bottom slabs. Each bore carries a two lane carriageway. The structure was built c1998. Planned works include upgrading lighting to LEDs, installing detection systems and wayfinding signs, and renewing safety systems and equipment.
4. A102 Blackwall Tunnel Southbound 	A single bore, single directional tunnel, approximately 1174m long, carrying the A102 under the River Thames. The structure predominantly comprises cast iron segments with reinforced concrete sections towards either end. The structure was constructed c1967. Planned works include upgrading the ventilation system, upgrading emergency access/egress, upgrading and renewing the tunnel safety and operational systems.
5. Hogarth Flyover Deck Replacement 	IAR Gate 4 and Project Authority Submission approved at SAB on 06/0514. The planned works are a full deck replacement
6. A40 Westway Structures Refurbishment 	The Westway is made up of approximately 50 individual structures along a 5.6km of largely elevated road between Wood Lane to the north and Marylebone Flyover to the south. The structures are predominantly of concrete construction with a mixture of pre-stressed and post tensioned decks. The structures were built in the late 60s and 70s. Planned works include repairs to post-tensioning members, replacing expansion joints and waterproofing, concrete repairs, refurbishment of sign gantries and parapet upgrades.

7. A316 Country Way Viaduct 	A 23 span continuous reinforced concrete box girder bridge deck supported by reinforced concrete columns and abutments. The structure was built c1975. Planned works include replacing expansion joints, repairing post-tensioning, repairing the drainage system and concrete repairs.
8. A3203 Lambeth Bridge Refurbishment 	A five span bridge carrying the A3202 and two footways across the River Thames in central London. The deck comprises steel arch girders and concrete slab supported by concrete piers clad with granite. There are ornamental balustrades and lamp columns in cast iron and ornamental granite obelisks on the approaches. The structure was constructed c1932 and is Grade II listed. Planned works include replacing corroded steelwork, repainting, waterproofing and renewal of joints and bearings.
9. A202 Vauxhall Bridge Refurbishment 	A five span bridge carrying the A202 and two footways over the River Thames. The deck comprises steel arch girders with a steel plate and concrete slab supported by granite faced concrete piers and abutments. The structure was constructed c1906 and is Grade II* listed. Planned works include replacing corroded steelwork, repainting, waterproofing and renewal of joints and bearings.
10. A302 Westminster Bridge Painting 	A seven span bridge carrying the A302 and two footways over the River Thames. The deck comprises wrought iron arched girders and concrete deck slab. Previous major maintenance has included strengthening of the deck, scour protection to the piers and replacement of the cast iron fascias. The structure was constructed c1862 and is Grade II* listed. Planned works included repainting and refurbishment of the deck drainage system.
11. A3220 Battersea Bridge Refurbishment 	A five span bridge carrying the A3220 and two footways over the River Thames. The bridge deck is of wrought iron, cast iron and concrete construction supported by granite and brickwork piers. The bridge was constructed c1890 and is Grade II listed. Planned works include replacing corroded steelwork, repainting, waterproofing and renewal of joints and bearings.

12. A406/A41 Brent Cross Structures 	The A406/A41 Brent Cross interchange is made up of approximately 18 structures. The structures are all concrete in construction and were built c1965. Planned works include waterproofing, parapet upgrades, bearing and expansion joint replacement and concrete repairs, and improvements to headroom and alignment all in conjunction with the major development of the shopping centre.
13. A316 Twickenham Bridge Refurbishment 	A five span concrete arch deck supporting internal columns and a concrete deck slab. Ornamental brass railings are provided to the deck edges and staircases. The structure was constructed c1933 and is Grade II* listed. Planned works include concrete repairs (arches, abutments and approaches), replace waterproofing and renewal of joints and bearings.

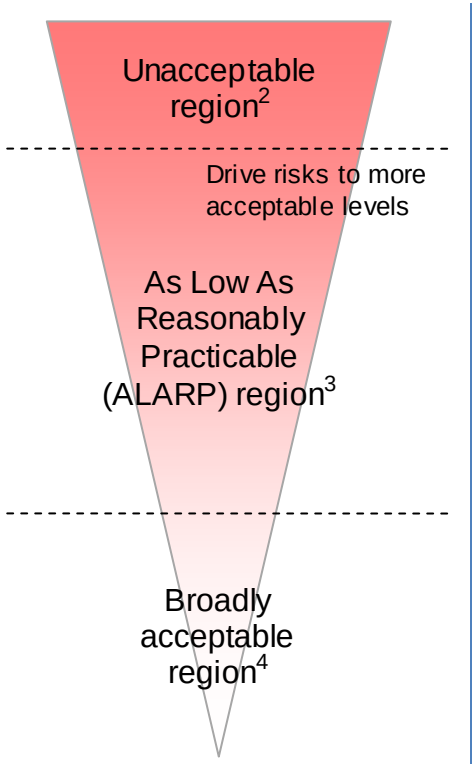
Appendix 2 TfL Bridges by Condition Category

TfL has 1,806 bridges and structures, the number of these in each of the condition categories is shown below.

Condition Category	Number of structures
Very Good	964
Good	612
Fair	214
Poor	16
Very Poor	0
Total	**1806**

The STIP portfolio of investment is addressing many of the structures in the Poor category, the others are being addressed through business-as-usual capital renewals.

Appendix 3: AMD Risk Categories and Matrix

Risk Category (£k)	Description[1]	Risk Acceptable
≥ 5,000	Critical – the asset represents an unacceptable risk to network safety and/or reliability and TfL's reputation, action must be taken to reduce the level of risk	
≥ 1,000 & < 5,000	Very High – network safety and/or reliability are at or below broadly acceptable levels, and action must be taken to improve safety and reliability	
≥ 50 & < 1,000	High – action must be taken to maintain network safety, reliability and/or State of Good Repair at or above acceptable levels, interventions may be further justified on the basis of reduced whole life costs	
≥ 5 & < 50	Medium – action should be taken to deliver preferred levels of network safety, reliability and State of Good Repair, to fully achieve Surface Transport and TfL outcomes, and to reduce whole life costs	
< 5	Low – action may be appropriate on the basis of whole life cost savings and reducing future disruption.	

Notes:
1. The level of risk is used to prioritise and inform decisions and activities
2. Unacceptable region – risks cannot be justified except in the most extraordinary circumstances
3. ALARP region – acceptable only if risk reduction is impractical or if its cost is disproportionate to the improvement gained – the degree of acceptability depends on the level of disproportionality between risk reduction (or benefit gained) and cost
4. Broadly acceptable region – risk reduction unlikely to justify intervention, however, whole life cost savings may justify intervention

	1 in x	NOTE: All risk scores are in £000's									
Likelihood	**1**	10.00	50.00	100.00	500.00	1,000.00	5,000.00	10,000.00	50,000.00	125,000.00	250,000.00
	2	5.00	25.00	50.00	250.00	500.00	2,500.00	5,000.00	25,000.00	62,500.00	125,000.00
	5	2.00	10.00	20.00	100.00	200.00	1,000.00	2,000.00	10,000.00	25,000.00	50,000.00
	10	1.00	5.00	10.00	50.00	100.00	500.00	1,000.00	5,000.00	12,500.00	25,000.00
	20	0.50	2.50	5.00	25.00	50.00	250.00	500.00	2,500.00	6,250.00	12,500.00
	25	0.40	2.00	4.00	20.00	40.00	200.00	400.00	2,000.00	5,000.00	10,000.00
	50	0.20	1.00	2.00	10.00	20.00	100.00	200.00	1,000.00	2,500.00	5,000.00
	100	0.10	0.50	1.00	5.00	10.00	50.00	100.00	500.00	1,250.00	2,500.00
	200	0.05	0.25	0.50	2.50	5.00	25.00	50.00	250.00	625.00	1,250.00
	500	0.02	0.10	0.20	1.00	2.00	10.00	20.00	100.00	250.00	500.00
	1,000	0.01	0.05	0.10	0.50	1.00	5.00	10.00	50.00	125.00	250.00
	2,500	0.00	0.02	0.04	0.20	0.40	2.00	4.00	20.00	50.00	100.00
	5,000	0.00	0.01	0.02	0.10	0.20	1.00	2.00	10.00	25.00	50.00
	10,000	0.00	0.01	0.01	0.05	0.10	0.50	1.00	5.00	12.50	25.00
	50,000	0.00	0.00	0.00	0.01	0.02	0.10	0.20	1.00	2.50	5.00
	100,000	0.00	0.00	0.00	0.01	0.01	0.05	0.10	0.50	1.25	2.50
	1,000,000	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.13	0.25
		10	50	100	500	1,000	5,000	10,000	50,000	125,000	250,000
		Consequences									

Figure 3: Risk Matrix

Appendix 4: STIP Risk Scores

STIP Project	Current Safety Risk (£)	Current Functionality Risk (£)	Current Environment Risk (£)	Current Finance Risk (£)	Total Current Risk (£)	Residual Safety Risk (£)	Residual Functionality Risk (£)	Residual Environment Risk (£)	Residual Financial Risk (£)	Total Residual Risk (£)	Comments
Upper Holloway Bridge Replacement	110,783	834,136	506	9,977	955,402	3	13	0	0	15	
Ardleigh Green Railway Bridge Replacement	290,471	1,405,332	1,405	40,493	1,737,701	3	14	0	0	17	
Highbury Corner Bridge	1,105,659	571,506	749	10,334	1,688,248	138	47	0	0	185	
Woodlands Retaining Wall	108,375	281,759	924	0	391,057	0	0	0	0	0	
Chiswick Bridge	16,945	169,612	339	479,940	666,836	1	11	0	21,562	21,574	Residual risks: waterproofing which is being maintained through localised repairs
Power Road Rail Bridge	1,128,258	919,411	4,597	4,260	2,056,526	3	2	0	0	5	
Fore Street Tunnel	1,046,600	1,324,750	55,164	125,000	2,551,514	37,000	35,000	1,000	0	73,000	Enclosed tunnels are high risk assets. These risks are managed through real time operations. The benefits of further educing the risks do not outweigh the costs.
Hammersmith Flyover Phase 2	3,308,673	3,512,237	7,024	286,785	7,114,719	1,654	1,756	4	0	3,414	
Rotherhithe Tunnel refurbishment	156,150	3,517,112	202,552	96,250	3,972,064	95,000	105,000	75,341	0	275,341	See above tunnels comments
George Green Tunnel - M&E renewal	214,000	2,464,000	80,584	43,000	2,801,584	45,000	16,000	29,974	0	90,974	See above tunnels comments
Green Man Tunnel - M&E renewal	120,000	1,332,000	46,438	34,500	1,532,938	23,000	9,000	17,273	0	49,273	
Blackwall Tunnel - SB ventilation	605,000	2,473,000	160,348	99,750	3,338,098	589,000	546,000	59,643	0	1,194,643	See above tunnels comments – also, the residual risk is higher for Blackwall due to the high consequence. The likelihood of closure is considerably reduced, but further reduction requires substantial investment and returns a poor cost/benefit ratio. More impactful solutions, such as the construction of Silverton Tunnel, are required to reduce the consequence side of the equation.
Hogarth Flyover reconstruction	649,783	2,670,133	4,156	58,956	3,383,028	11,579	227,534	100	0	239,210	Residual risk due to the 20mph restrictions after the works. If the substructure were to be replaced, however, it may be possible to allow higher speeds but the cost of this does not outweigh the benefits.
Westway	786,311	3,364,052	32,807	382,686	4,565,856	197	841	8	0	1,046	
Country Way Viaduct	4,127	115,253	184	1,625,652	1,745,217	722	20,169	32	0	20,924	
Lambeth Bridge	12,578	36,260	354	193,772	242,964	1	3	0	240	244	
Vauxhall Bridge	8,618	33,636	261	118,911	161,426	1	4	0	0	6	
Westminster Bridge	27	295	2	286,944	287,268	27	295	2	253	577	
Battersea Bridge	204,068	1,177,973	9,145	32,877	1,424,062	51	294	2	146	494	
Brent Cross Structures	103,390	1,026,594	1,643	34,103	1,165,730	52	513	1	0	566	
Twickenham Bridge (Refurb)	15,531	253,896	406	129,033	398,866	1	17	0	0	18	
Total annual risk	**9,995,347**	**27,482,947**	**609,588**	**4,093,223**	**42,181,104**	**803,433**	**962,513**	**183,380**	**22,201**	**1,971,526**	

Appendix 5: STIP Interim Measures

Structure / Project	Interim Measures Description	Frequency
Highbury Corner Bridge	Visual monitoring of web and top flange of main beams	6 monthly
Power Road Rail Bridge	Hammer tapping to identify additional areas of loose and spalling concrete	6 monthly
Woodlands Retaining Wall	Monitoring of retaining wall movements	Monthly
Hammersmith Flyover (Phase 2)	Acoustic monitoring of pre-stressing wire to identify any additional breaks	24x7
Hogarth Flyover Deck Replacement	Monitoring of spalling concrete	Weekly
Hogarth Flyover Deck Replacement	Regular inspections of the bridge deck	Monthly
Hogarth Flyover Deck Replacement	Additional propping added to support Span 17	Once - completed May-14
Westway	Acoustic tapping of expansion joints to monitor loose and cracked teeth in the metal comb joint	6 weekly
Rotherhithe Tunnel Retaining Wall	Crack monitoring	6 monthly