Assisting Decisions

Quantified Risk Assessment for Nottingham Ring Road Integrated Transport Major Scheme

Report for Nottingham City Council

May 2008



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Appendix A Project Risk Log

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1 Introduction

1.1 The scheme

1.1.1 Nottingham City Council is promoting a scheme to increase the role of the Ring Road as the principal strategic orbital route (bypassing the City Centre). The scheme proposes improvements to public transport reliability and interchange as well as enhancing conditions for pedestrians and cyclists.

1.1.2 Following preparation of the Business Case submission for the scheme, a Gateway Review 1 was undertaken by the 4p's. As part of the recommendations made by the 4p's following the Review, it was suggested that a Quantified Risk Assessment (QRA) be undertaken, using external advice.

Risk Management Implementation Strategy (RMIS)

1.1.3 Management of the project within Nottingham City Council has been undertaken in line with PRINCE2 principles and, in line with those management procedures, a Project Initiation Document (PID) was prepared. The PID included a section on Risk Management that covered:

- identification of risks;
- a project risk log;
- evaluation of risks; and
- counter measures to reduce or control the identified risks.

1.1.4 These steps meet three of four requirements for QRA as laid down by the DfT in its TAG Unit 3.5.9 – The Estimation and Treatment of Scheme Costs. To meet the final DfT requirement - to quantify the potential impact on scheme costs – a Workshop and subsequent analysis work have been initiated.

A Definition of Risk and Opportunity

1.1.5 A risk or an opportunity exists if there is a chance (probability) that an event might occur, and then if it does occur, what would be the impact (consequence) of this event on the project objectives or outcomes.

Assess and Quantify Risks and Opportunities

1.1.6 The workshop was convened to review all current management and/or engineering related risks and opportunities and evaluate the probability of occurrence and quantify the impact the occurrence might have on the project.

2 Workshop

2.1 Objectives

2.1.1 The workshop was held at Nottingham City Council offices on 7 September 2007 and attended by the following participants:

Table 2.1 - Workshop participants

Name	Organisation	Responsibility
David Whittle	MVA Consultancy	Workshop Facilitator
Dave Jones	Nottingham City Council	Transport Strategy – Business Case & Traffic Analyses
Steve Hunt	Nottingham City Council	Engineering Design & Management
Chris Capewell	Nottingham City Council	Bridges & Structures
Alistair McClean	Nottingham City Council	Traffic Signals
Peter Mann	Nottingham City Council	Highway Design
Caroline Stylianou	Nottingham City Council	Traffic Management
Andrew Houldsworth	Nottingham City Council	HC & M
Peter Allen	Nottingham City Council	Property Plus
Mark Garlick	Nottingham City Council	Public Transport
Richard Allen	Nottingham City Council	Head of Estates
Rachel Jones	Nottingham City Council	Major Projects
Nick Benbow	MVA Consultancy	Business Case & Traffic Analyses

2.1.2 The planned objectives of the Workshop were to:

- outline any further risks that were not yet identified;
- assess the probability (potential likelihood) and impact of each risk and opportunity;
- update the Risk Register for the project; and

- provide the basis for development of quantified and calculated cost and time ranges for each significant risk for the preparation of Quantified Risk Assessment (QRA) models

Additional benefits of the workshop were to:

- increase awareness of project risks and opportunities;
- aid communication between teams and individuals involved with Nottingham Ring Road Major Business Case; and
- the early identification of potential problems or difficulties.

Risk Assessment

Each risk and opportunity was assessed in the workshop to evaluate its:

- Probability
  - This is expressed in terms of a percentage, where 100% is bound to happen and 0% is impossible to happen.
  - Linkages to other risks were also explored to asses whether each risk occurs independently of other risks, or is dependent on another risk occurring or not.
- Impact
  - Ideally this is expressed as a three point estimate - a minimum cost should the risk occur, a most likely cost and a maximum cost. In practice, the minimum and maximum costs will rarely occur and the 'most likely' value will be used most of the time. The Council's risk log had identified the potential unmitigated impact associated with each risk, together with an assessment of the residual impact following implementation of appropriate mitigation measures. These values for the impact were reviewed at the workshop and used in the subsequent analyses, as described later in this report.

Contractor Perspective

To ensure the development of a robust business case, project risks and opportunities were also considered from the perspective of the contractor wherever appropriate and practicable.

Risk Matrix

The Council's Risk Log was framed around the use of five-point scales to quantify the probability of occurrence and the consequential potential impact. The two matrices set out below in Tables 2.2 and 2.3 were used to rate the Probability and Impact of each risk and opportunity. Wherever possible the Quantitative Matrix was used. However, where a risk or opportunity did not have a measurable monetary impact, then a qualitative assessment was made.

Table 2.2 - Quantitative Risk Assessment Matrix

Quantitative Matrix					
Probability			Consequence		
Description	Scale		Description	Scale (£m)	
Improbable	0 to 15%	1.	Insignificant	0 to 0.05	1.
Remote	16 to 30%	2.	Minor	> 0.05 to 0.25	2.
Occasional	31 to 60%	3.	Moderate	> 0.25 to 1.0	3.
Probable	61 to 85%	4.	Major	> 1.0 to 4.0	4.
Frequent	86 to 99%	5.	Catastrophic	>4.0 to 7.5 +	5.

Table 2.3 - Qualitative Risk Assessment Matrix

Qualitative Matrix			
Probability		Consequence	
Description	Scale	Description	Scale
Improbable	1. (Very Low)	Insignificant	1. (Very Low)
Remote	2. (Low)	Minor	2. (Low)
Occasional	3. (Medium)	Moderate	3. (Medium)
Probable	4. (High)	Major	4. (High)
Frequent	5. (Very High)	Catastrophic	5. (Very High)

Risk Classification

The following Risk Classifications were used to categorise all risks, taken from PID appendix 6.Table 2.1

Political pressure	The risk that changes to the scheme may be required as a result of political pressure.
Insufficient human resource	The risk that there will be insufficient project management resources and design resources to meet the programme.
Unforeseen design challenges	The risk that when detailed design is undertaken that unforeseen problems arise.
	The risk that there is a disruption in the design process/ construction because of railway structures
Safety Audit and Monitoring	The risk that a safety audit may highlight a hazard that was previously unknown.
Objections from stakeholders	The risk that there is objection from statutory consultees: ■ English Heritage ■ English Nature ■ Environment Agency ■ Countryside Agency
	The risk that there will be local objection from stakeholders and users including TROs.
Programming of RRM with other schemes	The risk that there will be conflict with other major highway schemes at a conurbation/regional level.
Land acquisition	The risk that there is a problem obtaining land.
	Delays in CPO procedures over 12 months.
Delivery Delay	Decision delay by DfT
	Delays to delivery programme.
Disruption of services	The risk that the Medilink bus services are affected as a result of a policy change from Hospitals.
	The risk that there will be a disruption to bus services and others during construction.
Insufficient contractors resources	The risk that there will be insufficient contractor resources available.
Termination of contracts	The risk that a contractor will pull out of a contractor.
Cost escalation	The risk that costs may escalate.

3 Quantified Risk Assessment

3.1 The process

3.1.1 Before adding the impact of possible risks to project delivery, the base cost of the project was given as £25.69m. This cost was valid as of 7th September 2007.

3.1.2 The project *risk register* was reviewed and revised at the QRA workshop. The updated risk register (reproduced in Appendix A) contains the list of possible situations that would lead to cost increases, together with the *likelihood rating* and their *impact rating*.

3.1.3 The likelihood rating grades the probability of a given situation on a scale of 1 to 5, and the associated descriptions and probabilities are summarised in Table 3.1.

Table 3.1 - Likelihood ratings

Description	Probability	Scale
Improbable	0 – 15%	1
Remote	16 – 30%	2
Occasional	31 – 60%	3
Probable	61 – 85%	4
Frequent	86 – 99%	5

3.1.4 Similarly, the impact rating grades the additional cost on a scale of 1 to 5, and the associated descriptions and costs are summarised in Table 3.2. The "catastrophic" level was set at a level of cost increase that would exceed the level of funds likely to be available to the Council and which would make it almost certain the project could not be completed. The remaining grades are in rough geometric progression.

Table 3.2 – Impact ratings

Description	Cost range	Scale
Insignificant	Less than £50,000	1
Minor	£50,000 - £250,000	2
Moderate	£250,000 - £1,000,000	3
Major	£1,000,000 - £4,000,000	4
Catastrophic	Over £4,000,000	5

3.1.5 The likelihood and impact ratings can be multiplied together to produce a *risk rating*, ranging from 1 to 25. A risk rating of four or less indicates a negligible risk; a rating of five to ten a tolerable risk, and a rating of over eleven a serious risk.

3.1.6 The risk rating was not used as part of the QRA, although it served as a useful way to highlight which risks needed most attention for mitigation measures.

3.1.7 Palisade's @Risk software was used to determine the probability distribution for the additional costs. This used a Monte Carlo simulation with 100,000 iterations.

3.1.8 In general, the risks were independent of one another. However, some risks were judged to have likelihoods that depended on whether or not another risk (the *precursor risk*) occurred. These risks are summarised in Table 3.3, together with the associated likelihoods.

3.1.9 Risk #1 ("Political pressure") was a more complex case. It was judged that any of five different risks occurring would increase the likelihood of risk #1 occurring. Consequently, the likelihood used in the simulation depended on how many of the precursor risks occurred as set out in Table 3.3.

Table 3.3 – Related risks

Risk #	Depends on	Likelihood if precursor risk doesn't occur	Likelihood if precursor risk does occur
12	11	2	5
13	19	2	3
18	17	2	3
1	7, 8, 15, 20, 23		*No precursor risks occur:* 2 *One or two precursor risks occur:* 3 *Three or four precursor risks occur:* 4 *All five precursor risks occur:* 5

3.1.10 The risk register also includes mitigation measures to reduce the likelihoods and impacts for each risk. These are shown in the risk register in Appendix A. The mitigated risks were simulated as all being independent. The mitigated risks represent a "base case" scenario.

3.2 Results

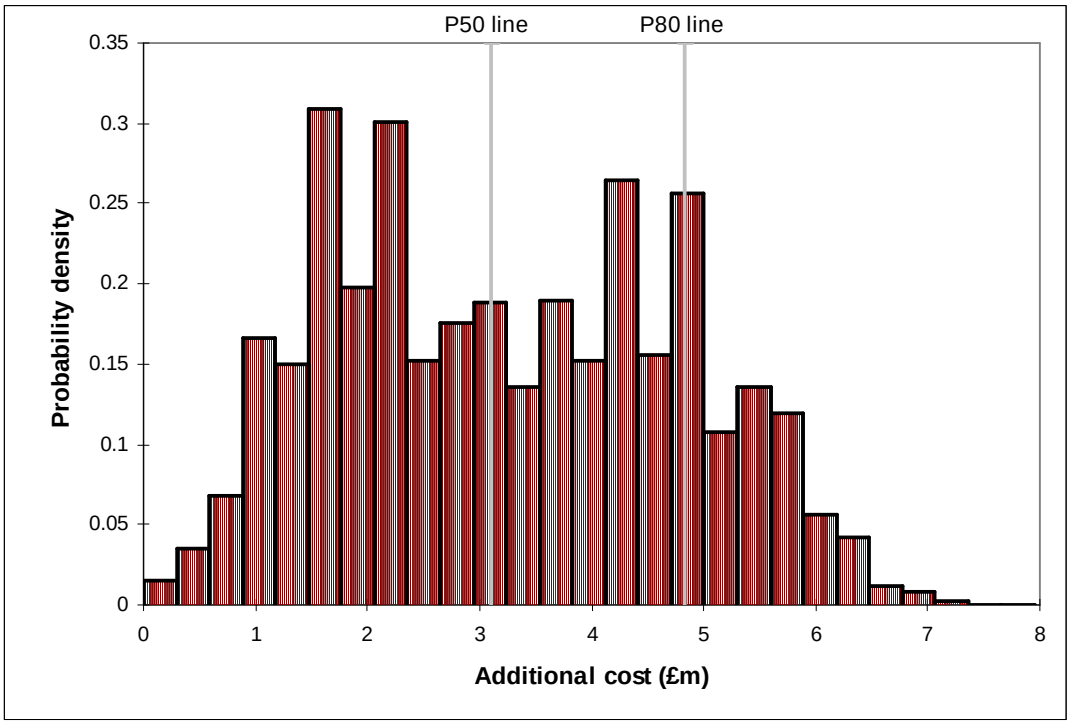
3.2.1 The key results for the unmitigated risks are summarised in Table 3.4. The single point estimate is the cost of the project with no overruns or extra costs. The P50 and P80 costs are, respectively, the cost at which there is a 50% and 80% chance of the project cost being less than the figure given.

Table 3.4 - Key results (unmitigated)

Item	Cost	Increase on base cost
Single point estimate	£25.69m	-
Pmean	£28.94	£3.25 (12.7%)
P50 level	£28.79m	£3.10m (12.1%)
P80 level	£30.51m	£4.82m (18.8%)

3.2.2 The probability distribution of the unmitigated additional cost is shown in Figure 3.1. The mean additional cost was £3.25m. (The mean is greater than the P50 level because the distribution. has a positive skew).

Figure 3.1 - Probability distribution for unmitigated additional cost



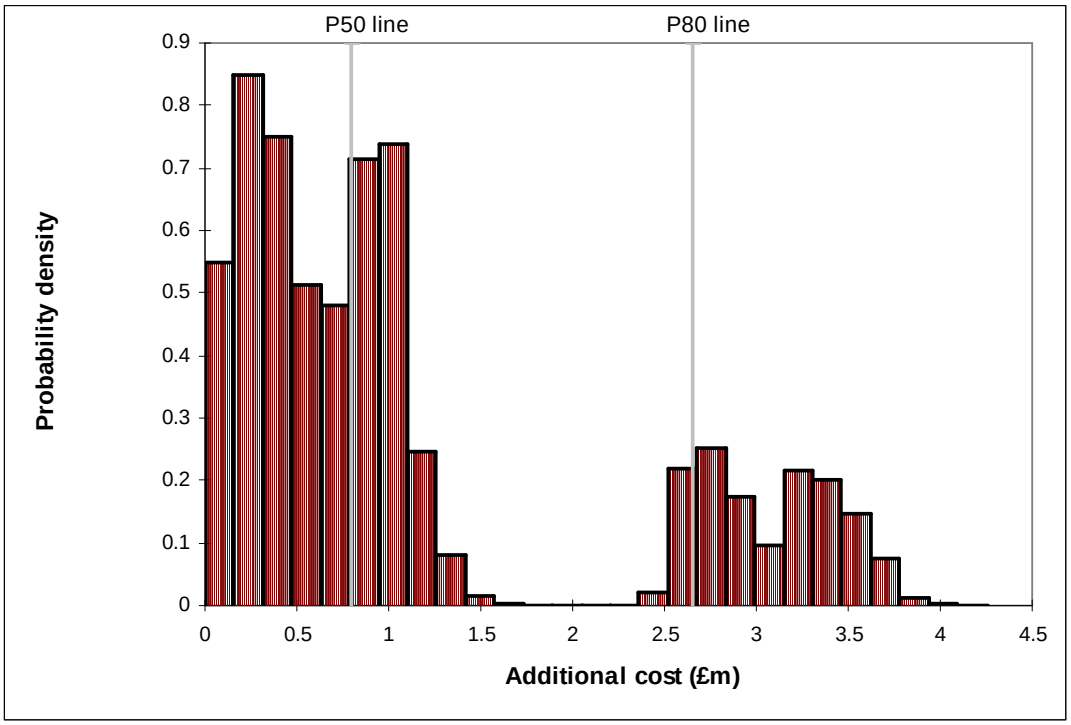
3.2.3 The key results with the mitigation measures in place are summarised in Table 3.5. It includes the savings at the P50 and P80 levels resulting from the mitigation measures.

Table 3.5 - Key results (mitigated)

Item	Cost	Increase on base cost	Reduction from unmitigated cost
Single point estimate	£25.69m	-	-
Pmean	£26.83m	£1.14m (4.4%)	£2.11m (65%)
P50 level	£26.49m	£0.80m (3.1%)	£2.30m (74%)
P80 level	£28.34m	£2.65m (10.3%)	£2.17m (45%)

3.2.4 The probability distribution of the mitigated additional cost is shown in Figure 3.2. The mean additional cost was £1.14m. The distribution has two distinct peaks, a result of how the likelihood and impact ratings were distributed after the mitigation measures were considered.

Figure 3.2 - Probability distribution for mitigated additional cost



3.2.5 The results given in this section show that there are major savings to be made by implementing the risk mitigation measures.

4 The Next Steps

4.1 How the results of the QRA are used by the DfT.

4.1.1 The QRA has determined the expected outcome (as distinct from the planned outcome) for the scheme costs. This is also known as the mean or unbiased outcome and represents the weighted average of all the potential outcomes and associated probabilities. It is therefore the risk-adjusted mean estimate of the cost of the scheme, and it is to this that optimism bias is to be added.

4.1.2 Upon accepting the scheme for **Programme Entry**, the DfT will set a **Quantified Cost Estimate** (QCE), based on the risk-adjusted mean estimate as submitted. The Department will also set an **Approved Scheme Cost** (ASC), which represents the QCE plus an **Additional Risk Layer** determined by the level of Optimism Bias applied to the scheme, (i.e. ASC = QCE + Optimism Bias).

4.1.3 The DfT will normally contribute a maximum of 90% of the QCE (which includes a 50% contribution towards the Preparation Costs post Programme Entry) together with 50% of any increase in the cost over the QCE up to the ASC ceiling.

4.1.4 The balance of scheme costs (i.e. 10% of the QCE and 50% of the Additional Risk Layer) will need to be met by local contributions.

4.1.5 Any expenditure above the ASC will need to be met entirely by local contribution.

Appendix A – Risk log

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Ring Road Major Risk Analysis

Nottingham City Council

Risk Register Date	9th September 2007

				Status Quo / Prevailing Ratings					**Residuals**			
Risk No.	**Description of duty, Responsibility or concern and risk**	**Description of Potential IMPACT (with estimated costs if possible)**	**Description of LIKELIHOOD Factors**	**LIKELIHOOD Rating**	**IMPACT Rating**	**Risk Rating**	**Risk Owner**	**Additonal Controls / Mitigations / Countermeasure Actions & their "in operation" dates**	**Residual LIKELIHOOD rating**	**Residual IMPACT Rating**	**Residual Risk Rating**	**Risk no.**
1	Political Pressure	Change to scheme	Current administration is supportive of scheme; would only arise as a consequence of local public issues	Depends on {7,8,15,20,23}	3		PEG	Amend proposals to reach compromise. Engage Councillors at Executive Board *and keep local members informed of proposals and issues*	**2**	**2**	4	1
			...Given that none of {7,8,15,20,23} occur	2	3	6						
			...Given that 1-2 of {7,8,15,20,23} occur	3	3	9						
			...Given that 3-4 of {7,8,15,20,23} occur	4	3	12						
			...Given that all of {7,8,15,20,23} occur	5	3	15						
2	Insufficient project management resources to meet the programme	Delays to programme until resources become available	Combination of large capital programme and constrained establishment gives signifiant potential for occurrence	2	2	4	PEG	Seek external assistance (ie consultants/agency)	**2**	**1**	2	2
3	Insufficient design and supervision resources (people) to meet the programme	Delays to programme until resources become available	Combination of large capital programme and constrained establishment gives signifiant potential for occurrence	2	3	6	PEG	Seek external assistance (ie consultants/agency). Structures section to be monitored	**2**	**2**	4	3
4	Detailed Design &/or construction processes uncover unforeseen problems	Delays to programme &/or increased cost	Scale of works and high level of local knowledge reduce potential of occurrence	2	2	4	PEG	Amend design process *use external design resources or re-prioitise over other work committments*	2	1	2	4
5	Disruption in design process/construction of railway &/or NET structures	Delays to programme &/or increased cost	Scale of works and high level of local knowledge reduce potential of occurrence	3	3	9	PEG	Early involvement with Network Rail/Central Trains/NET. Monitor resources in progress meetings	2	1	2	5
6	Results from Safety Audit and Road Safety Assessment	Changes to scheme	Stage 1A audit has been undertaken - therefore major issues have been ironed out & downstream potential for risk to arise is reduced.	1	1	1	PEG	Involve Road Safety input as part of the design process	1	1	1	6
7	Objection from statutory consultees: English Heritage, English Nature, Environment Agency, Countryside Agency	Delays to programme &/or increased cost	No issues raised by statutory bodies to date; no wildlife surveys completed to date; no identified risk of archeologicl sites; watercourses at risk from construction.	1	1	1	PEG	Consultation with consultees	1	1	1	7
8	Local objections to scheme (construction programme) - stakeholders and users (including TRO's)	Delays to programme &/or increased cost	Proposals involve some further restrictions on local movements; construction has potential to create local annoyance.	3	2	6	PMG	Proactive publicity to promote benefits. Management plan in place for staged implementation of TROs. Method of working will reflect need to minimise impacts on frontage property.	2	1	2	8
9	Conflict with other major highway schemes - conurbation/regional level	Delay due to programme interface with other major works eg Broadmarsh, Eastside, NET 2, A453 & M1 widening	Size of programme & no of schemes planned makes conflict likely	4	2	8	PMG	NRSWA process/monitor. Scheme has been registered. Monitor RFA progress. Continue to ensure scheme is afforded priority.	2	2	4	9
10	Delays by statutory undertakers	Delays to construction programme	Existing highway; knowledge of stats locations by design team is good.	2	2	4	PEG	Early involvement and placing orders/confirming work. Some flexibility due to extent of scheme	1	1	1	10
11	Problems obtaining land	Delays to construction programme. Escalation of compensation costs.	Risk arises from potential for mis-referencing of sites; advanced design means land needed for construction is identified.	3	4	12	PEG	CPO procedures anticipated and to be initiated following Programme Entry (December). Informal negotiations already commenced	1	4	4	11
12	Delays in CPO *inquiry decision* over 18 months	Significant delays to construction programme	CPO procedure commencement dependent on Programme Entry.	Depends on #11	2		PEG	Review programme	1	1	1	12
			... Given 11 occurs	5	2	10						
			... Given 11 doesn't occur	2	2	4						
13	Funding Risk	RFA allocation/delay by DfT/Programme Entry - any delays likely to result in 1 year delay. Potential for cost escalation from unforeseen factors - could impact on size (& affordability) of local contribution.	RFA is subject to periodic review; other calls on local finances (eg NET) may be concurrent.	Depends on #19	2		PEG	Continue engagement with DfT and Funders; strong management plan to minimise unforeseen issues.	2	2	4	13
			... Given 19 occurs	3	2	6						
			... Given 19 doesn't occur	2	2	4						
14	Unforeseen delays to construction programme due to scale of works	Longer contract period/cost escalation	Resource demand profile is not flat - potential for shortage of quality labour available at time needed.	3	3	9	PEG	Established project management procedures in place. Buildability reviewed by HCM & as preferred contractor, is well known.	2	2	4	14
15	Medilink bus services affected by change in policy from Hospitals	Assisting Medilink buses *is a benefit* of the scheme - changes have potential for loss of public support; political pressure (but no direct impact on capital costs)	NHS services have been under regular review & are subject to frequent change; therefore potential for change is high.	1	2	2	PEG	Introduction of commercial replacement services *or other service options*	1	2	2	15
16	Availability of contractor's resources	Delays to programme until resources become available - main issue of concern is availability of supervisory & specialist resources.	Demands from concurrent schemes likely to put pressure on key resources.	2	1	2	PEG	Make *early contractor involvement a* fundamental part of procurement process	1	1	1	16
17	ECI Contractor pulls out of contract	Delay whilst alternative contractor appointed	ECI via external contractor is no longer the favoured procurement route - low likelihood of occurrence.	1	1	1	PEG	Plan is to engage HCM for all work except structures. NCC preference to use known 'partner' contractors - reduces risks of the unknown. Ultimate recourse is find alternative contractor	1	1	1	17
18	Procurement failure	Delays and cost. Procedural issues (financial regulations)	ECI via external contractor is no longer the favoured procurement route - low likelihood of occurrence.	Depends on #17	3		PMG	Review ECI. Consideration of HCM involvment based on TP lessons learned. Engage contractor for the bridge	1	2	2	18
			... Given 17 occurs	3	3	9						
			... Given 17 doesn't occur	2	3	6						
19	Risk of cost escalation from estimate	Loss of funding; scale down proposals. Increase in level of local contribution.	Scheme is typical construction - main spend on structures & stats. Costs assessed using construction price inflation estimates - therefore potential for escalation has been minimised.	3	3	9	PEG	*Review RFA commitments pre - programme entry*. Monitor expenditure/financial commitments carefully. Contractor involved in advice on costs giving reassurance of cost by scope/funding. Reconsider phasing of construction	3	3	9	19

20	Disruption to bus services and others during construction - importance of local knowledge	Loss of public support; political pressure	Radial routes will be affected during construction, with consequent potential to delay bus services.	3	3	9	PMG	Good proactive public communications required, consider rearranging works or changing temporary traffic management at specific locations. Full engagement with bus operators/routing. Contingency plan for temporary diversions.	2	2	4	20
21	Impact on emergency service response times during construction	Need for restrictions on construction methods &/or times of working to be imposed.	Planned construction method and sequencing is aimed to minimise delays to traffic.	2	1	2	PMG	Full consultations and dialogue with emergency services both before & during construction.	2	2	4	21
22	Local elections in 2011	Delays to construction programme, particularly on run-up to election	*Working conditions are difficult (disruption and delays)* & hence potential to give rise to complaints from public..	2	2	4	PEG	Engage Councillors at Executive Board. Ensure members are well briefed on positive outcomes from scheme. Planned construction method and sequencing is aimed to minimise delays to traffic	1	1	1	22
23	Local objections due to loss of trees	Delays to programme &/or design changes	Trees affected by TPO's being retained; others will be lost.	2	1	2	PMG	Proactive publicity to promote overall benefits - policy to replant on a 2-4-1 basis will result in net increase in no of trees.	1	1	1	23

Scoring matrix

			Impact Scores				
			None	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
	Remote	1	1	2	3	4	5
	Unlikely	2	2	4	6	8	10
Likelihood	Possible	3	3	6	9	12	15
Scores	Likely	4	4	8	12	16	20
	Almost Certa	5	5	10	15	20	25

Scores in the boxes are the "Risk Rank" which is equal to the product of the Impact and Likelihood scores

Risk Register Construction Steps

1 Identify the individual risks associated with each corporate plan priority outcome specified on the "Corporate Plan Risk Register" worksheet, the first one.

2 Agree specific departmental "Other duties, responsibilities and concerns" not explicit in the Corporate plan.
Enter these in the "Othr dties, rsp & cncrns risks" worksheet

3 Identify the risks threatening each of the individual entries entered in the "Othr dties, rsp & cncrns risks" worksheet

4 Give each risk an impact and likelihood score according to the "rules" of the scoring matrix above.
The "Risk Rank" will be automatically calculated. This is the initial rank score before a management plan has been specified. It is sometimes called the "natural" risk rank.
Risks that have rank score of 12,15,16,20 or 25 are serious risks
that need a bespoke management strategy. A risk management strategy comprises on-going counter measures
(sometimes called controls or mitigations) and contingency actions to be taken if the risk materialises.

5 Identify existing counter measure for each of the "red" risk. Are they adequate?

6 Develop a risk management plan if the existing counter measure are considered insufficient.

7 Enter the key existing counter measures and the new action(s) in the risk management plan referred to in 6..

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