Forth Replacement Crossing

CLEARANCE DRAFT

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Audit Scotland is a statutory body set up in April 2000 under the Public Finance and Accountability (Scotland) Act 2000. We help the Auditor General for Scotland and the Accounts Commission check that organisations spending public money use it properly, efficiently and effectively**.**

Contents

Key facts

- £1.34 billion - project cost - the largest infrastructure project in Scotland in recent years
- 8-16 per cent less - project cost - than the estimated £1.45 to £1.6 billion at the start of construction
- 10 weeks later than the contract end date, eight months later than first estimated - the new crossing opened on 31 August 2017
- 4 main elements to the ten-year project: Queensferry Crossing, M9 Junction 1a, Fife Intelligent Transport System (ITS) and the Contact and Education Centre.
- 13.7 miles (22km) long - overall project, includes major motorway upgrades to the north and south of the bridge
- First use of ITS in Scotland - automated system to vary mandatory speed limits and smooth traffic congestion

Summary

Key messages

- **Transport Scotland's management of the Forth Replacement Crossing project delivered value for money, although some of the wider benefits of the project have still to be demonstrated. Its procurement of the construction contracts was competitive and helped to deliver the project under budget. The final cost of the project was £1.34 billion - around 8-16 per cent less than the £1.45-£1.6 billion estimated at the start of construction. The new crossing opened at the end of August 2017. Due to bad weather, this was eight months later than first estimated and ten weeks later than the mid-June contract completion date.**
- **The Scottish Government identified a clear need for a new crossing after extensive investigations of the existing Forth Road Bridge revealed corrosion of the main cables. Repairing the existing bridge was not economically viable. Transport Scotland assessed a cable-stayed bridge as the preferred option for a new crossing. It had several advantages over alternative designs and included features to make the crossing more reliable and resilient.**
- **Transport Scotland managed the project effectively. There was a clear project scope and the budget included all relevant costs. Sound governance and wide-ranging risk management and quality assurance measures were in place. The team provided regular, consistent and up-to-date information to the Project Board about costs, risks, quality and timescales. This provided a strong foundation for the project to succeed. Other critical success factors were:**
  - **relevant and wide-ranging skills and experience within the team and Project Board, and investment in external expertise early in the project**
  - **strong and consistent leadership, an open and transparent approach, timely decision making, and positive working relationships with the contractors**
  - **drive and ambition of those involved in delivering the project to do it well and get it right first time**
  - **extensive engagement and communication with stakeholders.**
- **It is too early to know whether all the project's expected wider outcomes will be achieved, but the overall aim of maintaining a reliable road link between the Lothians and Fife has been delivered. Transport Scotland has a plan for evaluating progress towards achieving the FRC project's objectives, and is due to carry out a full post-project evaluation in late 2019. The plan details how performance relating to journey times and traffic flow will be measured, but more detail is required on other outcome measures. For example, how it will assess the impact of improved network connections and junctions, and the project's contribution to economic growth.**

Recommendations

The public sector can learn from the way Transport Scotland managed the Forth Replacement Crossing (FRC) project.

The Scottish Government should:

- **Share good practice from the FRC more widely, highlighting generic project management lessons that could be applied to other types of projects. Examples include governance arrangements, working relationships, cost estimating, financial management, quality assurance, communication and stakeholder engagement, education and community benefits, openness and transparency.**

Transport Scotland should:

- **Continue to look for opportunities to apply good practice from the FRC project to future projects. It should also consider publishing the lessons learned so they can be shared widely across the public sector and outside Scotland.**

To deliver its projects, Transport Scotland needs to be able to attract sufficient interest, encourage high-quality bids and keep procurement competitive.

Transport Scotland should:

- **consider the appropriate level of risk-sharing between Transport Scotland and contractors and the extent to which contractors are allowed to contribute to design and innovation on contracts.**

Some benefits of the project have still to be demonstrated. To clearly demonstrate the wider intended benefits of the project, Transport Scotland should:

- **include more detail in its benefits realisation plan and be clear about how it will evaluate outcomes and the information required to measure this effectively**
- **continue to report in public about the project and progress in achieving the intended benefits**
- **set out a clear plan of how it will support public transport providers to meet increasing demand for travel across the Forth.**

Background

1. The Forth Replacement Crossing (FRC) is the biggest publicly funded infrastructure project in Scotland in recent years at an overall cost of £1.34 billion. This includes the total costs from when it was first scoped in 2007, up to the end of a five-year maintenance period in 2022. It has been funded from the Scottish Government's capital budget. The Cabinet Secretary for Finance and Sustainable Growth announced the Scottish ministers' decision to build a new crossing on 19 December 2007. Transport Scotland led on delivering the FRC project.[1] The

[1] Transport Scotland is a Scottish Government agency. It is responsible for national transport services and infrastructure.

new crossing opened to traffic on 30 August 2017. Exhibit 1 sets out key milestones for the project.

2. The main element of the project is a new bridge across the River Forth, the Queensferry Crossing, connecting Fife with Edinburgh and the Lothians. The new bridge is west of the existing Forth Road Bridge and required changes to the road network north and south of the bridge. Transport Scotland split the construction work into three contracts of varying size and value, plus a contract for an education centre. These were:

   - **Fife Intelligent Transport System (ITS) (£13 million)**, which is infrastructure and technology installed along the route of the new crossing to monitor and manage traffic. This was installed from junction 3 of the M90 north of the bridge to the M9 south of the bridge. The automated system is designed to improve traffic flow, reduce congestion and improve road safety.[2]
   - **Principal contract (£790 million)**, which included constructing a three-tower cable-stayed bridge and new connecting roads at the north and south ends of the bridge.[3] It also included enhancing a major interchange north of the bridge (Ferrytoll), creating a new junction south of the bridge (at Queensferry), and installing ITS technology throughout.
   - **M9 Junction 1a (£26 million)** to improve the junction with the M9 and create new connections to West Lothian to help reduce heavy traffic on local roads. It also included ITS technology.
   - **Contact and Education Centre (CEC) (£3 million)** to construct a purpose-built facility to serve as a focal point for community engagement and education during the building of the Queensferry Crossing.

3. Transport Scotland identified the need for a replacement crossing after inspections of the Forth Road Bridge detected the cables were deteriorating. This would potentially have required weight restrictions on the bridge from 2017. Transport Scotland commissioned a Forth Replacement Crossing Study to identify options for a replacement crossing, which took place from 2006 and 2007. The study concluded that the cables could be replaced on the existing bridge, but at significant cost and disruption to traffic over a 7-9 year period. The Scottish Government did not consider this as a viable option and it decided to replace the crossing (see Part 1).

[2] ITS displays mandatory instructions and information to drivers through overhead gantries on the main road and signals on the slip roads. It manages several facilities, including lane use and variable speed limits on the main road and controls the rate at which slip road traffic can join. Reducing the speed of vehicles approaching a junction can slow the build-up of congestion. It also allows drivers more time to assess manoeuvres they plan to take, and makes it easier to execute them.

[3] A cable-stayed bridge has one or more towers with the weight of the deck supported by several cables running directly from either side of the towers to the deck.

Exhibit 1

The Forth Replacement Crossing project timeline

The Queensferry crossing opened just under ten years after Scottish ministers approved the project.

*Change this to show how different stages of project ran alongside each other/ overlapped

Milestone	Date
Forth Replacement Crossing Study published	June 2007
Ministerial statement about the decision to build a cable-stayed bridge	19 December 2007
Project design and development started	January 2008
Ministerial statement about the Forth Road Bridge to operate as a dedicated public transport crossing	10 December 2008
Procurement notice for principal contract published	June 2009
Forth Crossing Bill introduced to the Scottish Parliament	November 2009
Tendering process for principal contract started	December 2009
Forth Crossing Act passed	January 2011
Business case finalised	March 2011
Principal contract awarded	April 2011
Construction and site works started	Summer 2011
Fife Intelligent Transport System (ITS) operational	December 2012
Contact and Education Centre opened	January 2013
M9 Junction 1a opened	February 2013
Queensferry Crossing opened	30 August 2017

Source: Transport Scotland

4. As part of the FRC study, Transport Scotland set eight transport planning objectives, which became the objectives for the project:

- Maintain cross-Forth transport links for all modes to at least 2006 levels.
- Connect to the strategic transport network to aid optimisation of the network as a whole.
- Improve reliability of journey times for all modes.
- Increase travel choices and improve integration across modes to encourage modal shift of people and goods.
- Improve accessibility and social inclusion.
- Minimise the impact of maintenance on the effective operation of the transport network.

- Minimise the impact on people, and the natural and cultural heritage of the Forth area.
- Support sustainable development and economic growth (including supporting Scottish firms, employment, skills and training during the construction phase).

5. The project was not intended to increase the capacity of the route for traffic. The business case states that increased demand for travel across the Forth will need to be met by public transport. This is in line with the Scottish Government's objective to maintain traffic volumes and increase the use of sustainable transport. As part of the project, Transport Scotland developed a managed crossing strategy. This involves the existing bridge becoming a dedicated public transport crossing for buses, taxis, motorcycles (less than 125cc), cyclists and pedestrians. Other measures include a dedicated bus lane from Fife into Edinburgh and increased park and ride facilities in Fife. Part 3 of this report assesses Transport Scotland's progress against the intended benefits of the project.

6. Overall the project took around ten years to complete. The Queensferry Crossing is the tallest bridge in the UK and the longest three-tower cable-stayed bridge in the world. It is intended to have a useful life of least 120 years. Transport Scotland and the contractors applied advanced engineering and technological methods to overcome major challenges as they built the crossing. This contributed to making the crossing more reliable and resilient than the Forth Road Bridge. (Exhibit 2)

About this audit

7. The aim of our audit was to assess whether the Scottish Government's delivery of the FRC project provided value for money. We did this by assessing:
   - if there was a clear business case for the project and a competitive procurement approach
   - the governance and management of the project, including delivering the project to time, cost and quality targets, and how the project costs were calculated
   - whether the objectives and intended benefits were clearly set out from the start and the progress made towards achieving them.

8. Our audit also looked at good practice and learning from the project. We focused on the principal contract as this was by far the largest. We drew on the key messages and recommendations made in our previous reports on major capital and infrastructure projects.

9. The report has three parts:
   - Part 1 considers the need for the project and the business case.
   - Part 2 examines how Transport Scotland managed the project, whether there was a competitive procurement approach, and whether there were effective arrangements in place to ensure the project met time, cost and quality targets.
   - Part 3 assesses Transport Scotland's progress in achieving the intended benefits and outcomes of the project, evaluating the project and lessons learned.

10. Our findings are based on reviewing documents, analysing information on costs, and interviews. The interviews included staff in Transport Scotland, the contractors, the Scottish Government, and community groups. Appendix 1 summarises our audit methodology. Appendix 2 lists the members of our advisory group who provided help and advice throughout the audit.

Exhibit 2

Key facts and features of the Queensferry Crossing

The design includes additional features to improve reliability and resilience.

*Present info in an infographic

Reliability and resilience features

- Two-lane carriageways plus extra-wide hard shoulder - less disruption from accidents/ breakdowns, potential for bus use if diverted from Forth Road Bridge, allows flexibility to run three traffic lanes plus pedestrian and cycle lane if cables on existing bridge deteriorate.
- Wind shielding - reduces potential for bridge closures from high winds
- Dehumidification system inside the bridge deck and towers to prevent corrosion
- Hi-tech monitoring of health and structure of bridge - monitoring of cables and effect of weather and traffic load on bridge structure, allows defects to be identified early
- Cables can be repaired or replaced individually without closing lanes on the bridge, can also be easily visually inspected
- Intelligent Transport System - first in Scotland, provides mandatory variable speed control and state of the art electronic messaging
- First wide-scale application of a new, highly durable road surfacing - highly resilient and longer lasting than traditional road surfacing
- Long-lasting coatings applied to the structure to prevent corrosion

Source: Transport Scotland

Part 1: Need for the project

There was a clear need for the project

Key messages

- **The Forth Replacement Crossing (FRC) project was in line with national policy and strategies. Ministers identified it as one of four priorities in 2008 to most effectively contribute towards the Scottish Government's purpose of increasing sustainable economic growth.**
- **The Scottish Government identified a clear need for the project after extensive investigations of the existing bridge revealed corrosion of the main cables that would mean restricting traffic from 2017. Scottish ministers made a timely decision to proceed with a replacement crossing to maintain the important road network between Edinburgh and Fife.**
- **Transport Scotland considered several options, including repairing the existing bridge. Transport Scotland assessed a cable-stayed bridge as the preferred option as it was cheaper than repairing the existing bridge or alternative types of crossing, such as a tunnel. It was also easier to implement, had a shorter construction time and fewer risks. The design makes the crossing more reliable and resilient by including wind shielding, hard shoulders and automated traffic management systems.**
- **The business case was comprehensive, followed relevant guidance, and clearly set out the need for the project and the scope. The FRC project team was clear about the purpose and objectives of the project, and the risks and budget.**

The FRC project was in line with national policy and strategies

11. The aims of the FRC project fit with the Scottish Government's national economic policy and strategic priorities for major transport projects. These are to sustain and increase economic growth, invest in infrastructure and improve journey times and tackle congestion.[4] [5] The project is also in line with Transport Scotland's vision of increasing sustainable economic growth through the development of national transport projects; and delivering a safe, efficient, reliable and environmentally acceptable network that meets current and future needs.

12. Ministers identified the FRC project as one of four transport priorities in 2008 to most effectively contribute towards the Scottish Government's purpose of increasing sustainable economic growth. This was based on 29 recommendations for transport investment priorities

[4] *Scotland's Economic Strategy*, Scottish Government, first published in 2007 and updated in 2015.
[5] *National Transport Strategy*, Scottish Government, first published in 2006 and updated in 2016.

up to 2032.[6] Transport Scotland's delivery of the project meant that a crucial element of the transport network was maintained before any restrictions to traffic using the existing bridge were required. This would have had a negative impact on the economy and travel times across the Forth (see paragraph 16 for estimated costs).

There was a clear need for the project

13. The Scottish Government identified a need for the project based on clear evidence that the lifespan of the existing bridge was limited and required significant and disruptive maintenance to sustain it. In 2004, routine maintenance work by the Forth Estuary Transport Authority (FETA) on the Forth Road Bridge identified that the main cables supporting the bridge were corroding. Although it had been maintained since it opened in 1964, the increased volume of traffic and increased weight of heavy goods vehicles (HGVs) had begun to take its toll. In 2006, the bridge carried an average of around 66,000 vehicles every day, almost five times the volume of traffic using the bridge initially. Between 1966 and 2005, the average annual increase in traffic on the bridge was 4.2 per cent, higher than the overall annual increase for Great Britain of 2.8 per cent.[7]

The Scottish Government made a well-evidenced decision to proceed with a replacement crossing

14. Transport Scotland commissioned a Forth Replacement Crossing Study in 2006. The study looked at the performance and sustainability of the existing network, including the results of ongoing investigations into the condition of the existing bridge. It considered options for either repairing or replacing the existing bridge. The findings and recommendations were published in a series of reports between 2006 and 2007.[8] A Scottish Parliament briefing summarised these and analysed the costing and economic benefits methodology.[9]

15. Further monitoring of the existing bridge, carried out as part of the study, detected further new breaks within the individual wires that make up each cable, confirming that the problem was progressing. The cables had suffered an 8-10 per cent loss in strength and without remedial action would fall below safety levels by 2013/14. There was also evidence of fatigue in the viaducts, bridge deck and road surfacing, largely owing to increasing numbers and weight of HGVs putting additional strain on the bridge. Since the 1960s, the weight of HGVs allowed on British roads has increased from 24 to 44 tonnes. The assessors estimated that HGVs

[6] The other three priority projects were: Edinburgh to Glasgow Rail Improvements Programme (EGIP), Highland Main Line Improvements and Aberdeen to Inverness Rail Improvements. *Strategic Transport Projects Review*, Scottish Government, 2008.

[7] *Forth Replacement Crossing Study - Report 1: Assess Existing, and forecast Future, Conditions of the Transport Network within the Vicinity of the Forth Road and Rail Bridges*, Transport Scotland, November 2006.

[8] *Forth Replacement Crossing Study* (*Reports 1-5, and Non-technical Summary)*, Transport Scotland, November 2006-June 2007.

[9] *The Forth Replacement Crossing First Principles*, Financial Scrutiny Unit Briefing, Scottish Parliament Information Centre, February 2010.

crossing the bridge would need to be restricted from as early as 2017, followed by restrictions to general traffic.[10]

16. Dehumidification technology was installed during 2006/07 to stop the cables deteriorating further, but the first indication of its success would not be available until 2011/12. A programme of extensive work would also have been needed to return the bridge to a fully operational level. This would have required frequent lane closures, taken an estimated 7-9 years to complete, and would have significantly disrupted travel across the bridge and in the surrounding area. In 2008, FETA estimated that the associated costs could be in the region of:
    - £91-£126 million for design and construction costs
    - £235-£309 million for costs associated with increased travel time during the works
    - £0.44-£1 billion a year reduction in economic output during the works
    - £0.54-£1.3 billion a year reduction in turnover for affected businesses
    - a loss of 3,200 jobs for the duration of the works which could be permanent.[11]

17. In December 2007, Scottish ministers announced their decision to replace the crossing to maintain the important road network between Edinburgh and Fife.[12] This was based on the uncertainties about the success of repairing the existing bridge, the disruption to traffic and cost to the economy over a long period of time.

Transport Scotland identified the preferred option for the new crossing through an extensive options appraisal

18. Transport Scotland carried out an extensive options appraisal to identify the location and type of the replacement crossing. This followed Scottish Transport Appraisal Guidance and was subject to external peer review by procurement and construction experts.[13] A long list of 65 possible options was generated following a workshop in late 2006 with representatives of Transport Scotland, the Scottish Government, and the consultants involved in the study. Exhibit 3 shows how the initial options were considered and narrowed down to reach the final choice of a cable-stayed bridge between South Queensferry and East of Rosyth. Scottish ministers approved this as it was not as expensive as tunnel alternatives, easier to implement, had a shorter construction time and fewer risks associated with the ground conditions.[14]

[10] *Forth Replacement Crossing Study - Report 1: Assess Existing, and forecast Future, Conditions of the Transport Network within the Vicinity of the Forth Road and Rail Bridges)*, Transport Scotland, November 2006.

[11] *Feasibility Study for Replacement or Augmentation of the Main Cables on Forth Road Bridge - Final report*, Forth Estuary Transport Authority, 2008.

[12] *Statement on Transport by the Cabinet Secretary for Finance and Sustainable Growth (John Swinney)*, Plenary Official Report, Scottish Parliament, Session 3, 19 December 2007.

[13] *Scottish Transport Appraisal Guidance*, Scottish Government, September 2003, updated June 2008.

[14] *Forth Replacement Crossing Study - Report 3: Option Generation and Sifting,* Transport Scotland, December 2006.

Exhibit 3

Forth Replacement Crossing options appraisal

An extensive options appraisal was carried out to identify the location and type of the replacement crossing.

*present visually showing how options were filtered (incorporate a map to show location?)

65 initial options, including different types and locations of crossing, such as bridges and tunnels in various locations, rail, ferries and hover crafts. ↓

19 options were rejected during an initial sift as they did not meet the transport planning objectives, were not technically feasible, or were constrained by environmental, navigation and physical factors. For example:

- ferries and hovercrafts would not provide sufficient capacity
- arch and swing bridge options would not provide the required spans
- bridges and tunnels in some locations were rejected because they were uneconomic or beyond practical engineering limits. ↓

Following consideration of physical and environmental constraints:

- options were narrowed down to bridges or tunnels in five possible locations
- two locations, East and West of Bo'ness, were rejected as they were too far from the existing road network. ↓

Following further detailed investigation into the remaining options:

- bridges in two of the remaining locations were rejected due to adverse impact on the environment and protected areas
- a tunnel in one location was rejected due to severe impact on the environment and difficult and risky construction.

The remaining options were a tunnel in two possible locations or a suspension bridge or cable stayed bridge in one location. ↓

The final options were compared based on factors including estimated cost, construction time, risks, environmental impact, and economic benefits:

- the tunnel options were significantly more expensive
- the suspension bridge option was slightly more expensive
- the cable stayed bridge option could be built more quickly than the other remaining options and it had fewer risks associated with construction. ↓

Final option: A cable stayed bridge between South Queensferry and East of Rosyth.

Source: Forth Replacement Crossing Study - Report 3: Option Generation and Sifting, Transport Scotland, December 2006

There was a comprehensive business case for the project

19. Transport Scotland had an initial business case in place at the time of the ministerial announcement to go ahead with building a cable-stayed bridge in December 2007. Transport Scotland continued to develop it as the initial work for the project was carried out and the Forth Crossing Bill progressed through the Scottish Parliament. Transport Scotland finalised the business case in March 2011 after the Act was passed and it had completed the procurement process for the principal contract.

20. The business case was comprehensive, followed relevant HM Treasury guidance, and clearly set out the need for the project and the scope.[15] This meant that the FRC project team was clear about roles and responsibilities, and the project's purpose and objectives, risks and budget. The business case was the basis for the detailed project plans that were developed and revised throughout the project. It included detailed information on the following:
    - Purpose, objectives and benefits
    - Key roles and responsibilities, and governance arrangements
    - Costs and affordability
    - Identified risks
    - Procurement approach
    - Stakeholder engagement
    - Safety and environmental issues
    - Quality assurance
    - Community benefits
    - Equality issues.

[15] *The Green Book: Appraisal and evaluation in central government*; and *Public sector business cases using the five case model: guidance*, HM Treasury, last updated April 2018.

Part 2: Management of the project

Transport Scotland managed the project highly effectively

Key messages

- **Transport Scotland put in place robust project planning from the beginning of the project. The initial project plan linked to the business case and clearly set out the purpose and objectives. This was revised throughout the project and provided an effective framework for managing the project. Transport Scotland set out clear timescales for the project and effectively managed any changes to minimise the effect on time, cost and quality. Due to bad weather, the new crossing opened eight months later than first estimated. This was ten weeks later than the contract completion date of 16 June 2017.**
- **Transport Scotland used a good cost-estimating approach for projecting the initial budget and tightly managed costs. The FRC team regularly reported costs to the Project Board and revised the budget appropriately throughout the project. The final cost of the project was £1.34 billion - around 8-16 per cent less than the £1.45-£1.6 billion estimated at the start of construction.**
- **Transport Scotland put in place sound governance arrangements. These included clear roles and responsibilities, terms of reference and lines of accountability. Transport Scotland identified, revised and updated risks regularly and put in place extensive quality assurance measures. It had a sound approach to procurement and built up good relationships with the contractors.**
- **Transport Scotland carried out extensive and timely consultation and engagement with key stakeholders throughout the project. This led to high satisfaction within local communities about the level of information provided and the opportunity to engage with the project.**

Transport Scotland managed the FRC project well and in line with good practice

21. Analysis of major projects around the world has found that only one in ten large-scale projects are delivered to time and budget. Road projects have an average cost overrun of around 20

per cent.[16] Growing evidence of good practice indicates that critical factors for major projects to succeed include:

- Investing time in planning the project and not proceeding until the scope, design and budget have been identified.
- Thoroughly analysing a wide range of options before committing to a project concept or design to avoid lock-in too early in the planning and design stage. Once a particular approach has been agreed it is difficult and costly to change.
- Identifying potential risks in planning to minimise delays in the project starting and therefore costs escalating.
- Building in enough allowance for optimism bias at the start of the project and reducing this appropriately as the project proceeds. Optimism bias should reduce as costs become more certain. It is often underestimated and should not reduce to zero until the project has been fully completed.[17]
- Honestly and accurately estimating costs and benefits. Strategic misrepresentation is a common cause of project failure. This is where planners deliberately underestimate costs and overestimate benefits to get a project approved.
- Using reference class forecasting for more accurate cost estimates. This involves taking an outside view of the project and basing forecasts on actual performance in a reference class of comparable projects. Taking this approach should avoid both optimism bias and strategic misrepresentation.[18]

22. The FRC project followed much of this good practice. Our 2008 review of major capital projects set out a model of good project management practice.[19] This outlined basic, adequate and advanced practices against different aspects of project management, including vision and direction, planning, and execution. The approach taken in the FRC project met advanced practice levels.

23. Transport Scotland put in place effective project planning from the beginning of the project. This included a clear scope and sound arrangements for governance, risk management and quality assurance. The project plan provided an effective framework for managing the project. It set out the purpose and objectives of the project and linked to the business case. The budget was comprehensive and was regularly reviewed and revised throughout the project. The Project Board monitored costs, risks, quality and timescales regularly. This provided a

[16] *Over budget, over time, over and over again: Managing major projects*, The Oxford Handbook of Project Management, Oxford University Press, April 2011.

[17] Optimism bias is the tendency for appraisers to be over-optimistic about projects' estimates of costs, timescales and benefits. It is good practice to build in allowances for unforeseen problems that increase costs and time.

[18] *What You Should Know About Megaprojects and Why: An Overview*, Bent Flyvbjerg, Project Management Journal, April/ May 2014.

[19] Review of major capital projects in Scotland: How government works (Appendix 3), Audit Scotland, June 2008.

strong foundation for the project to succeed. Several factors particularly contributed to the project's success:

- Relevant and wide-ranging skills and experience within the team and Project Board, and investing in external expertise, for example in bridge design, bridge engineering and international contract law.
- Strong and consistent leadership, an open and transparent approach, arrangements to allow quick decision making at the right levels, and positive working relationships with the contractors. This was facilitated by the FRC team and all contractors being based at the same site throughout the project.
- An ongoing drive and ambition by those involved in delivering the project to do it well and get it right first time.

The procurement of the contracts was carried out alongside the parliamentary Bill process

24. Transport Scotland set an ambitious timescale to complete the new crossing by the end of 2016. This was driven by the findings from the appraisal stage and inspection of the cables on the existing bridge, which indicated that traffic may need to be restricted from 2017. This led to the procurement and Bill processes being run concurrently, from mid-2009 to April 2011, to allow enough time for the construction period.

25. The Forth Crossing Bill gave the Scottish ministers power to build a new bridge over the Forth and to build and improve related roads and structures. It also gave them power to authorise the purchase, or temporary ownership and use, of land for construction works. As more detail became available from the tendering dialogue discussions, this fed into the parliamentary hearings and debates, which in turn helped to inform the project requirements.

Transport Scotland identified the skills and expertise required in the team in the early stages of the project

26. The National Audit Office's (NAO) 2016 review of contract management and emerging best practice emphasises the importance of extensive planning before the procurement options are put together (a year or more for more complex contracts).[20] The NAO has also highlighted that the quality of project initiation is highly predictive of project success.[21]

27. In carrying out its initial project planning, Transport Scotland recognised where it required external expertise and procured this in the early stages of the project. This included advisors for insurance, land valuation, contract and legal issues. Transport Scotland appointed a joint venture of two global engineering firms, Jacobs and Arup, (JAJV) in January 2008 to prepare and manage the project development, design, promotion, procurement and supervision of construction. As part of that commission, JAJV provided a core team, co-located and working

[20] *Commercial and contract management: insights and emerging best practice*, National Audit Office, November 2016.
[21] *Guide: Initiating successful projects*, National Audit Office, December 2011.

with Transport Scotland staff, initially in Transport Scotland's Glasgow office and later in a site office just north of the new crossing. This formed the overall team that delivered the FRC project, known as the Employer's Delivery Team (EDT). The contractors and designers were also based in the same site office.

28. Investment in getting the right skills and knowledge within the team early in the project meant there was a clear scope and an understanding of the requirements and risks of the project, for both Transport Scotland and contractors. Detailed information about the costs, requirements for design, risks, procurement approach and contract was available in time for the tendering process for the principal contract.

Transport Scotland carried out extensive work to understand the market before starting procurement

29. Transport Scotland carried out a range of activities before the tendering process to gain a better understanding of the market. This included considering the risk appetite of market participants, procurement routes, and the most appropriate form of contract. This allowed Transport Scotland to consider how to allocate risk and set contract terms. Activities included:
    - An industry day to provide information about the FRC project, which 140 delegates from 60 companies attended.
    - Attendees to the industry day were invited to complete a questionnaire seeking views on aspects of the project. This included the type of contract and risk allocation, tender costs, risks to contractors, securing funding and specific issues about constructing the bridge.
    - Information from the questionnaires and further discussions were considered in the procurement and contract proposals.

There was a sound approach to procurement of the contracts

30. The procurement approach followed relevant Scottish Government guidance and EU procurement rules.[22] The design and build procurement approach Transport Scotland chose is a tried and tested method and one that HM Treasury recommends for major projects.[23] The approach provides certainty over costs and transfers many of the risks, such as the design, to the contractor who is best placed to manage them. There was good knowledge and experience of design and build contracts within Transport Scotland. In our 2008 review of major capital projects, we highlighted that Transport Scotland had developed a reliable fixed-price design and build contracting strategy, particularly for roads projects. This had resulted in a high degree of cost certainty for many projects.[24]

31. The range of contracts allowed contractors of varying size and type to become involved in the overall project (see paragraph 2). For the principal contract, there were two bidders: Forth Crossing Bridge Constructors (FCBC) and Forthspan. Each was a consortium of four

[22] *Public Procurement in Scotland*, Scottish Parliament Information Centre, March 2012.
[23] Design and build procurement approach: the client engages a contractor who then employs designers.
[24] Review of major capital projects in Scotland: How government works, Audit Scotland, June 2008.

construction and engineering companies plus bridge designers with international expertise.[25] Transport Scotland used a competitive dialogue approach during the tendering process. It met with each bidder separately ten times in 2010. This allowed the bidders to become familiar with the requirements of the project and for Transport Scotland to be assured of the bidders' ability to deliver the project. During this period, Transport Scotland carried out considerable ground investigation and marine conditions work. This helped bidders to understand and mitigate some of the risks from unforeseen issues arising as construction work progressed.

Transport Scotland put in place measures to keep the procurement process competitive

32. Transport Scotland provided an outline of the design requirements and the contractors were required to meet certain minimum quality thresholds set out in guidance for building roads and bridges. Therefore, the main criteria Transport Scotland used in assessing the bids was cost (92.5 per cent cost and 7.5 per cent quality). Bidders' expected performance against set key performance indicators (KPIs) was also used to assess the bids. For the smaller M9 Junction 1a and Fife ITS contracts, there were four and three bidders respectively, providing good competition. For the principal contract, Transport Scotland put in place several measures to maintain a competitive procurement process and keep both bidders interested. The project team also built in measures to the contract to maximise value for money and to encourage savings, added value and innovation (Case Study 1).

33. Information from consulting with the market highlighted that contractors were concerned about the level of costs associated with bidding for such a complex project. This was particularly relevant because the Bill had still to be approved before the project could go ahead. Transport Scotland agreed to pay both bidders' reasonable costs, up to £10 million, if the contract did not go ahead. It also agreed to pay half of the unsuccessful bidder's reasonable costs, up to a maximum of £5 million, to encourage competition. Transport Scotland paid £4.2 million to the unsuccessful bidder in compensation for the costs they incurred.

34. Transport Scotland's research informed its understanding of the appetite for risk within the market and the most appropriate contract. Transport Scotland's legal advisors recommended an internationally recognised contract form that transfers most of the risks to the contractor.[26] The high-level terms of the contract were shared with bidders at the beginning of the tendering process. Contractors specified certain risks they were less willing to take on and Transport Scotland agreed to retain them. These were additional costs from higher than expected rates of inflation and insurance for a major oil and gas pipeline running through the site. The risk of damage to the pipeline during construction had the potential to be extremely costly - estimated

[25] Forth Crossing Bridge Constructors (FCBC) consortium: Hochtief (Germany), American Bridge (USA), Dragados (Spain) and Morrison Construction (Scotland). Forthspan consortium: Balfour Beatty (UK), BAM Nuttall (UK), Morgan Sindall (UK), Vinci (France), replaced by MT Hojgaard (Denmark) during the tendering process).

[26] *Engineering, Procurement and Construction/ Turnkey Contract 1st Edition (1999 Silver Book)*, FIDIC (Fédération Internationale des Ingénieurs-Conseils/ International Federation of Consulting Engineers), 1999.

at up to £100 million. Transport Scotland insured the whole project against loss and third-party liability for £1.5 billion.

Case Study 1

Measures built into the principal contract to maximise value for money

The project team built in measures to the contract to maximise value for money and to encourage savings, added value and innovation. These included:

- Setting a fixed-price contract, informed by a detailed costing of the project.
- Allowing the contractors to suggest changes to the design that would bring benefits and savings, known as value engineering. Any saving made would be shared equally by Transport Scotland and the contractor. This was used to good effect for the Ferrytoll viaduct at the north end of the new crossing where the contractor proposed changes to the original design. This provided a better environmental and cheaper solution and saved around £20 million.
- 25 key performance indicators (KPIs) were built into the principal contract, grouped under three main areas: project planning and completion, impact on the environment, and community engagement and training. These required the contractor to demonstrate how it was delivering key objectives, with performance linked to payments. Several KPIs for training and employment were aimed at supporting the economy. Failure to deliver any of the KPIs resulted in a deduction from payments made to the contractor for ongoing work. (Details of all the KPIs are included in Appendix 3)
- Certain specifications were set for the design of the project, including simple, sleek towers on the bridge for easier and quicker construction and quality control, and less risk to safety. The design also included making use of existing road networks as much as possible to minimise costs. Other elements, including the methods and materials used, were not specified and the bidders could decide on the most effective and efficient approaches, within recognised engineering standards.

Source: Transport Scotland

35. Transport Scotland awarded the principal contract to FCBC in April 2011 after it provided the more competitive tender, taking into account both costs and quality. FCBC's bid of £790 million was considerably lower than Forthspan's bid and Transport Scotland's estimated cost of £0.9-£1.2 billion. Key aspects of FCBC's bid that potentially reduced costs were using both steel and concrete to build the bridge deck, rather than all steel, and making use of the existing port at Rosyth and barges to access the construction site. FCBC also aimed to meet or exceed more of the KPIs.

36. The two contractors that bid for the principal contract told us that Transport Scotland expected them to take on a higher level of risk than they were comfortable with. They also expressed concern about the limited scope for contributing to the design of the new crossing because Transport Scotland had already specified much of this. For future projects, Transport Scotland needs to consider the appropriate level of risk-sharing and innovation allowed on contracts.

This is important for Transport Scotland to attract sufficient interest, encourage high-quality bids and keep procurement competitive.

Appropriate governance arrangements were in place throughout the project

37. In our 2013 review of key transport infrastructure projects, we reported that there was clear and well-defined project governance in the early stages of the FRC project.[27] This was maintained throughout the project. Gateway reviews at key stages of the project confirmed that the governance arrangements, leadership and positive team approach were driving successful delivery of the project.[28] The reviews also identified good practice. This included learning being applied from previous projects and the development of professional knowledge within Transport Scotland.[29]

38. The governance arrangements were clearly set out in the business case and project plans, including key roles and lines of accountability. All main roles, responsibilities and delegated authorities were clearly defined, understood and allocated to suitably qualified and capable individuals. Transport Scotland appointed an Investment Decision Maker, Project Owner and Project Sponsor in line with relevant guidance.[30] (Exhibit 4) The Project Director was an engineer with extensive experience of managing major infrastructure projects, including several successful bridge projects around the world. Transport Scotland staff, who held the other main roles, were all engineers with transport project experience. Project Board members' wide range of knowledge and technical expertise meant they had a good understanding of the complex project and could provide sufficient challenge.

39. Overall there was consistency in key personnel throughout the project, which can be difficult to maintain in a long-term project. The Project Manager was in post throughout the whole project and the Project Director was in post from the procurement stage of the project until after the new crossing opened. This meant that good knowledge and expertise built up over time was maintained. Any changes to other key personnel were managed well, with good handovers and induction.

[27] Scotland's key transport infrastructure projects, Audit Scotland, June 2013.

[28] Governance arrangements are the complex processes of management, decision-making and control that are required to progress a major project.

[29] A gateway review is a short, focused review of a project carried out at key decision points in its life cycle by a team of independent experienced practitioners.

[30] *Scottish Public Finance Manual - Major Investment Projects*, Scottish Government, last update September 2017.

Exhibit 4

Overview of the governance arrangements for the FRC project

The governance arrangements were clearly set out and maintained throughout the project.

*show this as an organisation chart

Cabinet - Scottish Ministers	Scottish Government (SG) Strategic Board
Project Board ↑ ↗ **Chair**: Transport Scotland (TS) Chief Executive & Chair of TS Board - Investment Decision Maker (IDM) TS Director of Major Transport Infrastructure Projects (MTRIPS) - Project Owner TS Director of Finance TS Director of Trunk Roads & Bus Operations SG Director of Internal Audit SG Deputy Director of Finance SG Deputy Solicitor 5 Non-Executive Directors Responsibilities: supporting the IDM and Project Owner by providing scrutiny and strategic direction about progress of the project to meet the Ministers' programme for delivery.	← **Financial and Risk Advisory Group (FRAG)** **Chair**: TS Director of Finance TS Director of MTRIPS - Project Owner FRC Project Director & Employer's Representative - Project Sponsor FRC Project Manager & Deputy Employer's Representative TS Finance Directorate representative SG Finance Directorate representative EDT Operations Director EDT Programme and Budget Manager Non-executive member Responsibilities: supporting the Project Board by providing advice on procurement, finance and risks for the FRC project to ensure value for money.
Construction Management Board ↑ ↗ **Chair**: FRC Project Director & Employer's Representative - Project Sponsor FRC Project Manager & Deputy Employer's Representative Head of Policy, Governance and Stakeholder Liaison EDT Operations Director FRC Strategic Communications Manager FRC Main Crossing and Structures Manager Chief Resident Engineers and Technical Managers for both the Main Crossing and the Network Connections External Parties and Compliance Manager FRC Roads and Infrastructure Manager Network Operations Manager Responsibilities: scrutinising the day to day running of the project and providing technical advice to the Project Director on development and progress.	← **Project Reference Groups:** - Traffic Management - Marine Liaison - Noise Liaison - Environmental Liaison ← **Stakeholder Interests:** - Government departments - Transport Scotland Directors - Transport Operators and Mobility - Enterprise and economy - Public and community
Employer's Delivery Team (EDT) ↑ Transport Scotland FRC team + Jacobs Arup Joint Venture (JAJV)	← **Employer's Advisors:** - Insurance - Financial - Legal - Quality - Media

Key governance roles:

Investment Decision Maker (IDM): keeps Ministers informed of progress and any developments that could undermine the project's business case.

Project Owner: keeps the IDM informed of progress, adheres to SG Project and Programme Management Principles, and puts in place effective arrangements to manage the project and its associated risks.

Project Sponsor: has overall accountability for the project and delivering the agreed business benefits, acts as the representative of the organisation and plays a vital leadership role.

Source: Forth Replacement Crossing Project Execution Plan, Transport Scotland, November 2016

40. The structure of committees, frequency of meetings, level of information and supporting documentation meant there was appropriate and timely reporting of key issues to the Project Board. There were high-quality arrangements for managing performance and finance and regular reporting on these. This included a systematic approach to managing changes and risks. There was a positive culture and open and transparent approach within the Project Board and project team. There were also good relationships with the lead contacts for the contractors, who attended the weekly Construction Management Board meetings to discuss ongoing progress and management of the project. The FCBC Project Director attended the Project Board meetings.

41. The Employer's Delivery Team (EDT) produced monthly reports throughout the project covering health and safety, programme progress, updates to costs and forecasts, quality, risk register and compliance with external requirements, such as air quality and noise and vibration levels. The EDT reports were discussed in detail at Finance and Risk Advisory Group (FRAG) meetings and key points raised at Project Board meetings a week later. The Cabinet Secretary Economy, Jobs and Fair Work was also updated every 2-4 weeks. This allowed issues to be raised promptly at the appropriate level and decisions to be made quickly.

42. Discussions and decisions by the FRAG and Project Board about changes to project costs and other significant changes are clearly documented in minutes. There was effective scrutiny of key decisions made by the Project Board by external peer reviewers with relevant expertise in the early stages of the project, gateway reviews at key stages, and Non-Executive Directors throughout the project.

There were effective controls in place to manage change

43. Transport Scotland managed the timescales and any changes effectively to minimise the effect on time, cost and quality. It set out clear timescales for the project from the start in the Bill, business case and project plans, and reviewed these regularly as the project progressed. A comprehensive programme covering all aspects of the project was established by Transport Scotland, with a dedicated programme manager allocated within the Employer's Delivery Team. Progress was monitored closely by the Construction Management Board, chaired by the Project Director, and reported monthly within EDT reports.

44. FCBC worked closely with the Met Office to obtain frequent, detailed weather forecasts to mitigate the effect of weather on timescales. These included wind speed and direction at different heights in the Forth (up to 200 metres above ground level). FCBC used a Met Office tool to plan weather-dependent activities up to 15 days in advance. Before construction started, the Met Office provided detailed analysis of the climate at the site. This included rainfall levels and the likely effects of wind at different points in the day and year.[31] During the

[31] *Forth Replacement Crossing Project Update*, Transport Scotland, February 2014.

procurement process, Transport Scotland had also provided the contractor with weather data for the previous ten years. During critical periods of the bridge construction, the weather was considerably worse than conditions experienced in previous years:

- During late 2015 and early 2016, wetter and windier weather than predicted caused delays to construction. There was 40-50 per cent of downtime during January, February, April and May, 2.5 times greater than expected based on previous forecasts.
- During winter 2016/17, windier weather than predicted caused delays to weather-dependent activities, such as removing the cranes at the bridge towers, which could only be done in wind speeds less than 25 mph. This also delayed other work as people could not work at deck level while the cranes were being removed for safety reasons. Much of this work had originally been planned for during the summer, but the earlier delay in 2016 meant this work was completed during the winter.

45. The Project Board approved two changes to the timescales for the work programme towards the end of the project, which affected the planned opening date of December 2016. Ahead of both changes, FCBC fully reviewed the work programme and sought advice from independent experts to explore options to mitigate delays and determine a revised opening date. Additional challenge and scrutiny measures were put in place to enable the Project Board to fully understand the issues and get assurance that all possible options were considered:

- **First change from December 2016 to May 2017**: The Project Board increased the frequency of meetings and the Employer's Delivery Team provided additional information. The FCBC Director attended Project Board meetings to explain the issues, which allowed detailed discussion and challenge. In June 2016, the Project Board approved a revised opening date of May 2017.
- **Second change from May 2017 to a ten-week range from July to September 2017**: The Investment Decision Maker brought in members of Transport Scotland's senior management team to consider various options and provide additional challenge and scrutiny. The Project Director produced reports, detailing the progress and work still required to open the Queensferry Crossing. These were updated every two weeks to allow close monitoring of progress. The team reviewed risks more frequently to help focus on the key aspects affecting the timescales. In March 2017, the Project Board approved a revised opening date - a ten-week range from mid-July to the end of August, based on the best and worst-case scenarios provided by the Employer's Delivery Team.

46. The new crossing opened on 30 August 2017, eight months later than first estimated and ten weeks later than the contract completion date of 16 June 2017. This was reasonable given the prolonged adverse weather conditions during key stages of construction. In line with the terms of the contract, Transport Scotland allowed the contractor additional time to complete the work due to adverse weather conditions. This did not affect the project cost as the contractor was not entitled to payment of any costs incurred because of any delays.

Risks were identified, monitored and updated throughout the project

47. Transport Scotland effectively identified and managed risks throughout the project and risk was a key focus of the Project Board. The Employer's Delivery Team Operations Director led on risk management. Risks were prioritised based on probability and impact and risk owners were identified for each risk.

48. The risk register was updated quarterly and risks were removed as they were eliminated from the project. This was collated and reported monthly in EDT reports. These highlighted the top five risks by cost (for example, disputes between the contractor and the employer) and the top five strategic risks (for example, failing to achieve planned opening dates to traffic). Risks were discussed at each committee and Project Board meeting. Ways to reduce risks were a major focus throughout the project. For example, on health and safety, there were reports on any incidents, near misses and injuries and the Project Board regularly discussed measures to reduce these.

Extensive quality assurance measures were put in place

49. Transport Scotland put in place extensive processes and controls throughout the project to deliver work that met the project scope and followed required engineering standards and regulations. The FRC team carried out regular checks and inspections and full-time site supervision. Transport Scotland appointed independent assessors to provide assurance that all parties, including the Employer's Delivery Team, had appropriate quality systems in place throughout the construction period. The assessors also carried out a programme of audits. Quality was monitored throughout the project and reported in the monthly EDT reports.

50. There are recent well-documented publicly funded infrastructure projects where inadequate quality assurance has led to serious failings. This includes the DG One leisure centre in Dumfries and Galloway and schools in Edinburgh. The Institute of Civil Engineers has raised concerns about supervision, inspection and testing on building projects reducing over the years for financial reasons. It highlights the need for the construction industry to ensure that designs are appropriately checked and construction sites independently supervised.[32] Transport Scotland built in effective quality assurance measures to the contract and required the contractor to meet rigorous standards (Case Study 2). FCBC was required to provide detailed progress reports, including copies of quality assurance documents, test results and certificates of materials used. FCBC had overall responsibility for quality control and assurance of the works. It employed a number of people to support this:

- A designer who was responsible for supervising the works to ensure construction was in accordance with the design
- A checker who was responsible for verifying the design as competent

[32] *Wall collapse at Scottish school highlights lack of supervision in modern construction*, Civil Engineering, May 2018.

- A safety auditor who was responsible for auditing temporary traffic management schemes and the permanent works.

Case Study 2

Examples of how Transport Scotland built quality assurance into the project

The Bill set out the required quality standards and these were built into the contract for the design specification, construction regulations and requirements:

- The Bill set out requirements on the design, findings from the Forth Crossing studies, and national and local transport and planning policy. It also introduced the Code of Construction Practice that set out a series of objectives and measures for the contractors to manage and operate the construction works reasonably. These included limiting noise, vibration and dust caused by construction activities, and minimising disruption to traffic.
- The principal contract included 10 key performance indicators (KPIs) on supervision and quality control. One example was a requirement for FCBC to inspect the deck sections as they were being installed and follow recommended quality bridge deck fabrication procedures. FCBC also had to establish a virtual spinning room, where everyone involved in the project was invited to propose their ideas on how to improve the works, for example improving quality or saving money. People who suggested the best and feasible ideas received a reward based on how much the idea added value to the project.
- The terms of the principal contract required the contractor to set up and maintain a quality assurance system to demonstrate compliance with the requirements of the contract. This included a certification process from design through to completion and handover, with verification by the contractor, designer and checker (plus a safety audit). It also required the contractor to:
    - Provide all necessary supervision to plan, arrange, direct, manage, inspect and test the work. This had to be provided by enough people who had adequate knowledge of English and of the operations for executing the work safely and satisfactorily.
    - Allow the employer's personnel at all reasonable times full access to all parts of the site and to all places from which materials were being obtained. Access also had to be provided during production, manufacture and construction.
    - Allow the employer to carry out surveillance activities, audit records, examine, inspect, measure, test or check progress.

Source: Audit Scotland fieldwork

51. The principal contract includes a five-year defects correction period following the bridge opening. This is standard on contracts of this nature and the contractor is responsible for correcting any defects that arise during this period. The contractor is also required to complete any outstanding works and snagging by the end of each year in which it is identified. The contractor determines the programme for this work. In January 2018, Transport Scotland provided a summary to the Scottish Parliament of the remaining work the contractor is to carry

out after the bridge opened.[33] Transport Scotland could have managed the public's expectations better by communicating that further work and snagging would be required when the Queensferry Crossing was opened.

52. During August 2017, the contractor identified that the road surfacing had been laid slightly too high on either side of the joints where the bridge joins the viaducts. There was insufficient time to rectify this before the bridge opening on 30 August. It did not affect the safe and effective operation of the bridge, but over time the impact of traffic would have a detrimental effect on the joints. At its meeting in September 2017, the Project Board agreed that the contractor would need to rectify it before the speed limit could be raised to 70 mph. FCBC investigated potential solutions to repair it with minimal disruption, but recommended replacing the road surfacing at both ends of the northbound carriageway, requiring lanes closures for up to six days. The Project Board agreed that FCBC's proposal was the most appropriate solution at its meeting in November 2017. The contractor completed the work in early December. During this time, northbound traffic was diverted to the Forth Road Bridge and southbound traffic continued to use the Queensferry Crossing. The contractor met the cost of the repairs and lane closures.

There was tight financial management of the project

A good cost-estimating approach was used in estimating the initial budget

53. Transport Scotland had good cost-estimating arrangements in place for projecting the initial budget. All cost estimates and analyses were prepared by JAJV and independently reviewed by EC Harris, an international asset consultancy firm. Reasonable costs were included for risk and optimism bias following HM Treasury guidance. Appropriate inflation rates were applied and included inflation costs specific to types of service, labour and materials to be used. Initial estimates included the operating and lifecycle refurbishment costs. These were realistic and provided Transport Scotland with an understanding of the whole-life budget for the project. (Exhibit 5)

54. The initial bridge design included two lanes for public transport and two footpath and cycle ways. The estimated cost for the project was £3.2-£4.2 billion for a replacement crossing and connecting roads. In 2008, FETA reported that work to prevent further corrosion to the cables on the Forth Road Bridge would allow it to continue to be used to a limited extent. Transport Scotland changed the scope of the project to incorporate the existing bridge as a dedicated public transport crossing. It narrowed the width of the replacement bridge, removing the proposed public transport, cycle and pedestrian lanes. This considerably lowered the estimated cost to £1.72 to £2.34 billion. The Minister for Transport, Infrastructure and Climate Change announced the details of this proposed managed crossing scheme to the Parliament in December 2008.

[33] *Transport Scotland letter to the Rural Economy and Connectivity Committee*, Scottish Parliament, 8 January 2018.

Exhibit 5

Cost-estimating approach for projecting the initial project budget

Transport Scotland's cost-estimating approach for projecting the initial budget of £1.72-2.34 billion in November 2008 was comprehensive and followed relevant guidance and industry standards.

Different methods were used to calculate the initial estimate and outturn costs for various elements of the budget, in line with industry standards:

- Quantity-based estimates for network connections - using industry data, and comparable cost information from other infrastructure and roads projects.
- Resource-based estimates for the bridge cost - applying the amount of labour, plant and materials required for construction processes and activities. This took into account the geographical location and the specific circumstances of building the FRC. For example, UK legislation, health and safety and environmental regulations, the geology of the seabed and conditions for the foundations, specialist plant such as barges to put sections of the crossing in place, and shipping lanes.
- Costs for optimism bias and risk were included in line with HM Treasury guidance.
    - Optimism bias was calculated at 8 per cent for the network connections, 22 per cent for the bridge, and 15 per cent for employer's costs (we explain optimism bias in paragraph 21).
    - In any large civil engineering project there are costs arising from inherent risks and uncertainties, such as weather or ground conditions. This was assessed using a risk register containing discrete risks quantified based on the probability and severity of each risk. For uncertainties in cost estimations a percentage range was applied to each cost item from the capital cost estimates. Allowances included for foreseeable risks and opportunities were £45 million for the network connections and £70 million for the bridge.
- New construction costs are liable to non-recoverable VAT. So, the costs were calculated on the basis that this would apply to the new bridge, along with 85 per cent of the roads to the south and 65 per cent of the roads to the north.
- Costs for inflation and costs of capital charges were added. Construction rates of inflation are higher than general inflation. The projected average annual construction inflation rate had a median value of approximately 5.3 per cent. Costs for financing the project (cost of capital charges) were calculated at 3.5 per cent of the cumulative capital spending on the project in line with relevant government accounting guidance.

Note: Figures stated are those included in the Forth Crossing Bill, November 2009.

Source: Audit Scotland review of cost estimating documentation and reports (Scheme definition, SPICe FRC Cost Analysis briefing, BiGGAR Economics report, Bill Financial Memorandum)

55. Over the next few years, Transport Scotland carried out project development work, including ground and marine investigations, reviewing design and developing a competitive procurement approach. It also further analysed costs and reduced the levels of optimism bias, cost of capital charges and allowance for increases in inflation rates. As a result, Transport Scotland further reduced the estimated costs. The FRAG and Project Board approved the first project budget at the beginning of the construction phase in July 2011 at £1.45 to £1.6 billion.

56. A Scottish Parliament briefing in 2010 provided benchmarking data for a number of comparable cable-stayed bridge projects. This showed that the projected costs were reasonable and often favourable to similar projects. The report shows several comparator costs to benchmark the new bridge against comparable projects around the world.[34] An unusual design feature of the FRC is its wide hard-shoulder lanes, 4.2 metres instead of the required 3.3 metres, in either direction.

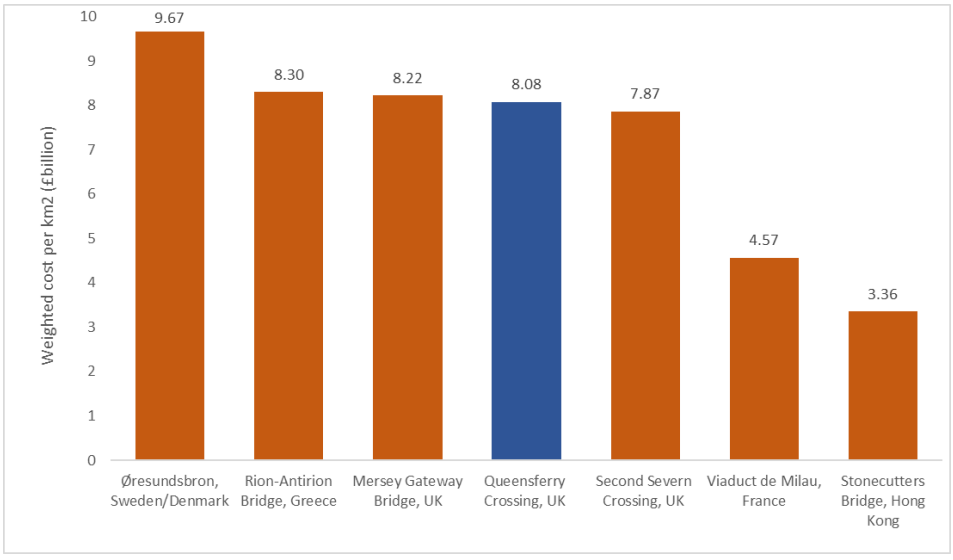
57. Exhibit 6 shows the weighted cost of each square kilometre of bridge and approach viaduct. It therefore takes into account lane width, not just the number of lanes. Once this is factored in, the cost of the FRC is largely in line with other similar bridges such as the Rion-Antirion in Greece, and the Mersey Gateway and Second Severn bridges in the UK. The Øresund bridge connecting Denmark and Sweden is the most expensive, but this was subject to stringent environmental standards and an artificial island had to be constructed to connect the bridge with a tunnel. The Viaduct de Milau and Stonecutters bridges in France and Hong Kong, which both have towers constructed only on land, are much cheaper.

Exhibit 6

Comparison of costs for cable-stayed bridge projects

The projected costs for the FRC project were reasonable and favourable compared to similar projects.

*To incorporate info on the factors contributing to differing costs



Source: The Forth Replacement Crossing Analysis of Costs, Scottish Parliament Information Centre, February 2010

Costs were monitored and reported clearly throughout the project

58. The FRC team managed and monitored costs effectively throughout the project. It regularly gave cost updates and forecasts in the EDT reports to both the FRAG and Project Board

[34] *The Forth Replacement Crossing Analysis of Costs*, Scottish Parliament Information Centre, February 2010.

(either monthly or quarterly). The team continually revised cost estimates, making appropriate adjustments to allowances for risk, optimism bias and inflation rates. Reports were consistent in form based on up-to-date cost information and clearly outlined key movements. This allowed members to easily identify, follow and scrutinise movements in cost. Financial reporting was a standing item at both the FRAG and Project Board meetings and decisions were clearly documented in the minutes.

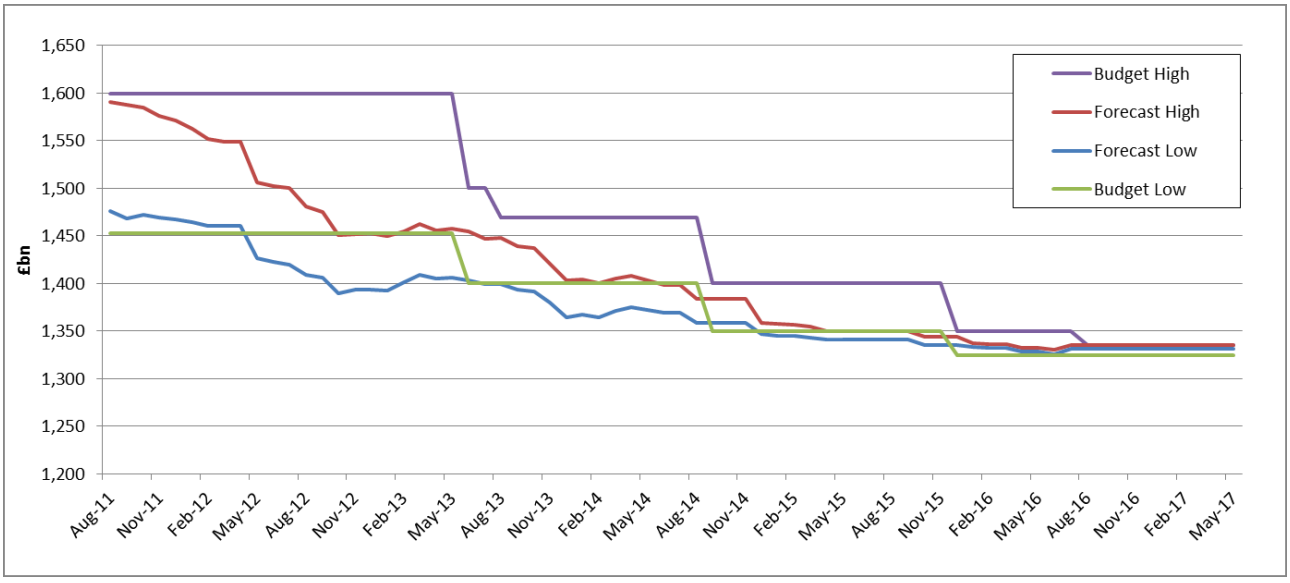
The project was delivered under budget

59. Tight financial management by the FRC team and effective scrutiny by the FRAG and Project Board led to Transport Scotland delivering the project under budget. The final FRC project cost was £1.34 billion. This was around 8-16 per cent less than the £1.45-£1.6 billion estimated at the start of construction and all approved budgets. The main reductions in costs were in allowances made for optimism bias, risks, non-recoverable VAT and increases in inflation rates. Exhibit 7 shows how the overall costs reduced during the project.

Exhibit 7

Changes to the FRC budget, 2011 to 2017

Project costs reduced from a projected £1.45 to £1.6 billion in 2011 to £1.34 billion in 2017.



Source: Transport Scotland EDT reports

60. Some key changes to the overall costs between 2011 and 2017 included:

- Risk allowance reduced from £93 million to £59 million. Overall these costs were less than estimated as some of the identified risks did not materialise. For example, almost £5 million allowed for finding unexpected marine grounds was not required.
- Non-recoverable VAT reduced by around £27 million after a more detailed analysis of how it should be applied to the individual contracts and a reduction in the employer costs.

- Price fluctuation costs were £60-£205 million less than first projected, based on the initial project cost range. This was a result of inflation continuing to be significantly lower than forecast.
- Optimism bias decreased overall from £52 million to zero as the project progressed.
- One of the main increases in costs related to the principal contract, which increased from £790 to £836 million. This was largely from:
- costs for risks that materialised, particularly for works related to the pipeline
- mitigating the severity or probability of risks occurring
- variations on the contract (agreed additions, omissions or substitutions), including increases in costs of land, Intelligent Transport System, network connections and utilities.
- There were smaller increases in other elements of the project - M9 Junction 1a (£2 million), the CEC (£1 million) and in Employer's Costs (£4 million)

Transport Scotland consulted and engaged well with people with an interest in the project

61. Transport Scotland identified the groups and communities that would be affected by the FRC project and consulted and engaged with a wide range of stakeholders throughout the project. In 2008, it set out its initial plans for how and when it would do this, which it reviewed and updated at key stages.[35] Transport Scotland built a Contact and Education Centre (CEC) as part of the project (Exhibit 8) maintained a website which provided up-to-date information and documentation to the public, media and stakeholders. Other methods included newsletters, leaflets and briefing sessions. The FRC team considered stakeholders' feedback and used it to inform some aspects of the design and the approach to the project. This included:
    - Over 160 stakeholders had the opportunity to contribute to developing the design of the crossing and connecting roads, such relevant public bodies, community councils and more than 100 landowners and tenants.
    - Altering the design and location of a South Queensferry Junction after local communities raised concerns about the impact on the landscape and views, and elevation of the route.
    - Adding dedicated slip roads for public transport providing a more direct link to the main road after concerns from the public about potential delays on the proposed route.

62. The contractors were obliged to carry out a range of measures and engagement activities, such as setting up a dedicated team for liaising with the publican and dealing with deal with enquiries and complaints.[36] The team also attended local community council meetings to update residents on progress give stakeholders an opportunity to feedback their views, raise concerns and ask questions. As part of the requirements of the Code of Construction Practice, Transport Scotland established four working groups to monitor and approve the contractor's

[35] *Engaging with Communities*, Transport Scotland, September 2008.
[36] *Forth Replacement Crossing Code of Construction Practice*, Transport Scotland, November 2009.

work and minimise disruption. The contractor consulted with these groups before carrying out any relevant work:

- Marine Liaison Group - included representatives from the navigation and harbour authorities, the operator of Rosyth Dockyard and the emergency services.
- Environmental Liaison Group - included representatives from local authorities, Scottish Natural Heritage, the Scottish Environment Protection Agency, Marine Scotland and Historic Scotland.
- Traffic Management Working Group - included representatives from trunk and local road authorities and the emergency services.
- Noise Liaison Group - included representatives from each of the relevant local authorities and Scottish Natural Heritage.

Exhibit 8

Contact and Education Centre (CEC), South Queensferry

The CEC provided a dedicated facility for providing information, educating and consulting about the FRC project

- More than 80,000 people participated in a wide range of activities at the CEC as part of the FRC outreach and education programme.
- Project exhibition - Members of the public could learn about the construction of the FRC project, view detailed bridge models and meet members of the project team to ask questions. More than 25,000 people have visited since 2013.
- FRC project presentations - Universities, colleges, professional organisations and community organisations could visit for a presentation about the construction of the Queensferry Crossing and a question and answer session with a member of the FRC project team. Monthly presentations about the project were also held for members of the public. More than 35,000 people have attended presentations.
- FRC schools programme - Pupils from primary and secondary schools could visit to learn about the project, with a focus on science, technology, engineering and maths (STEM) related activities. Around 28,000 pupils participated.

Source: Transport Scotland

63. The FRC team was proactive with engagement and communication. For example, it recognised that long-term substantial works at the Ferrytoll interchange, north of the new bridge, were going to cause a lot of concern within the local community. The team recognised it needed to provide clear communication to minimise disruption to local residents, businesses and commuters. It did this by developing a specific package of information, including digital information, dedicated events, an email subscription and drop-in sessions with engineers and contractors to answer any questions. This approach proved to be effective as the Ferrytoll works were received well by the local community. Feedback about the disruption was that it was not as bad as anticipated.

Part 3: Intended benefits of the project

Transport Scotland needs to be clear how it will measure the intended benefits

Key messages

- **The overall aim of maintaining a reliable road link between the Lothians and Fife has been achieved. The Queensferry Crossing opened to traffic on 30 August 2017. It is too early to know whether Transport Scotland will achieve all the wider project outcomes it set.**
- **Transport Scotland has a plan for evaluating progress towards achieving the FRC project's objectives, and is due to carry out a full post-project evaluation one year after the FRC became fully operational. The plan details how performance relating to journey times and traffic flow will be measured, but more detail is required on other outcome measures and when these will be delivered. For example, how it will assess the impact of improved network connections and junctions, and the project's contribution to economic growth.**
- **The FRC project has put in place infrastructure to help support increased use of public transport. Transport Scotland now needs to clearly set out its plans on how it will support public transport providers to meet increasing demand for travel across the Forth. This should include actions and timescales.**
- **Transport Scotland has kept a comprehensive record of lessons learned throughout all stages of the project, covering a wide range of topics. This enabled learning to be shared across other Transport Scotland projects.**

The overall aim of providing a continuing and reliable important road link has been achieved

64. Transport Scotland delivered its overall aim for the FRC project of maintaining a reliable road link between the Lothians and Fife. The Queensferry Crossing opened to traffic on 30 August 2017. It closed again from 2 and 5 September for the opening events, before reopening to traffic on 6 September 2017. The project provided a replacement bridge designed to be more reliable than the existing bridge. Some of the other planned outcomes will take longer to achieve. (Exhibit 9)

Exhibit 9

Transport Scotland's progress against the FRC project objectives

It is too early to know whether Transport Scotland will achieve all the planned outcomes, but some have been achieved or partly achieved.

FRC project objectives	Progress towards achievement of objectives
Maintain cross-Forth transport links for all modes to the level of service offered in 2006.	Achieved. The Queensferry Crossing, existing Forth Road Bridge and connecting roads provide a cross-Forth link for all modes of transport.
Connect to the strategic transport network to aid optimisation of the network as a whole.	Achieved. Queensferry Crossing is designated as motorway and connects to the existing road network. Improvements made to the road network North and South of the bridge. Existing bridge dedicated to public transport.
Improve reliability of journey times for all modes.	Achieved supporting infrastructure. Dedicated public transport route. Improved connections to existing road network. Hard shoulders and wind shielding on the replacement bridge to improve resilience and reliability. ITS technology to manage flow of traffic. *Still to assess reliability of journey times.*
Increase travel choices and improve integration across modes to encourage modal shift of people and goods.	Achieved supporting infrastructure. New park and ride facilities at Halbeath and improved facilities at Ferrytoll. Dedicated bus lanes. *Still to assess use of different types of transport and changes in use of more sustainable transport, such as buses or trains.*
Improve accessibility and social inclusion.	*Still to assess impact of improved network connections and junctions. Project aimed to increase travel options for all groups of people by improving public transport connections and providing improvements for pedestrians and cyclists.*
Minimise the impact of maintenance on effective operation of the transport network.	Achieved supporting infrastructure. Queensferry Crossing designed for reduced maintenance and minimal disruption from maintenance and repairs.
Minimise impact on people, and the natural and cultural heritage of the Forth area.	*Still to assess performance against objectives set out in the environment statement. Project aimed to minimise impact of works on local communities. Consultation with environmental working groups before/ during construction.*
Support sustainable development and economic growth.	*Still to assess e.g. impact on carbon emissions, changes to employment patterns, decisions by businesses on locating in the local area and access to labour, and impact the on economic development.*

Source: Audit Scotland fieldwork

Transport Scotland needs to be clear how it will deliver and measure all the project's intended benefits

Transport Scotland plans to carry out a full post-project evaluation

65. Transport Scotland has developed a plan for evaluating progress towards achieving the FRC project's objectives. In line with guidance for major transport projects, Transport Scotland plans to carry out detailed evaluation of the project at one year, three years and five years after the managed crossing scheme became fully operational.[37] This is on 1 February 2018, when the Queensferry Crossing became a motorway and the Forth Road Bridge became a dedicated public transport crossing. In the year one evaluation report, Transport Scotland are required to confirm whether there are any indications that the project will not achieve the objectives. In the subsequent reports at years three and five, Transport Scotland should provide an assessment of whether the project has achieved the objectives.

66. Transport Scotland also carried out an initial review after one month, which showed…[*awaiting info from TS] It plans a second review once the ITS across the Queensferry Crossing is fully operational, currently scheduled for around September 2018.

Transport Scotland needs to be clearer about how it will measure progress in achieving benefits

67. The evaluation plan includes what will be covered in each stage of evaluation, and some detail about how performance will be assessed. There are specific proposals for how performance relating to journey times and traffic flow will be measured and compared with data from before the new crossing opened. The plan includes the routes that will be measured, the timings of the data collection and the sources of the data that will be used. Transport Scotland needs to include more detail about how it intends to evaluate the progress of several of the project's other objectives and intended benefits. For example, Transport Scotland plans to:

- Survey transport users and consult with disability groups to assess whether it has achieved its objective of improving accessibility and social inclusion. It is not clear what specific information it will collect. The current plan does not state what topics the survey would include, when and how the survey would take place, which disability groups will be consulted with and what the consultation would involve.
- Compare pre-opening and post-opening employment patterns using secondary data sources to assess whether it has achieved its objective of supporting sustainable development and economic growth. It also plans survey the business community to understand the impact on location and access to labour. It is not clear what secondary

[37] *Scottish Trunk Road Infrastructure Project Evaluation (STRIPE) - Final Guidance*, Transport Scotland, August 2016.

data sources it will use, when or how it will collect the data, which members of the business community will be surveyed, or what questions will be included.

68. Although a formal evaluation has not yet taken place, informal monitoring has shown a slight improvement to journey times and resilience. Journeys in both directions have seen a reduction of a couple of minutes on average, and bus journey times have improved, particularly towards Edinburgh in the mornings. As at June 2018, on three occasions since the Queensferry Crossing opened when bad weather would have caused the Forth Road Bridge to close to HGVs and buses, traffic was able to continue to use the new bridge. The project also exceeded targets for creating jobs and training places. During each year of construction, the FRC project committed to deliver:
    - 45 vocational training positions – 105 were delivered
    - 21 professional body training places – 32 were delivered
    - 46 positions for people who were long-term unemployed – 51 were delivered.

69. The FRC was the first project where Transport Scotland required contractors to advertise the tender of subcontracts on the Public Contracts Scotland procurement portal.[38] All job opportunities were also advertised in local job centres. Across all contracts for the FRC project, Scottish firms were awarded a value of around £351 million sub-contracts or supply orders out of a total of £709 million (50 per cent) consisting of:
    - 312 out of 575 sub-contracts, with a value of around £188 million out of £494 million (54 and 38 per cent respectively).
    - 55,860 out of 60,596 supply orders, with a value of around £163 million out of £215 million (92 and 76 per cent respectively).

Transport Scotland now needs to set out a clear plan for improving public transport across the Forth

70. Transport Scotland's policy is to support an increase in people using public transport and active travel, including cycling and walking. The FRC project has provided some opportunities for improving public transport across the Forth. Transport Scotland now needs to clearly set out its plans for how it will support public transport providers, such as private bus companies, to meet increasing demand for travel across the Forth. This should include how it plans to encourage more people to use public transport, including actions and timescales. The FRC project has put in place infrastructure to help increase the number of people using public transport. This includes:
    - a dedicated public transport route including the Forth Road Bridge, with buses using parts of the hard shoulder on approach roads when they are congested
    - improved resilience and reliability of bus travel in bad weather, by using the hard shoulder on the Queensferry Crossing as a bus lane

[38] Public Contracts Scotland procurement portal is the Scottish Government's official national website for viewing and applying for public sector contract opportunities.

- new and improved park and ride facilities in Fife
- an option to introduce light rapid transit on the Forth Road Bridge, such as guided bus or tram based light rail.

71. Transport Scotland published a Forth Replacement Crossing Public Transport Strategy in partnership with a range of other organisations including local authorities and providers of public transport. It was published in 2010, refreshed in 2012, and prepared alongside the FRC Managed Crossing Scheme. The aims of the FRC project relating to the strategy included:
    - offering opportunities to maintain and enhance sustainable public transport growth
    - providing appropriate support for the Scottish Government's purpose of increasing sustainable economic growth
    - contributing to the carbon emissions reduction targets required by the Climate Change (Scotland) Act 2009.

72. The strategy included several projects to improve public transport in the Forth area. Some of these were included as part of the FRC project including Ferrytoll and Halbeath park and ride facilities and hard shoulders for running buses.[39] Progress on some other projects included in the strategy is unclear, such as proposed additional bus lanes on some main roads and further improvements to public transport connections in Edinburgh and the surrounding area. Transport Scotland plans to publish an update on progress in late 2018.

There has been a strong focus on sharing the lessons learned from the project

73. The FRC team kept a comprehensive record of lessons learned throughout the project. It covered a wide range of topics and highlighted areas of good practice as well as areas that required improvement. Transport Scotland shared lessons learned from the project regularly with colleagues through workshops, team meetings and documentation. For example, Transport Scotland further developed the FRC's school education programme for its projects to convert the A9 and A96 roads into dual carriageways. Transport Scotland has also shared information and lessons learned more widely, including with professional engineering institutions and various government transport departments from around the world.

74. Key aspects of good practice members of the FRC team highlighted that particularly helped to make the project successful include:
    - Co-location: FRC project team members from Transport Scotland, JAJV, and FCBC being based in the same location worked very well. It was easier to be more proactive and mitigate risks, any issues could be addressed as they came up, and it helped good communication and working relationships.

[39] The Halbeath Park and Ride in Fife provides more than 1,000 car parking spaces (including 48 disabled spaces), 12 electric car charging points and 10 bicycle lockers. There are pick-up and drop-off points, a taxi rank and bus shelters. It opened in November 2013 and usage levels are reported to be high. [*to get usage stats] [to put in info panel beside text]

- Project planning: Good planning right from the start meant that effective governance arrangements were in place and Transport Scotland had the right people in post at the right time. This helped to minimise disruption to the project because the project members were well prepared, efficient and experienced.
- Stakeholder engagement - Early and sustained engagement with stakeholders worked well. There were limited numbers of complaints and identifying stakeholder groups early enabled the team to put an effective communication strategy in place.

75. The public sector can learn a lot from the way Transport Scotland managed the FRC project. Transport Scotland should continue to look for opportunities to apply good practice from the FRC project to future projects. It should also consider publishing the lessons learned so they can be shared widely across the public sector and outside Scotland. The Scottish Government should share good practice from the FRC more widely, highlighting generic project management lessons that could be applied to other types of projects, such as IT projects.

Appendix 1: Audit methodology

We reviewed and used a range of information during our audit, including the following:

- Project appraisal
- Forth Crossing Bill
- Parliamentary committee evidence
- Business plan
- Project plans
- Procurement documentation
- Contract documentation
- Governance arrangements
- Risk register
- Quality assurance
- Gateway reviews
- Project Board and Finance and Risk Advisory Group (FRAG) meeting papers
- Employer Delivery Team monthly progress reports
- Analysing cost information, including reviewing the budget assumptions, basis for the costs, and how these were applied

We spoke to representatives from:

- Transport Scotland, including a Non-Executive Director
- Scottish Government
- Forth Crossing Bridge Contractors (the consortium that built the Queensferry Crossing)
- Forthspan (the other consortium that bid for the Queensferry Crossing contract)
- Forth Bridges Operating Company (Amey)
- North Queensferry Community Council and Queensferry District Community Council
- Mersey Gateway Project

Appendix 2: Advisory group members

Audit Scotland would like to thank members of the advisory group for their input and advice throughout the audit.

Member	Organisation
Ainslie Mclaughlin	Scottish Government
Alex Mulchrone	Project Management Institute
Lawrence Shackman	Transport Scotland
Michelle Rennie	Transport Scotland
Milagros Monstaza	Project Management Institute
Ronnie Hunter	Institution of Civil Engineers

Note: Members sat in an advisory capacity only. The content and conclusions of this report are the sole responsibility of Audit Scotland.

Appendix 3: KPIs

25 key performance indicators (KPIs) linked to payments were built into the principal contract to incentivise the contractor to deliver key objectives.

Ref	KPI description
1-15	**Project Planning and Completion**
1-5	Advance planning, including weekly progress monitoring, progress sheets, 3D visualisation.
6-10	Supervision and quality control, including procedures for production inspections of bridge deck, document management systems, tracking of construction progress and items using GPS, virtual Spinning Room.
11-15	Records, including electronic linked workflow of certificates, plan and records, as-built plans and 3D models of completed construction.
16-20	**Training Partnerships**
16	Provide sponsorship to community education or training throughout the construction period
17	Provide cash/facilities/access to expertise to a minimum of two PhD students per year
18	Deliver at least one construction-related talk/lecture/seminar to a training provider/educational institution in each Scottish region per year (overall minimum 8 per year).
19	Employ a minimum of 10 further education students per year on average for them to gain work experience.
20	Arrange a minimum of 1 school, college or university visit per month on average for the duration of construction.
21-25	**Wider Social Responsibilities** Including dealing with complaints promptly and complying with agreed limits for noise, vibration and dust.
	Total carbon used Achieving an agreed target of 130.4k tonnes of carbon used in the steel and cement for construction and transporting the materials by road, rail and sea.

Each set of KPIs had a value and each KPI had a weighting. Payments were calculated each year based on the contractor's average performance. The KPI payment for carbon was calculated as the difference between an agreed baseline value and the actual value. No additional payment was made for performance exceeding the stated targets for the KPIs.

The Contractor also committed to provide 45 vocational training places (SVQ Level 2 Training or Equivalent) and 21 professional training places (Professional Body Approved Training Scheme).

Source: Principal contract KPI Payment Reduction Regime