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Forth Replacement Crossing

Report to Inform an Appropriate Assessment for the Firth of Forth SPA

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Jacobs Arup - Jacobs U.K. Limited and Ove Arup & Partners International Limited Consortium

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Executive Summary

Jacobs Arup has been commissioned by Transport Scotland to provide reports to inform Appropriate Assessments (RIAA) for Natura 2000 sites which could be significantly affected by the proposed Forth Replacement Crossing (FRC).

Legislative context

This report provides information for use in an Appropriate Assessment of the effects of the Forth Replacement Crossing (FRC) on the Firth of Forth Special Protection Area (SPA) classified under Article 4 of the European Union Birds Directive 79/409/EEC. Article 4.1 of the Directive requires the selection of the 'most suitable territories' as SPAs for sites supporting species which are rare or vulnerable in Europe, listed on Annex I of the Directive. Article 4.2 requires the selection of SPAs for regularly occurring migratory species not listed on Annex I, with particular attention to be paid to the protection of wetlands, with the main focus being on wetlands of international importance (The Ramsar convention)[1].

SPAs are protected under the European Union Habitats Directive (92/43/EEC). In relation to SPAs, Article 6 of the Habitats Directive requires that any plan or project not directly connected with or necessary to the management of the site, but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to an Appropriate Assessment of its implications for the site in view of the site's conservation objectives'. Based on this assessment, 'competent national authorities shall agree to a plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned', unless there are no alternative solutions and imperative reasons of overriding public interest. In Scotland, this process is implemented through the Conservation (Natural Habitats &c.) Regulations 1994 as amended (hereafter referred to as the Habitats Regulations).

The approach to the Appropriate Assessment of the Firth of Forth SPA was set out in a scoping document prepared in October 2008 which was sent to Scottish Natural Heritage (SNH) (Jacobs Arup 2008). Comments from SNH on the scoping report have been used to inform this report. The Appropriate Assessment for the Firth of Forth SPA will be determined by the Scottish Ministers.

Ecological context

The Firth of Forth SPA includes a mosaic of intertidal habitats (Figure 1) and is classified under Article 4.1 on the basis of regularly supporting wintering and passage populations of European importance of a number of species of waterfowl and seabird listed on Annex I of the EU Birds Directive. The SPA also qualifies under Article 4.2 for supporting wintering populations of both European and International importance of migratory waterfowl species and an assemblage of wintering waterfowl. The FRC will result in the temporary loss of SPA habitat on the northern landfall of the Main Crossing (refer to Figure 1 & Table 6). The southern landfall will result in the loss of non-SPA habitat but with the potential for the greatest disturbance to qualifying species. The report to inform the Appropriate Assessment focuses on the potential implications of the FRC for the Firth of Forth SPA, in view of the site's conservation objectives.

The proposed project

The FRC comprises a new cable-stayed bridge (2.7km long including approach viaducts) with three single column towers, wind shielding and a single deck carrying two general lanes of traffic and a hard shoulder in each direction. To the south of the bridge, a new section of dual carriageway will link the crossing to the existing A90. To the north, a new section of dual carriageway will connect the bridge to the A90/M90. The proposed new bridge passes across the Firth of Forth SPA (Figure 3).

Likely significant effects

Potential adverse effects of the FRC on the Firth of Forth SPA have been identified and assessed based on a review of the scientific literature, information and data gathered during

[1] Ramsar Convention

The Convention covers all aspects of wetland conservation and comprises three elements of activity: the designation of wetlands of international importance as Ramsar sites; the promotion of the wise-use of all wetlands in the territory of each country; and international co-operation with other countries to further the wise-use of wetlands and their resources.

consultation, and surveys carried out specifically to inform an Appropriate Assessment of the potential effects of the FRC on the SPA. The key potential effects of the FRC on the Firth of Forth are likely to arise from the construction and, to a lesser extent, the operation of the new bridge.

Implications identified as having the potential for adverse effects on the integrity of the Firth of Forth SPA are: visual and noise disturbance to the qualifying species during bridge construction as a result of engineering activities, boat movements and the presence of construction personnel and machinery; and pollution risks during construction and operation.

Where implications are considered to have the potential to adversely affect the integrity of the Firth of Forth SPA the data have been used to design mitigation to address these impacts.

Implications of the FRC for the conservation objectives and site integrity of the Firth of Forth SPA

Subject to the implementation of appropriate mitigation, it is concluded that the construction and operation of the FRC will not have an adverse effect on the integrity of the Firth of Forth SPA, in view of its conservation objectives.

No other plans and projects have been identified which could have a potential effect, in combination with the FRC, on the conservation objectives or site integrity of the Firth of Forth SPA.

The description of the proposed scheme provided in this report represents a Stage 3 design. Responsibility for completing a detailed design will lie with the appointed contractors. The engineering activities and construction programme are those envisaged as a possible scenario, but the contractor will determine the actual details or construction. As such, there may be changes to some aspects of the proposals and adoption of selected options. However, design specifications and measures which are essential in terms of the mitigation of any effects on the integrity of the Firth of Forth SPA will be enforced as contractual obligations. Any changes to the scheme assessed in the RIAAs will require consideration by the Competent Authority and the contractor would be required to adhere to any other conditions or restrictions imposed by the Competent Authority in relation to Appropriate Assessments carried out for the Project insofar as they relate to these sites.

As well as reports to inform Appropriate Assessments for the FRC, Jacobs Arup has been commissioned to undertake an Environmental Impact Assessment of the proposed replacement bridge and associated road network. The Environmental Statement (ES) for the project (Jacobs Arup, 2009f.) will report on all likely significant environmental impacts of the proposed scheme and describe appropriate mitigation measures.

1 Introduction

1.1.1 Jacobs Arup has been commissioned by Transport Scotland to provide information to inform Appropriate Assessments for Natura 2000 sites which could be significantly affected by the proposed Forth Replacement Crossing (FRC).

1.1.2 This report provides information for use in an Appropriate Assessment of the Forth Replacement Crossing (FRC) on the Firth of Forth Special Protection Area (SPA) classified under Article 4 of the European Union Birds Directive 79/409/EEC.

1.1.3 The Firth of Forth SPA (Figure 1) is designated for: five Annex I species qualifying under Article 4.1 of the EU Birds Directive, five migratory species under Article 4.2 and its large overwintering waterfowl assemblage (10 individually cited species plus an additional 17 wildfowl).

1.1.4 The proposed scheme comprises a new cable-stayed bridge (2.7km long including approach viaducts) with three single column towers, wind shielding and a single deck carrying two general lanes of traffic and hard shoulders in each direction. To the south of the bridge, a new section of dual carriageway will link the crossing to the existing A90. To the north, a new section of dual carriageway will connect the bridge to the A90/M90. The proposed new bridge crosses the Firth of Forth SPA and will be located to the west of the Forth Road Bridge. The northern landfall of the new bridge at North Queensferry will be about 300m from the Forth Road Bridge and the southern landfall, west of Port Edgar, nearly 1km away.

1.1.5 The approach to the Appropriate Assessment of the Firth of Forth SPA was set out in a scoping document prepared in October 2008, which was sent to SNH (Jacobs Arup 2008). Comments from SNH on the scoping report have been used to inform this report.

1.2 Requirements for Appropriate Assessment

1.2.1 SPAs are classified under the European Union Birds Directive (79/409/EEC). The procedures that must be followed when considering developments affecting European site (SPAs and SACs) are specified in Article 6 of the Habitats Directive (92/43/EEC). In Scotland, this process is implemented through the Conservation (Natural Habitats &c.) Regulations 1994 as amended (hereafter referred to as the Habitats Regulations).

1.2.2 Under Regulation 48(1) of the Habitats Regulations, the 'competent authority', in this case The Scottish Government, must undertake an Appropriate Assessment 'on the implications for the site in view of the site's conservation objectives', where a plan or project:

- 'is likely to have a significant effect on a European site in Great Britain (either alone or in combination with other plans or projects); and
- is not directly connected with, or necessary to, the management of the site'.

1.2.3 The term 'European site' refers to SPAs classified under the Birds Directive and Special Areas of Conservation (SACs) designated under the Habitats Directive.

1.2.4 Guidance (EC 2002, DMRB 2009, Scottish Executive 2006) on Appropriate Assessment sets out four stages in the process, as follows (refer to also Figure 2):

- Stage One: Screening - the process which identifies the likely effects upon a Natura 2000 site from a project or plan, either alone or in combination with other projects or plans, and considers whether these effects are likely to be significant;
- Stage Two: Appropriate Assessment - the consideration of the effect of the project or plan, either alone or in combination with other projects or plans, with respect to the site's structure and function and its conservation objectives in order to assess if the integrity of the European site will be adversely affected. Additionally, where there are adverse effects, an assessment of the potential mitigation of those effects;

- Stage Three: Assessment of alternative solutions - the process which examines alternative ways of achieving the objectives of the project or plan that avoid adverse effects on the integrity of the Natura 2000 site; and
- Stage Four: Assessment where no alternative solutions exist and where adverse effects remain - an assessment of compensatory measures where, in the light of an assessment of imperative reasons of overriding public interest (IROPI), it is deemed that the project or plan should proceed.

1.2.5 In relation to SPAs, Article 6 of the Habitats Directive (implemented through Regulations 48 and 49 of the Habitats Regulations, as amended) requires that 'any plan or project not directly connected with or necessary to the management of the site, but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to an Appropriate Assessment of its implications for the site in view of the site's conservation objectives'. Based on this assessment, 'competent national authorities shall agree to a plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned', Exceptionally, where an appropriate assessment concludes there will be adverse affects on site integrity, Competent Authorities may agree to a plan or project if there are no alternative solutions and imperative reasons of overriding public interest.

1.2.6 Site integrity is defined as 'the coherence of the site's ecological structure and function across its whole area, or the habitats, complex of habitats or populations of species for which the site is or will be classified'; the decision as to whether a site is adversely affected should focus on and be limited to the conservation objectives (EC, 2000).

1.2.7 In carrying out an Appropriate Assessment, mitigation measures, aimed at minimising or avoiding the negative impact of a plan or project during or after its completion, may be considered as an integral part of the plan or project (EC, 2000).

1.3 The relationship between the proposed scheme and the Firth of Forth SPA

1.3.1 The proposed scheme is not a plan or project which is directly connected with or necessary to the management of the Firth of Forth SPA for nature conservation purposes. It is also considered likely to have a significant effect on the Firth of Forth SPA. Therefore, an Appropriate Assessment is required.

1.3.2 A report to inform a strategic Appropriate Assessment for the proposed scheme (Jacobs et al., 2007a) considered four options: three tunnels and a bridge. The consideration of alternatives is important in the unlikely event that a plan or project must be carried out in spite of a negative assessment of the implications for a Natura site. In such a case, there is a legal requirement to demonstrate the absence of alternative solutions (Article 6.4 of the Habitats Directive transposed into domestic law in Regulation 49 of the Habitats Regulations).

1.3.3 The report to inform a Strategic Appropriate Assessment of the FRC (Jacobs et al., 2007a) identified the potential, in the absence of mitigation, for the construction and operation of three crossing options (Bridge at Corridor D, Tunnels C and D; Jacobs et al.,, 2007a) to cause adverse effects on the Firth of Forth SPA; but also concluded that with mitigation in place it should be possible to ensure that there should be no adverse effect on the integrity of the site. The proposed bridge at corridor D was subsequently recommended as the preferred option for the proposed replacement crossing (Jacobs et al., 2007b) for the following reasons:

- Cost - it is significantly cheaper than the tunnel options.
- Construction Programme - it can be delivered quicker.
- Construction Risk - it has fewer risks associated with its construction.

- Economics - it has the best Benefit to Cost Ratio (BCR).

1.3.4 The report to inform the Strategic Appropriate Assessment was completed at a time when few details were available on the design and construction of the bridge option and the mitigation measures that were proposed were generic rather than specific. It was recognised that there would be a legal requirement for further assessment of the final proposed scheme option at a detailed project level (Jacobs et al., 2007a; SNH, 2008).

1.4 Objective of this report

1.4.1 The objective of this report is to provide robust information to enable Scottish Ministers to undertake an Appropriate Assessment of the effects of the proposed scheme (including permanent, construction and operational effects) on the integrity of the Firth of Forth SPA, in view of its conservation objectives. The assessment methodology has been informed by guidance from the EU (EC, 2000, 2002) and DMRB (2009) and provides information that allows consideration of the results to allow the determination of the Appropriate Assessment by the Scottish Ministers. Information is provided on:

- the ecological interests of the Firth of Forth SPA;
- the likely nature and scale of the effects on the SPA from the proposed FRC;
- the mitigation proposed to avoid or reduce these effects;
- an in-combination assessment of other relevant plans and projects with the potential to affect the Firth of Forth SPA in-combination with the FRC; and
- the implications for the conservation objectives and integrity of the SPA.

2 Firth of Forth SPA

2.1 Introduction

2.1.1 This section presents the following information on the Firth of Forth SPA and its qualifying species (Appendix A). The information presented derives from existing site documentation (including the SPA citations and its conservation objectives prepared by SNH) and the results of consultation. It comprises:

- details of the qualifying species and the populations present at the time each site was classified;
- the SPA conservation objectives;
- the national (UK and Scottish) conservation status of SPA qualifying species;
- the conservation status of SPA qualifying species within each SPA, based on the most recent site condition monitoring reports from Scottish Natural Heritage (SNH, 2004a,b,c);
- recent population estimates of qualifying birds within the SPA, based on Wetland Bird Survey (WeBS) data from 2002/03 to 2006/07; and
- published information on the migration of waterbirds through the Firth of Forth.

2.1.2 SPAs are classified under Article 4 of the Birds Directive. Article 4.1 requires the selection of the 'most suitable territories' as SPAs for sites supporting species which are rare or vulnerable in Europe, listed on Annex I of the Directive. Article 4.2 requires the selection of SPAs for regularly occurring migratory species not listed on Annex I, with particular attention to be paid to the protection of wetlands and particularly to wetlands of international importance. The UK criteria for SPA selection and the rationale for the UK SPA network are set out in Stroud et al. (2001). Thresholds for SPA selection for Annex I species are the presence of 1% or more of the British population of a given species, whereas for migratory species the threshold is 1% or more of the relevant international or biogeographic population. While SPAs are selected for particular species based on their occurrence during the breeding, winter or passage seasons legal protection is also provided for these species occurring on a site throughout the year. The Firth of Forth qualifies under Criteria 5 and 6 of the Ramsar Convention (7UK154) with protected area overlapping that which qualified as an SPA under the Birds Directive. As the interests of the Ramsar site are the same as for the Firth of Forth SPA any effects on the Ramsar site will be addressed as part of this report.

2.2 Firth of Forth SPA

2.2.1 The Firth of Forth SPA is a mosaic of estuarine and coastal habitats from the coast at Fife and East Lothian upstream to Alloa. A suite of habitats are found including intertidal flats, rocky shores, saltmarsh, lagoons and sand dunes. Several large urban areas, including Edinburgh, are adjacent to the site and these include several areas of heavy industry. Furthermore the Forth is one of the most important shipping areas in Scotland.

2.2.2 The Firth of Forth SPA is designated for: five Annex I bird species qualifying under Article 4.1 of the EU Birds Directive: five migratory species under Article 4.2 (Table 1) and its large overwintering waterfowl assemblage (10 individually cited species plus an additional 16 wildfowl and Sandwich terns) (Table 2). Bird names used in this report follow the vernacular names recommended by the British Ornithologists' Union (BOU, 2009).

2.2.3 Throughout this report the term 'waterfowl' is used to refer to all qualifying bird species of the SPA; 'waders' refers to all wader species; 'wildfowl' includes all qualifying species which are not waders or terns and Sandwich terns are assessed independently (Table 2).

Table 1: Qualifying bird species of the Firth of Forth SPA (source: JNCC, 2001)

Bird Species	Qualifying Criterion			Time of Year[4]
	Article 4.1 Annex[1]	Article 4.2 Migratory[2]	Article 4.2 Assemblage[3]	
Sandwich Tern *Sterna sandvicensis*	✓		✓	Post-breeding/Passage
Bar-tailed Godwit *Limosa lapponica*	✓		✓	Over winter
Golden Plover *Pluvialis apricaria*	✓		✓	Over winter
Red-throated Diver *Gavia stellata*	✓		✓	Over winter
Slavonian Grebe *Podiceps auritus*	✓		✓	Over winter
Knot *Calidris canutus*		✓	✓	Over winter
Pink-footed Goose *Anser brachyrhynchus*		✓	✓	Over winter
Redshank *Tringa totanus*		✓	✓	Over winter
Shelduck *Tadorna tadorna*		✓	✓	Over winter
Turnstone *Arenaria interpres*		✓	✓	Over winter
Waterfowl Assemblage[5]			✓	Over winter

1 Refers to Article 4.1 of the EU Birds Directive (79/409/EEC) which requires the selection of the 'most suitable territories' as SPAs for sites supporting species listed on Annex 1 of the Directive.

2 Refers to Article 4.2 of the EU Birds Directive (79/409/EEC) which requires the selection of SPAs for regularly occurring migratory species not listed on Annex 1, species with a tick under the assemblage column are qualifying interests of the SPA as part of the migratory assemblage.

3 Refers to Article 4.2 of the EU Birds Directive (79/409/EEC) by regularly supporting at least 20,000 waterfowl.

4 Sites selected for waterbird species on the basis of their occurrence in the breeding, passage or winter periods also provide legal protection for these species when they occur at other times of year (JNCC, 2009).

5 Waterfowl assemblage listed in Table 2.

Table 2: Waterfowl assemblage: Qualifying bird species under Article 4.2 of the EU Birds Directive (79/409/EEC) for the Firth of Forth SPA

Bird Species*		Wildfowl or Wader
Red-throated Diver	*Gavia stellata*	Wildfowl
Slavonian Grebe	*Podiceps auritus*	Wildfowl
Great Crested Grebe	*Podiceps cristatus*	Wildfowl
Pink-footed Goose	*Anser brachyrhynchus*	Wildfowl
Shelduck	*Tadorna tadorna*	Wildfowl
Cormorant*	*Phalacrocorax carbo*	Wildfowl
Scaup*	*Aythya marila*	Wildfowl
Eider*	*Somateria mollissima*	Wildfowl
Long-tailed Duck*	*Clangula hyemalis*	Wildfowl
Common Scoter*	*Melanitta nigra*	Wildfowl

Bird Species*		Wildfowl or Wader
Velvet Scoter*	*Melanitta fusca*	Wildfowl
Goldeneye*	*Bucephala clangula*	Wildfowl
Red-breasted Merganser*	*Mergus serrator*	Wildfowl
Wigeon*	*Anas penelope*	Wildfowl
Mallard*	*Anas platyrhnchos*	Wildfowl
Sandwich Tern	*Sterna sandvicensis*	Seabird
Bar-tailed Godwit	*Limosa lapponica*	Wader
Golden Plover	*Pluvialis apricaria*	Wader
Knot	*Calidris canutus*	Wader
Redshank	*Tringa totanus*	Wader
Turnstone	*Arenaria interpres*	Wader
Oystercatcher*	*Haematopus ostralegus*	Wader
Ringed Plover*	*Charadrius hiaticula*	Wader
Grey Plover*	*Pluvialis squatarola*	Wader
Dunlin*	*Calidris alpina*	Wader
Curlew*	*Numenius arquata*	Wader
Lapwing*	*Vanellus vanellus*	Wader

* These species do not qualify in their own right but as part of the waterfowl assemblage for which the Firth of Forth SPA is classified under Article 4.2 of the EU Birds Directive (79/409/EEC)

2.3 Movements and Migration of Qualifying Species of the Firth of Forth SPA

2.3.1 The Firth of Forth SPA is classified for its over-wintering and passage populations of waterbirds, although it is noted that all qualifying species are protected when they occur on the site throughout the year. As well as the resident wintering populations, the Forth estuary in the vicinity of the proposed scheme is subject to an annual migration of waterbirds including waders (Evans 1968) and seabirds (Sandeman, 1974a, 1975; Taylor 1977, Griffin 1998). Some of these species migrate overland between the North Sea and the Atlantic, and begin their land crossing in the vicinity of the existing Forth Road and Rail Bridges. Various studies have provided evidence of overland movements of waders across southern Scotland between the Forth and the Solway (Evans 1968, Dougall 1981) and regular movements of waders up and down the East coast of Scotland (Evans, 1968, Elkins and Williams, 1972, Summers et al., 1975). There are considerable movements of waders within the Firth of Forth which have to cross both existing bridges (Pienkowski & Clark, 1979). Movements of waterfowl and seabirds may be less regular and no systematic published studies have been found. Peak numbers of many qualifying bird features of the Firth of Forth SPA occur in spring and autumn because of these migratory movements, which represent birds using of this area as a staging post.

2.4 Qualifying Species of the Firth of Forth SPA

Sandwich Tern

2.4.1 The number of post-breeding Sandwich terns (or post-fledged family groups) begins to increase around traditional feeding grounds in the Firth of Forth by late July/August before they continue their southern migration to the west coast of Africa in late September. The number of terns is heavily dependent on their breeding success and emigration/immigration with other populations within their biogeographic range, notably Holland (Birds of the Western Palearctic, 2004) which can result in large fluctuations in passage numbers.

Bar-tailed Godwit

2.4.2 Bar-tailed godwits overwintering in the Firth of Forth are mainly part of the Western Palaearctic biogeographical population which breeds in Scandinavia and north western Russia. Wintering numbers are known to fluctuate due to variation in breeding success and prevailing weather conditions (which may result in influxes) with birds exhibiting a degree of fidelity to staging and feeding grounds (Birds of the Western Palearctic, 2004).

Golden Plover

2.4.3 Golden plover are classed as partially migratory in Britain with only a small proportion migrating to Southern Europe. Resident breeding birds exhibit no strong directional movement during migration but may stay close to breeding grounds. Ringed British golden plovers have been recaptured as far north as Orkney to as far south as Cornwall (Birds of the Western Palearctic, 2004), although the southern wintering populations in England are believed to be mainly immigrants from the continent. In addition the British over-wintering population is augmented by the wholly migratory Icelandic population (Birds of the Western Palearctic, 2004).

Knot

2.4.4 Wintering knot in the Firth of Forth are largely part of the Canadian/Northern Greenland population which is one of 4 recognised biogeographical populations and are the nominate race *C. c. islandica*. Although mid-winter counts of knot in Britain can be almost entirely attributed to the *C. c. islandica* spring and autumn counts may contain significant numbers of knot originating in Russia (*C. c. canutus*). Large numbers of knot utilise a limited number of estuaries in Great Britain to build up large energy reserves to fuel their migration routes although their fidelity to specific locations is unknown (Birds of the Western Palearctic, 2004). Knot are present at moulting sites around Britain from late July and may move further west post moult and throughout the winter. Spring migrations, to breeding habitats, are more synchronised with larger flocks often recorded.

Redshank

2.4.5 Over-wintering redshank populations in Great Britain are comprised of two races (Icelandic race: *T. t. robusta*, Nominate race: *T t. totanus*) which exhibit a wide overlap in their ranges. A large proportion (~80%) of the redshank which breed in Great Britain (nominate race) over-winter near their natal grounds with a small proportion migrating to France, Portugal, Ireland and the Netherlands (Birds of the Western Palearctic, 2004). This population is supplemented by migratory redshank that winter in Britain, having arrived from breeding grounds in Iceland and the Faeroes (Icelandic race). The general direction of migration is south-westwards during autumn, which is reversed in the spring.

Turnstone

2.4.6 Turnstones have a circumpolar breeding distribution which comprises of six biogeographical populations. Of these three occur in Europe, all of which can occur in Britain during the winter. Turnstones exhibit a high degree of fidelity to wintering and migration sites between and within estuaries during the winter (Birds of the Western Palearctic, 2004).

Oystercatcher

2.4.7 Wintering oystercatchers around the north eastern coast of Britain are comprised of a resident/breeding population which is supplement by migratory birds from Iceland, Faroe Isles and Norway. These wintering populations are generally found in large numbers and associated with good foraging habitat. The International Waterbird Census reported that nearly a third of the north-west European population wintered in the UK. These wintering populations start to arrive at moulting/wintering grounds from late July and return to breeding sites between late January and April.

Ringed Plover

2.4.8 Ringed plovers have been described as having a 'leap-frog' migration strategy with the most northern breeding populations wintering the furthest south. It is likely that Britain is host to all three biogeographical populations of ringed plover during the winter period, which supplement the resident breeding population. Autumn migrations normally occur in August – September and return April to May and there is some evidence of fidelity to their wintering sites (Birds of the Western Palearctic, 2004).

Grey Plover

2.4.9 Wintering grey plover populations in Great Britain migrate from Russia and arrive from July onwards (and throughout winter) before beginning the return journey during April to late May (Birds of the Western Palearctic, 2004). Wintering grey plover belong to the East Atlantic Flyway biogeographic population which has recently undergone an increase.

Dunlin

2.4.10 The large majority of dunlin which over winter in Great Britain belong to the nominate sub-species *C. a. alpina* which breed in Russia and Scandinavia. These birds exhibit strong fidelity to their over-wintering sites and move little between or within years. Main migration periods through Great Britain are between August and September to wintering grounds before returning mainly during late May.

Curlew

2.4.11 Over-wintering curlew in Great Britain originate from Scandinavia (Finland and Sweden). The winter migration starts late June/July with the return passage normally starting between February and March (Birds of the Western Palearctic, 2004). Approximately 30% of the UK breeding population overwinters in the UK with two-thirds on estuaries and the remaining on non-coastal and adjacent farmland habitats. Migration from upland breeding sites occurs between July-August for adults and long-distance juvenile movements during August-October. The return migration occurs from February-March onwards (Birds of the Western Palearctic, 2004). Adult curlew exhibited high fidelity to roost sites along the north-east coast of Scotland moving relatively short distances amongst roost sites preferring undisturbed and sheltered sites (Rehfish et. al., 2003).

Lapwing

2.4.12 Wintering lapwing in Great Britain are mainly resident breeding birds whose numbers are supplemented by birds from Scandinavia, Denmark, Holland and North Germany. All these birds are part of the European biogeographical population. Lapwing are sensitive to cold weather and their distribution (and associated migration pattern) reflects this with large groups often congregating along coastal regions, rather than colder landlocked areas and may include large distance movement to warmer southern climates (Birds of the Western Palearctic, 2004). Dispersal from breeding areas begins in May and this movement merges into the autumn migrations during September/November dictated by the onset of frosts. Spring migration occurs from late January onwards and is generally a reverse of the autumn route.

Red-throated Diver

2.4.13 Red-throated divers move away from their breeding sites (freshwater water bodies) between September and October to winter in coastal areas. They generally return to natal grounds by April. Divers are known to migrate during both the day and night in small parties (Birds of the Western Palearctic, 2004). Red-throated divers wintering of the coast of the UK are thought to be part of the European/Greenland biogeographical population.

Slavonian Grebe

2.4.14 In general Slavonian grebes migrate to more southerly wintering grounds than their breeding habitats. The majority of breeding birds in Great Britain probably winter around the coasts of Britain and Ireland although there is evidence of some long distance migration (single ringed bird from Scotland recorded in the southern Mediterranean and also a Russian bird recorded in England). The Scottish population is also augmented by Icelandic and Scandinavian birds. Their autumn movements usually start around August with their spring migration occurring March-April. .

Great Crested Grebe

2.4.15 Some great crested grebes move to coastal areas (as well as large inland lakes) immediately after breeding. This movement continues through to August which is the peak migration to wintering grounds (Birds of the Western Palearctic, 2004). Spring migration (back to breeding grounds) occurs between March and April. The majority of great crested grebes that over winter in the UK coastal waters are resident/breeding populations and immigrants from continental Western Europe.

Pink-footed Goose

2.4.16 Pink-footed geese wintering in the UK are from a single biogeographical population which breeds in east Greenland and Iceland with up to three quarters of this population in Scotland. The main emigration to the UK occurs in early October to a few staging areas from which they disperse to traditional wintering sites (Birds of the Western Palearctic, 2004). The return (spring) migration occurs during April and May following the retreat of snow, and new grass growth in the north.

Shelduck

2.4.17 British shelduck are part of the north-west European biogeographical population (JNCC, 2001). In late summer the species forms large moulting aggregations. Many breeding shelduck from the UK migrate to the Waddenzee area of Germany in June to moult before a more leisurely autumn migration back to breeding areas between October and December (Jenkins, 1972, Birds of the Western Palearctic, 2004). Within the inner Forth Estuary, Kinneil Kerse supports a large flock of moulting shelduck, a rare feature in Britain (Bryant, 1978; SNH, 2000; JNCC, 2001)

Cormorant

2.4.18 British cormorants belong to the race *P. c. carbo* (rather than *P. c. sinensis*). Although not strictly migratory, cormorants do undertake widespread dispersal within the UK with a few individuals crossing to mainland Europe (Birds of the Western Palearctic, 2004). Ringed cormorants from a large colony on the Island of Lamb have been recovered in southern England, Northern Ireland and France (Summers & Laing, 1990).

Scaup

2.4.19 Scaup wintering populations in Britain are mainly composed of immigrant birds from Iceland, Fennoscandia and Russia. Peak autumn migration occurs between September and October with the return journey occurring around mid-March.

Eider

2.4.20 Eiders have a circumpolar distribution, with the resident breeding population in Great Britain exhibiting little dispersion. Over wintering populations are supplemented by immigration of continental birds (Birds of the Western Palearctic, 2004).

Long-tailed Duck

2.4.21 Wintering long-tailed duck in Great Britain are at the most south-western limit of their range and are likely to belong to the Iceland/Greenland biogeographical population (Birds of the Western Palearctic, 2004). Over-wintering numbers being to increase between September and October with the return migration likely to occur around April.

Common Scoter

2.4.22 Common scoters wintering in the UK are from the western Siberia/western and north-west Africa biogeographical population. Peak autumn migration (after moult migration) occurs during November with the return journey occurring around April/May.

Velvet Scoter

2.4.23 Birds wintering in the UK are thought to originate from Scandinavia and Siberia. Their post-moult migration to the North Sea generally occurs around October/November with birds returning to their breeding grounds from early March.

Goldeneye

2.4.24 Goldeneye in UK waters over-winter generally in more coastal areas especially if inland waters become frozen. They are part of the North-Western/Central European population with their main migration route being a south/western direction. The peak autumn migration occurs late August, returning from mid-February to March.

Red-breasted Merganser

2.4.25 Red-breasted mergansers, like many diving ducks, show a tendency for juvenile and female individuals to migrate further and earlier than males. UK breeding resident birds begin their autumn migration to coastal zones from early July onwards with the numbers supplemented by individuals which are likely to have migrated from northern and western European countries, but the exact composition of the wintering population is unclear (JNCC, 2001).

Wigeon

2.4.26 Wigeon are highly migratory with large numbers of over-wintering birds originating from places such as Iceland, Scandinavia and Russia. This highly gregarious bird's predominant migration route to Britain is west or even northwest from their moulting locations between August and September. They return to their breeding sites between March and April.

Mallard

2.4.27 The mallard is a widely distributed bird throughout most of the northern hemisphere. Over wintering populations of mallards in the UK are generally not supplemented by immigration of birds from the continent although there is some evidence of migration from Iceland (Birds of the Western Palearctic, 2004).

2.5 Conservation Status of Qualifying Species within the Firth of Forth SPA

2.5.1 The conservation status of qualifying species within the Firth of Forth SPA, based on site condition monitoring assessments by SNH in 2004 (SNH 2004a, b, c, 2009) is summarised in Table 3. It is understood that these site condition monitoring assessments are updated every six years. The 2004 assessment found all species to be in favourable condition, except for wigeon. Just over half (15 out of 28) of the 28 qualifying species were considered to be in favourable condition, but have shown marked declines when 1993-1998 five-year means are compared to those from 1996-2001 (SNH 2004a, b and c). The latest WeBS core count from the Firth of Forth SPA showed a mixed fortune in the five year winter peak

mean bird numbers of qualifying species (Table 4). The population estimates for five species (redshank, curlew, velvet scoter, wigeon and Sandwich tern) all increased to different degrees. However, the remaining 22 species all showed a decrease in their five year winter peak mean value. Some species (great-crested grebe, shelduck, scaup, long-tailed duck, goldeneye and mallard) exhibited gross changes their five year winter peak mean values. An overview of the results of the site condition monitoring for the qualifying features is shown in Table 3..

Table 3: Results of site condition monitoring assessments of qualifying species within the Firth of Forth SPA (SNH 2004a, b, c, 2009)

Visit Date	English Name	Population (SPA Citation)	Percentage Change[1]	Condition[2]
28/02/2001	Bar-tailed godwit	1,974	6% decline	Favourable (but declining)
28/02/2001	Common scoter	2,880	32% decline	Favourable (but declining)
28/02/2001	Cormorant	682	Negligible	Favourable Maintained
28/02/2001	Curlew	1,928	17% increase	Favourable Maintained
28/02/2001	Dunlin	9,514	11% increase	Favourable Maintained
28/02/2001	Eider	9,400	18% decline	Favourable (but declining)
28/02/2001	Golden plover	2,949	15% decline	Favourable (but declining)
28/02/2001	Goldeneye	3,004	5% decline	Favourable (but declining)
28/02/2001	Great crested grebe	720	45% decline	Favourable (but declining)
28/02/2001	Grey plover	724	16% decline	Favourable (but declining)
28/02/2001	Knot	9,258	36% decline	Favourable (but declining)
28/02/2001	Lapwing	4,148	Negligible	Favourable Maintained
28/02/2001	Long-tailed duck	1,045	33% decline	Favourable (but declining)
28/02/2001	Oystercatcher	7,846	8% decline	Favourable (but declining)
28/02/2001	Red-breasted merganser	670	8% decline	Favourable (but declining)
28/02/2001	Redshank	4,341	6% decline	Favourable (but declining)
28/02/2001	Red-throated diver	90	Negligible	Favourable Maintained
28/02/2001	Ringed plover	328	Negligible	Favourable Maintained
28/02/2001	Sandwich tern	1,617	37% increase	Favourable Maintained
28/02/2001	Scaup	437	12% decline	Favourable (but declining)
28/02/2001	Shelduck	4,509	Negligible	Favourable Maintained
28/02/2001	Slavonian grebe	84	17% decline	Favourable (but declining)
28/02/2001	Turnstone	860	22% decline	Favourable (but declining)
28/02/2001	Velvet scoter	635	Negligible	Favourable Maintained
28/02/2002	Mallard	2,564	Negligible	Favourable Maintained
28/02/2002	Pink-footed goose	10,852	Negligible	Favourable Maintained
28/02/2002	Waterfowl assemblage, non-breeding	95,000	Negligible	Favourable Maintained
28/02/2002	Wigeon	2,193	Negligible	Unfavourable No Change

1 = Change in numbers within the site when the five-year mean of 1993-1998 is compared to the 1996-2001 mean value

2 = The maximum limit of acceptable change in relation to SNH's Site Condition Monitoring is a decline of 50% in the wintering population over a 5 year period. This criterion is not used as a point of reference with respect to the information presented in this report to underpin an appropriate assessment for the FRC.

Table 4: Great Britain and biogeographical population status of Firth of Forth qualifying bird species

Species	Population estimate (SPA citation, (individual birds)[1]	Wetland Bird Survey (WeBS) Population estimates for the Firth of Forth – Core Counts		Great Britain Wintering Population		Percentage of Great Britain Population (Firth of Forth SPA citation)	Percentage of Biogeographic Population as cited for the Firth of Forth SPA
		Winter Peak Mean[4]	% of cited SPA population[5]	2006 APEP[2]	2001 JNCC[1]	JNCC[1]	JNCC[1]
Bar-tailed Godwit	1,974	1,327	67	65,430	52,500		2% of Western Europe
Turnstone	860	777	90	52,390	64,400		1% of European
Knot	9,258	5,557	60	283,600	291,000		3% of Western European/Canadian
Redshank	4,341	4,607	106	116,100	114,000		3% of European/West African
Golden Plover	2,949	2,580	88	250,000	250,000	1%	
Oystercatcher	7,846	6,819	87	315,200	359,000	2%	
Ringed Plover	328	273	83	32,450	28,600 (30,000)	1%	
Grey Plover	724	427	59	53,300	43,200	2%	
Dunlin	9,514	8,146	86	555,800	532,000	2%	
Curlew	1,928	2,889	150	147,100	115,000	2%	
Lapwing	4,148	2,865	69	1,500,000 – 2,000,000	1,500,000		
Red-throated Diver	90	72	80.0	4,850	4,850	2% of Great Britain	
Slavonian Grebe	84	66	79	725	400	21% of Great Britain	2% of Northwest Europe
Great Crested Grebe	720	175	24	15,900	9,800	7%	
Pink-footed Goose	10,852	5,580	51	241,000	192,000		6% of Icelandic/Greenlandic
Shelduck	4,509[3]	1,138	25	78,200	73,500		2% of North West Europe
Cormorant	682	433	63	23,000	13,200	5%	
Scaup	437	55	13	7,560	11,000	4%	
Eider	9,400	5,237	56	73,000	77,500	13%	
Long-tailed Duck	1,045	272	26	16,000	23,500	4%	
Common Scoter	2,880	2,375	83	50,000	27,350	8%	
Velvet Scoter	635	1,090	172	3,000	3,000	21%	

Species	Population estimate (SPA citation, (individual birds)[1]	Wetland Bird Survey (WeBS) Population estimates for the Firth of Forth – Core Counts		Great Britain Wintering Population		Percentage of Great Britain Population (Firth of Forth SPA citation)	Percentage of Biogeographic Population as cited for the Firth of Forth SPA
		Winter Peak Mean[4]	% of cited SPA population[5]	2006 APEP[2]	2001 JNCC[1]	JNCC[1]	JNCC[1]
Goldeneye	3,004	1,060	35	24,900	17,000	18%	
Red-breasted Merganser	670	446	67	9,840	10,000	7%	
Wigeon	2,139	2,182	102	406,000	277,800		
Mallard	2,564	1,283	50	352,000	500,000		
Sandwich Tern	1,617	2,802	173	10,5365	42,000	6%	1% of East Atlantic

1 = JNCC, 2001. Population estimates are for the years 1993/94-1997/98 for species that qualify under Article 4.1 and 1992/93-1996/97 for those species that qualify under Article 4.2

2 = Baker et al., 2006

3 = Represents moulting flock of shelduck

4 = WeBS five year winter peak mean between 2002/03 and 2006/07

5 = Winter peak mean (from latest WeBS counts) as a percentage of the cited SPA population

Table 5: Conservation status of qualifying bird species of the Firth of Forth SPA.

Species	Conservation Status			
	Birds of European Conservation Concern	Birds of UK Conservation Concern***	Wildlife & Countryside Act 1981 Schedule 1*	UK BAP/LBAP/Scottish Biodiversity List** (SBL)
Bar-tailed Godwit	SPEC 3: (Wintering) conservation status (localised in winter) but not concentrated in Europe	Amber WL, WI	General Protection	SBL -S2
Turnstone	-	Amber WI	General Protection	-
Knot	SPEC 3: Unfavourable (Winter) conservation status (localised in winter) but not concentrated in Europe	Amber WL, WI	General Protection	LBAP - Edinburgh
Redshank	SPEC 2: Unfavourable conservation status (declining) and concentrated in Europe	Amber BDMp1, BDMp2, WI	General Protection	-
Golden Plover	SPEC 4: Favourable conservations status but concentrated in Europe	Amber WI	General Protection	SBL -S2
Oystercatcher	-	Amber WL, BI, WI	General Protection	-
Ringed Plover	-	Amber BDMp1, WI	General Protection	-
Grey Plover	-	Amber WL, WI	General Protection	-
Dunlin	SPEC 3: Unfavourable (wintering) conservation status (vulnerable) but not concentrated in Europe	Red WDp2, WDMp1, BL, WL, WI	General Protection	SBL -S2
Curlew	SPEC 3: Unfavourable (wintering) conservation status (declining) but not concentrated in Europe	Amber BDMp1, BDMp2, WL, WI	General Protection	SBL -S5
Lapwing	SPEC 2: Unfavourable conservation status (declining) and concentrated in Europe	Red BDp1 BDMp2, WI	General Protection	UK BAP Priority Species SBL -S5 LBAP – Fife, Edinburgh
Red-throated Diver	SPEC 3: Unfavourable conservation status (vulnerable) but not concentrated in Europe	-	General Protection Schedule 1 (1)	SBL -S2
Slavonian Grebe	-	Amber BDMp1, BDMp2, BR, WR	General Protection Schedule 1 (1)	SBL -S2, S5
Great Crested Grebe	-	-	General Protection	LBAP - Edinburgh

Species	Conservation Status			
	Birds of European Conservation Concern	**Birds of UK Conservation Concern*** **	**Wildlife & Countryside Act 1981 Schedule 1***	**UK BAP/LBAP/Scottish Biodiversity List** (SBL)**
Pink-footed Goose	SPEC 4: Favourable conservation status at species level (secure) but concentrated in Europe	Amber WL, WI	General Protection	
Shelduck	-	Amber WL, WI	General Protection	-
Cormorant	-	-	General Protection	-
Scaup	SPEC 3: (Winter) conservation status (localised in winter) but not concentrated in Europe	Red WDp2 WL	General Protection Schedule 1 (1) Schedule 3 (3)	UK BAP priority species SBL -S3, S4, S5
Eider	-	Amber WDMp1	General Protection	-
Long-tailed Duck	-	-	General Protection Schedule 1 (1)	-
Common Scoter	-	Red BDp1, BDp2 BDMr1, BR, WL	General Protection Schedule 1 (1)	UK BAP priority species SBL -S1, S5
Velvet Scoter	SPEC 3: (Winter) conservation status (localised in winter) but not concentrated in Europe	Amber WL	General Protection Schedule 1 (1)	-
Goldeneye	-	Amber BR	General Protection Schedule 1 (2) Schedule 2 (1)	-
Red-breasted Merganser	-	-	General Protection	-
Wigeon	-	Amber WL, WI	General Protection Schedule 2 (1) Schedule 3 (3)	-
Mallard	-	Amber WDMp1, WDMp2	General Protection Schedule 2 (1) Schedule 3 (3)	-
Sandwich Tern	SPEC 3: Unfavourable conservation status (declining) and concentrated in Europe	Amber BDMr2, BL,	General Protection	SBL -S2, S5

* Source = JNCC, 2001

** = Refers to the status of a species with respect to the UK Biodiversity Action Plan, Scottish Biodiversity List and Local Biodiversity Action Plan. The Scottish Biodiversity List is a list of flora, fauna and habitats considered by the Scottish Ministers to be of principal importance for biodiversity conservation. The publication of the Scottish Biodiversity List satisfies the requirements of Section 2(4) of The Nature Conservation (Scotland) Act 2004. SBL S1 UK Priority Species on UKBAP list. SBL S2 Species for which Scotland, through the UK, has international obligations to safeguard., SBL S3 'Nationally Rare' at the UK level i.e. found in between 1-15 ten km squares, SBL S4 Species are present in 5 or fewer 10km squares or sites in Scotland. SBL, SBL S5 Decline of 25% or more in Scotland over the last 25yrs or other appropriate time period. The FRC is located within the Local Biodiversity Action Plan Areas for Fife and Edinburgh.

*** = Indicates red or amber listed species of conservation concern in the UK (Eaton et al., 2009). Red List Criteria: BDp1 = Rapid (>50%) decline in UK breeding population over last 25 years. BDp2 = Rapid (>50%) decline in UK breeding population over the longer term (since 1969). WDp1 = Rapid (>50%) decline in UK non-breeding population over last 25 years. WDp2 = Rapid (>50%) decline in UK non-breeding population over the longer term (since 1969). Amber List Criteria: BDMp1 = Moderate (25-49%) decline in UK breeding population over last 25 years. BDMp2 = Moderate (25-49%) decline in UK breeding population over the longer term (since 1969). WDMp1 = Moderate (25-49%) decline in UK non-breeding population over last 25 years. WDMp2 = Moderate (25-49%) decline in UK non-breeding population over the longer term (since 1969). BDMr2 = Moderate (25-49%) contraction of UK breeding range over the longer term (since 1969). BR = Five-year mean of 1-300 breeding pairs in UK. BL = >50% of UK breeding population in 10 or fewer sites, but not rare breeders (RB). BR = Five-year mean of 1-300 breeding pairs in UK. WL = 10% of UK non-breeding population in 10 or fewer sites. WI = >20% of NW European (wildfowl), East Atlantic Flyway (waders) or European (others) non-breeding populations in UK. WR = UK non-breeding population of less than 900 individuals

3 Forth Replacement Crossing

3.1 Introduction

3.1.1 The Forth Replacement Crossing (FRC) is designed to safeguard a vital connection in Scotland's transport network. Despite significant investment and maintenance over its lifetime, the Forth Road Bridge is showing signs of deterioration and is not suitable as the long-term main crossing of the Firth of Forth. Closures or restrictions upon traffic flow due to repair or refurbishment of the Forth Road Bridge are likely to have a severe impact upon the economy of the east of Scotland. In December 2007, after considering a number of options, the Scottish Government selected a cable-stayed bridge to the west of the Forth Road Bridge as the replacement crossing. As a result of further planning and research, and in light of a more positive prognosis for the future of the Forth Road Bridge, Transport Scotland has developed a managed crossing scheme for the Forth Replacement Crossing. Under this strategy the Forth Road Bridge is to become a dedicated public transport corridor carrying buses, taxis, pedestrians and cyclists. In the future it could be adapted to carry a Light Rapid Transit (LRT) system, such as a tram (Transport Scotland, 2009a).

3.1.2 The Forth Replacement Crossing Study (FRCS) was an earlier stage study commissioned under the Strategic Transport Projects Review (STPR). The STPR was undertaken by Transport Scotland to define the most appropriate strategic investments in Scotland's national transport network. The STPR identified the need for a replacement crossing of the Firth of Forth. The FRC formed part of the STPR, but due to its national significance, was fast tracked and progressed separately from the STPR. The STPR Environmental Report was published on 9 December 2008.

3.1.3 Work undertaken on the FRCS has followed Scottish Transport Appraisal Guidance (STAG), which is an appraisal framework designed to aid transport planners and decision-makers in the development of transport policies, plans, programmes and projects in Scotland. A number of different options were identified and appraised including bridges and tunnels at several locations. The findings of the FCRS formed the basis for the decision made by the Scottish Government to progress the Forth Replacement Crossing project. The preferred option of a cable stayed bridge to the west of the Forth Road Bridge was set out by the Scottish Government in a statement to Parliament on 19 December 2007.

3.1.4 The planning objectives developed for the FRCS are (Jacobs et al.,2007a):

- maintain cross-Forth transport links for all modes to at least the level of service offered in 2006;
- connect to the strategic transport network to aid optimisation of the network as a whole;
- improve the 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 impacts of maintenance on the effective operation of the transport network;
- support sustainable development and economic growth; and
- minimise the impact on people, and the natural and cultural heritage of the Forth area.

3.2 Design and Construction of the FRC

3.2.1 The description of works provided in this section is derived from the construction information available for the main crossing. The design and construction information focuses on the proposed new bridge as this is the element of the proposed scheme which is most likely to impact on estuarine birds including the qualifying species of the Firth of Forth SPA.

Additional aspects of the scheme are deemed not to have a significant impact on the conservation objectives of the site and, therefore, have been screened out and do not form part of this assessment.

3.2.2 It should be noted that the engineering activities, construction drawings and work programme provided in the report represent a specimen design and construction programme. Responsibility for completing the detailed construction methods will lie with the appointed contractors. As such, there may be changes to some aspects of the proposals and adoption of selected options. It is recognised that any changes which are likely to have a significant impact on the qualifying interests of the Firth of Forth SPA would result in requirements for a further Appropriate Assessment. Design specifications and other measures which are essential in terms of the mitigation of any adverse effects on the Firth of Forth SPA (as detailed in this report) will therefore be enforced as contractual obligations. Any changes to the scheme assessed in the RIAAs will require consideration by the Competent Authority and the contractor would be required to adhere to any other conditions or restrictions imposed by the Competent Authority in relation to Appropriate Assessments carried out for the Project insofar as they relate to these sites.

3.2.3 The proposed scheme will comprise a new bridge crossing over the Firth of Forth and additional connecting roads. To the south of the bridge, a new section of dual carriageway will link the crossing to the existing A90. To the north, a new section of dual carriageway will connect the bridge to the A90 / M90 (Figure 1).

3.2.4 The overall main crossing construction programme requires approximately 5 years (60 months) for completion. Construction is scheduled to start in 2011 and the bridge is due to open in 2016 (Transport Scotland, 2009a).

Work Programme

3.2.5 An indicative work programme for the proposed scheme, including construction activities, time period and duration is shown in Appendix D. This is based on construction commencing in July 2011.

3.3 Design and construction of the Main Crossing

3.3.1 The Main Crossing is designed to complement the existing bridges and setting (Figure 1). It will be 2.7km long, including approach viaducts, and of a cable stayed design, with three towers (south tower (ST), north tower (NT) and central tower (CT)) and spans of 650m between the ST and CT and the CT and NT. The cables between each span overlap at the mid-span region which provides an increased stability to the central tower (Figure 3b). The single bridge deck provides 47.85 m clearance to shipping and will carry two general lanes of traffic and hard shoulders in each direction. The hard shoulders also provide the flexibility to carry buses during periods of high wind and further public transport should it be required in the future. Wind-shielding on the new bridge will protect the crossing from the impacts of wind and provide a more reliable corridor, particularly for heavy goods vehicles. The southern approach to the bridge consists of six piers located within the Firth of Forth, with the remaining two piers found on the southern shore. The northern approach comprises one pier in the Firth of Forth and two piers on the northern shore.

Relocation of sewage outfall

3.3.2 The existing Scottish Water sewage outfall just to the north of Port Edgar has the potential to impede the construction of the Main Crossing and will therefore be diverted. This work will form part of the proposed Scheme and may be carried out as part of the advance works. Discussions are ongoing and an appropriate location will be agreed in consultation with Scottish Water and SEPA.

Outer Towers Foundations

3.3.3 The outer towers will be in deeper water and will require piling. Piling techniques such as driven piling are not considered viable due to the depth to rockhead and the comparatively high loading. Pile drilling will be employed which involves pushing and vibrating 3m-diameter steel casings into the underlying rockhead from a jack-up platform. A drill is then used to augur out soils and rock under seawater flush.

3.3.4 The piling process ensures that sediment release during drilling will be comparatively small. The void is then filled with reinforced concrete. Prior to the piling taking place for the north tower, approximately 33,000m^3 of material will require to be dredged; no dredging is anticipated to be required for the construction of the south tower. Concrete caissons will be manufactured in a dry dock, floated out, and located on piled foundations. Pier construction is programmed for a 13 month period between May 2012 and June 2013.

3.3.5 At the proposed south tower and north tower locations on the estuary bed there are 20m of superficial soils over sedimentary bedrock. On the southern shore, the rock becomes shallow and reaches the ground surface as the topography rises to Inchgarvie House (refer to Figure 3a). At the northern shore, the rock rises sharply at the upper reaches of the intertidal zone, and continues above surface in the shape of the igneous rock feature of St. Margaret's Hope.

3.3.6 The NT and ST foundations require large pre-cast pile caps to spread the tower loads into the pile group. For aesthetic reasons, this foundation may be formed below the low water mark, allowing only the slim tower to be visible under all tidal conditions.

3.3.7 The pre-cast foundation will be constructed on land and floated out to the location by barge. It will then be ballasted over the pile group and trimmed to level. The pile cap will then be grout bonded to the head of the piles. Following the completion of the foundations, the construction of towers will commence (Figure 3c).

3.3.8 The seawater flush from piling will be collected and pumped to a barge moored alongside the jack-up. The soil and rock chippings will be allowed to settle out in the barge and excess seawater will drain back into the sea. The full barge will then be taken to a predetermined licensed disposal site. Multiple barges will be used, with the number being a function of rate of piling distance to disposal site (Appendix D).

Central Tower Foundations

3.3.9 The central tower will be located on Beamer Rock, supported by a large single spread foundation. The use of a spread foundation means that no piling is required. Beamer Rock is a hard igneous volcanic rock intrusion that is nearly submerged at high tide. The spread foundation will be located within a pocket within the rock and will not be visible at any state of the tide.

3.3.10 Beamer Rock will be excavated using controlled blasting and/or other non-explosive techniques (such as the injection of high pressure gas). Due to its very hard igneous nature, the material is likely to be removed in large rock fragments. The rock will be excavated to a level of -5.5 Above Ordnance Datum (AOD). Excavation is not on the critical path so timing is flexible. The excavation is programmed to start in December 2012 for a six month period. Explosive blasting will avoid the tern nesting season and is programmed for a four month period between December 20011 and March 2012. Non-explosive techniques will be used to complete the excavation down to the required level. A total of 11,000m^3 of material will arise from these works; this will be collected by barge, where depending on its nature it will be re-used as structural or engineered fill or landscaping in the terrestrial construction phases. Some material unsuitable for re-use maybe deposited in a licensed disposal site. The excavated rock will be replaced with a large caisson that will be sunk and filled with concrete. The excavation around the caisson will be infilled with concrete to a profile similar to the existing rock (Figure 3c).

3.3.11 The depth of excavation is as follows;

- Mooring area to receive the caisson (SE of base): -4.15m AOD;
- Foundation base area: -5.5m AOD; and
- Foundation working area (NW of base): -3m AOD.

3.3.12 The preparation of Beamer Rock will result in the following quantities of excavated rock:

- mooring area (SE of base): 3,950m^3;
- foundation base area: 5,784m^3; and
- foundation working area (NW of base): 1,591m^3.

3.3.13 Blasting of the rock is likely to create peaks of noise and vibration that will dissipate rapidly in time and with distance from the blast location. The rate of dissipation depends on a number of factors associated with the blast itself and the local prevailing weather conditions.

3.3.14 There is little sediment on the upper reaches of Beamer Rock, and excavation will result in minimal displacement of sediment. However, sediment will be deposited on the lower flanks of the rock, which could be disturbed by explosive excavation. The release of rock into water will be minimal due to the design of excavation method, although some loss of rock may occur during excavation and the placement of material into barges.

Tower and Bridge Deck

3.3.15 Similar construction methods will be employed for all three towers. Construction of the towers will occur immediately after the completion of the foundation stage.

3.3.16 The towers are to be constructed using a self-climbing jump form which adapts to suit the changing shape of the tower. The Main Crossing towers are 200m in height, and tower construction will advance at an average 0.6m per day. Marine concrete batching plants will be moored at each tower location. For the marine central tower location, the large volume delivery of material to the base pier will be by marine plant. Concrete will be batched at these sites as required.

3.3.17 The construction of the deck will cantilever out (i.e. the structure will be supported at one end) from each tower in a balanced arrangement. The deck construction will have 4 deck construction fronts allowing the north tower main span fan construction, to start following the completion of the central tower main span fan. The construction of the viaducts will require less time than that of cable stayed bridge, and are not on the critical pathway, allowing seasonal flexibility.

3.3.18 The assembly of the deck will be undertaken within a fabrication facility off site. There are a number of potential fabrication yards close to the Main Crossing site, with many alternative sites existing further afield. Three options for assembly yards, at Rosyth Docks, Burntisland, and Methil are considered in the in-combination assessment (Appendix F). The completed deck units will be shipped to site, with each barge containing single or multiple deck units, with the latter preferable where the chosen assembly yard is located a considerable distance from the bridge.

3.3.19 The erection of the steel deck can follow several techniques including the use of the deck gantry or floating cranes to lift the deck segment into position. Around the towers, a floating crane approach may be preferred, whereas for the bridge span, deck gantry units will be applied. Construction rates are predicted to reach 2.1m to 2.25m per day at each cantilever tip.

Approach Viaducts and Support Towers

3.3.20 Viaduct piers will provide support at either end of the Main Crossing. These will be predominantly on land in the north and in the inter-tidal zone to the south (Figure 3a).

3.3.21 For the construction of the southern viaduct, three piers are expected to be piled, while the foundations for the piers closest to the shore will be spread foundations. It is intended that a 110m long earth bund will be constructed to enable a dry working environment for viaduct piers S5 and S6. A sheet pile cut-off is required to surround the excavation for Pier S6 and allow it to be excavated in the dry. The additional depth of excavation and the depth of weak deposits at Pier S5 lead to the requirement for a structural cofferdam to allow the excavation and construction of the foundation for the pier. The earth bund will also provide access to a 370m long piled access trestle and jetty supported by 76 driven steel piles will be constructed from viaduct pier S6 to pier S1 to facilitate access for dry working. These 0.9m diameter driven piles are likely to generate the highest noise levels associated with construction. Noise limits for construction works will be set in consultation with the local authority. This may also include limitations on working hours. Piling is expected to continue for a period of 2 months for the south pier.

3.3.22 The pier head of the trestle structure will also provide a mooring for service vessels for the construction of the bridge towers. The temporary structure will be in place for the duration of the crossing construction, a period of approximately five years. The steelwork for the viaduct will be fabricated off site. It will be assembled and launched from the assembly area behind the south bridge abutment.

3.3.23 Construction of the bund will require the preliminary dredging of weak material (6,000m^3) pre-construction, and the subsequent import of a significant amount of material (approximately 27,000m^3 of sand and rock armour). The delivery of this material is expected to generate in the region of 4,000 vehicle movements over a four month period commencing in February 2012.

3.3.24 The construction of the southern viaduct piers will require the dredging of an estimated 41,100m^3 of material and an additional 30,000m^3 to facilitate the access of a floating crane to place pile caps. Following the completion of construction, piles will be cut off 0.5m below the seabed surface and the bunds removed. This will require another 4,000 vehicle movements.

3.3.25 For the construction of the northern approach viaduct, only one pier foundation will be located in water, with the three other piers on land on St. Margaret's Hope. A 50m long piled trestle structure will be constructed to connect the north shore embankment with the viaduct piers. Twenty 0.9m diameter steel piles will be driven into the seabed to support the jetty. Like the southern jetty, piles will be cut off 0.5m below the seabed surface on completion of the bridge. Pier N1 of the northern viaduct will require the dredging of approximately 10,000m^3 of material prior to construction. The land based foundations will be spread foundations into rock.

Construction Access

3.3.26 Access to the north trestle is hampered by the steep topography of St. Margaret's Hope. The escarpment from the foreshore up to Admiralty House prevents vehicle access. A construction platform will therefore be created at the top of the escarpment to allow plant and materials to be lowered down to the foreshore.

3.3.27 Access to the south trestle would be provided via a new construction road linking the A904 to the Port Edgar Barracks. This would allow access from the construction compound located on the Echline Fields to the west of South Queensferry.

Dredging

3.3.28 Dredging will be required for the foundations for piers S1 to S4 of the Southern Viaduct section and to allow access for plant, for the foundations of the North Tower and pier N1 of the north viaduct (Figure 3a). It is provisionally programmed to take place over 54 days between 23 March and 13 June 2012 (Appendix D), with most of this time (46 days) spent in the vicinity of the southern shore. In total around 120,000m^3 of material will be dredged using a barge mounted open-bucket dredger prior to the construction of the north pier and approach viaducts in early 2012. While the disposal site has yet to be defined it is likely that one of the existing disposal sites on the Forth will be used. None of the dredged material is likely to be suitable for re-use as an engineering material. Under current arrangements a licence for disposal of dredged materials is required under the Food and Environmental Protection Act 1985 and an application must be made to Marine Scotland (formerly the Fisheries Research Services). A new Marine (Scotland) Bill, introduced to the Scottish Parliament on 29 April 2009, will require licence applications for all dredging activities.

3.3.29 Dredging of areas around piers will be carried out using a barge mounted back-actor. Around 55,000m^3 of dredged material will be removed and disposed at a location yet to be defined. None of the dredged material is likely to be suitable for reuse as engineering material. Likely underwater noise impacts due to dredging are not yet known, but this is not a high impact process. Dredging is likely to provide the largest amount of sediment release of all marine groundworks. At the point of excavation, based upon 5% loss of material, 2,750m^3 could be released as sediment plume.

Drainage of the Main Crossing

3.3.30 Drainage of the bridge from the low water mark on the south shore to the low water mark on the north shore will be direct to the Forth estuary. Drainage from the bridge over intertidal areas (north and south shore) will connect to the drainage systems for the north and south connecting roads (i.e. not direct to the Forth estuary).

Bridge Lighting

3.3.31 Proposed lighting for the bridge consists of three main elements, highway lighting, windscreen lighting and lighting for pylons and piers (Jacobs Arup 2009d). Two options for highway lighting are being considered, involving standard lights on 12m columns or low-level lighting fixtures. The outer bridge windscreens will be used as light reflectors either through the use of a series of linear uplighters or alternatively through the use of LED integral to the windscreen. The windscreen will consist of linear elements, set 1.5m above the deck which when lit will allow the bridge to appear as a continuous ribbon of light. The three towers will be lit by projectors, set at deck level, which will provide a layer of lighting upwards and downwards on the towers

Habitat Loss

3.3.32 There will be no permanent loss of SPA habitat during the operation of the FRC. However, during construction approximately 0.07ha within the SPA will be disturbed during the creation of pier N2 (Table 6). The area of SPA habitat that will be temporary affected will be landscaped and the intertidal habitat allowed to recolonise post construction and therefore this is not considered to be permanent habitat loss (Table 6).

3.3.33 The majority of the Main Crossing footprint is outside the demarcated SPA boundary. However, these areas are used by qualifying bird species of the Firth of Forth which, if affected could potentially affect the integrity of the SPA. Therefore, the assessment process has taken into consideration the potential impact of the Main Crossing on the qualifying features of the SPA and adjacent intertidal areas connected to the SPA.

3.3.34 Habitats affected by the Main Crossing that are outside the SPA boundary are outlined in Table 6. During construction, approximately 0.24ha of intertidal habitat will be lost on the

south shore under the footprints of the pile caps of piers S3 – S6 and the associated dredged pockets. The most southerly bridge pier that will affect the intertidal habitat (S6) will be located in the rocky upper shore and although the natural rock habitat will be removed the concrete pier structures will represent suitable hard substrate for recolonisation by flora and fauna. The permanent natural habitat loss associated with the construction of pier S6 will be approximately 0.02ha which is <0.001% of the equivalent SPA habitat. Following construction tidal movements will aid the re-establishment of the mudflats around the base of the piers resulting in a probable permanent loss of mudflat habitat in the region of 0.08 ha. The construction of each tower will result in the permanent loss of 0.13ha, of which two thirds is subtidal habitat (Northern and Southern Towers) and one third intertidal habitat at Beamer Rock (Table 6). Whist these structures will result in the permanent loss of habitat under their footprint they also provide additional surface area available for recolonisation through the water column and provide ideal habitat for many intertidal species and the communities they support.

Table 6: Description of areas affected by the Main Crossing

Area description	**Approximate Area (ha)**	
Firth of Forth SPA	6314	
Total intertidal area (Bennet & McLeod, 1998)	2330	
Whole survey area	3263	
Area of Firth of Forth SPA within the survey area boundary	165.49	
The area of Firth of Forth SPA within 250m either side of the Main Crossing	5.65	
The area of Firth of Forth SPA within 500m either side of the Main Crossing	12.58	
The area of Firth of Forth SPA within 1000m either side of the Main Crossing	30.54	
Activities associated with the Main Crossing	**Temporary**	**Permanent**
Area of intertidal habitat under piers (S3-6) at southern landfall of the Main Crossing	0.24	0.08
Area of subtidal habitat under piers (S1-2) at southern landfall of the Main Crossing	0.10	0.04
Area of habitat at Beamer Rock (Central Tower)	0.07	0.02
Area of subtidal habitat associated with the Northern and Southern Towers	0.05	0.05
Area affected under northern bridge pier (N1) in adjacent intertidal area connected to SPA	0.05	0.02
Area Firth of Forth SPA affected	0.07*	none
Total area of habitat within survey boundary affected	0.58	0.21

* = Activities associated with the construction of pier N2

4 Impacts of the FRC likely to have a significant effect on the Firth of Forth SPA

4.1 Introduction

4.1.1 This section considers a range of potential impacts of the Main Crossing on the conservation objectives for the qualifying species in order to assess any potential adverse effects on the integrity of the Firth of Forth SPA. It provides a rationale for assessing each element of the proposal and screening out those impacts not likely to have significant effects on the Firth of Forth SPA. All impacts with the potential to cause adverse effects on the integrity of the SPA are identified and the approach that has been taken in assessing these impacts and identifying any required mitigation is described.

4.1.2 A detailed assessment of each element that is likely to have an impact with the potential to affect the integrity of the site is addressed in Section 7. The likely nature, location and scale of all impacts considered to have the potential to adversely affect the integrity of the Firth of Forth SPA are then considered in detail in subsequent sections of this report, with mitigation proposed as appropriate to address any potential adverse effects. Data and information to underpin these assessments are derived from consultation with other organisations (refer to section 1 above), surveys carried out specifically for the FRC (methods detailed in Section 5 below and results in section 6), and a review of the scientific literature.

4.1.3 The starting point for identifying potential impacts of the FRC was the report 'Forth Replacement Crossing Study Strategic Environmental Assessment: Information to Inform a Strategic Appropriate Assessment of the route options for the FRC' (Jacobs/Faber Maunsell/AECOM 2007a). This report was, however, prepared at a time when little information was available on the proposed scheme (as would be expected at the strategic stage), so the assessment of impacts presented here has been updated to reflect the detailed information which is now available on the design and construction of the scheme, as well as a review of scientific papers and reports relevant to the impact of bridges on estuarine birds.

4.1.4 Considering the elements of the FRC scheme described above, it is the proposed new bridge which is most likely to impact on qualifying bird species of the Firth of Forth SPA. The impact assessment therefore focuses on the construction and operation of the proposed bridge. Operational impacts include those which are related to the operation of the bridge (i.e. its use by traffic) and permanent impacts resulting from the presence of the bridge which would occur whether or not the bridge was operational.

4.1.5 Information available from consultation and the scientific literature indicated that all the qualifying species of the Firth of Forth SPA are potentially subject to impacts from the proposed scheme.

4.2 Assessment Approach

4.2.1 This report assesses the potential adverse effects of the Main Crossing on the integrity of the Firth of Forth SPA.. To aid the assessment process, a modified flow chart of the likely impacts of an offshore windfarm was used (Figure 4, modified from Fox et al., 2006).

4.2.2 Bridge construction and operation may have adverse effects on bird populations. The severity of the implications depends on the likelihood and magnitude of the physical effects, which may impact the conservation objectives and affect the integrity of the SPA. Adverse effects associated with bridge construction and operation fall into two main categories: disturbance and habitat modification (Figure 4). A third category, the potential for bird mortality or injury due to collision with the bridge superstructure, is screened out of this assessment (refer to Section 4.5).

4.2.3 The potential physical and ecological effects of the Main Crossing on the integrity of the Firth of Forth SPA were assessed against the conservation objectives of the SPA (refer to Figure 4). A copy of the conservation objectives for the Firth of Forth SPA, together with a list of the qualifying species, as presented on the SNH website, is included in Appendix A. For the purposes of assessment, all qualifying species were considered to be equally important.

4.2.4 To inform the investigations of potential adverse effects on the Firth of Forth SPA, intensive field studies were undertaken to provide information on:

1. the type and number of birds that may be impacted by the FRC, and the extent and importance to bird populations of areas which may be impacted (through disturbance or habitat loss); and
2. levels of flight activity and types of flight behaviour, which can be used to assess the impacts of bridge structures on bird movements.

4.2.5 The likely nature, location and scale of any adverse effects which have the potential to affect the integrity and conservation objectives of the Firth of Forth SPA are discussed below and summarised in Table 11.

4.3 Disturbance

4.3.1 Within the scope of this report we have used the definition of *disturbance* outlined by Frid and Dill (2002). This paper describes *disturbance* as:

> *"a deviation in an animal's behaviour from patterns occurring without human influences";*

4.3.2 and *disturbance stimulus* as:

> *"a human-related presence or object [e.g., birdwatcher, motorized vehicle] or sound [e.g., seismic blast] that creates a disturbance".*

4.3.3 This report considers whether the potential impacts of disturbance resulting from the construction and operation of the Main Crossing have the potential to adversely affect the conservation objectives of the qualifying species of the Firth of Forth. Disturbance would be considered to adversely affect site integrity, if it contributes to:

- adverse impacts on any of the conservation objectives of the site;
- the long-term decline of a species on the site;
- the risk of reduction of the range of the species within the site; and/or
- the reduction in area of the habitat used by species within the site (EC, 2002).

Barrier to Bird Movement

4.3.4 During the construction and operation of the FRC there is a potential for engineering activities and noise associated with the bridge to disrupt flight behaviour and disturb qualifying species of the Firth of Forth SPA, creating a barrier to bird movements.

4.3.5 To investigate the potential impacts of the bridge design and superstructure the flight behaviour of SPA qualifying birds in relation to the existing Forth Road and Rail bridges was quantified to inform an assessment of their likely reactions to the third proposed bridge. These flight events were assessed to evaluate any potential adverse affects on the conservation objectives of the qualifying features and the integrity of the site.

Construction

4.3.6 Construction of the FRC may cause disturbance to estuarine birds through noise and vibration, the presence of construction personnel and machinery, and the use of boats to

access construction areas in the open water of the estuary. Lighting of construction sites may also cause disturbance to birds.

4.3.7 The Main Crossing could potentially segregate qualifying birds from their ideal distribution and/or habitat during construction. This impact may be caused by construction related disturbance stimuli that have the potential to act as barrier to bird movements thus limiting the distribution of SPA qualifying species. Disturbance stimuli can be from a multitude of sources such as above ambient noise and light levels and movements.

Operation

4.3.8 During operation, the presence of the bridge super-structure may affect the use of this area by birds, for example by presenting an obstacle which causes birds to alter flight behaviour, flight paths, or interfering with foraging behaviour. The worst case scenario is that the bridge will create a barrier effect for birds commuting or migrating up or downstream and will exclude them from foraging areas which are crossed by the bridge. The possibility of bird mortality due to collision with the bridge is considered in Section 4.5 below.

4.3.9 Studies of eight estuarine crossings in Scotland (Logie & Bryant, 1994) indicated that high level bridges do not cause negative impacts on local bird movements, feeding patterns or roosting sites. At the bridges studied, the majority of birds (more than 70%) were observed flying underneath the bridge decks. The key species considered in this study were waders and ducks. Whilst the findings may not be relevant to all of the qualifying species of the Firth of Forth SPA, and although it was not considered likely that the Main Crossing will affect local movements of birds, the potential for this to occur was investigated in terms of the potential for adverse impacts on the conservation objectives of the site.

4.3.10 There is no evidence that noise from the existing Forth Road and Rail Bridges has adverse impacts on birds using the Forth estuary. Generally, research suggests that birds habituate quickly to most new noise sources. No assessment has therefore been made of the potential operational impacts of bridge traffic noise on SPA qualifying species.

4.3.11 Maintenance activities for the Main Crossing, once in operation, have not been identified as causing potential disturbance to birds. This is on the basis that maintenance of the other bridges spanning the Firth of Forth has not had adverse implications for the Firth of Forth SPA.

Effective Displacement from Ideal Habitat caused by: Noise and Movement

4.3.12 Within the Firth of Forth SPA disturbance may displace birds from important feeding and roosting areas and could have energetic costs in terms of extending distances travelled between roosting and feeding grounds, and reducing foraging time and consequent energy intake. Disturbance may also impact areas used for feeding or regular commuting routes between breeding/roosting sites and foraging areas.

4.3.13 To enable an assessment of the potential impacts of the proposed scheme on qualifying interests of the SPA, the following issues were investigated:

- the numbers, distribution and behaviour (commuting, foraging, roosting and loafing) of other SPA qualifying species in the vicinity of the proposed route alignment;
- the distribution and behaviour of qualifying species of the SPA in relation to the existing Forth Road and Railway Bridges;
- the utilisation of artificial structures by qualifying species of the SPA for foraging, roosting and loafing behaviour;
- the impacts of disturbance on bird behaviour (from a literature review) – focused on SPA qualifying species; and

- the predicted sources, timing and levels of disturbance associated with the construction and operation of the proposed scheme, including surveys of ambient noise and a review of published information on the likely noise levels associated with various construction activities.

4.3.14 The potential for any given qualifying species to be disturbed and therefore to have an implication for the SPA conservation objectives and site integrity was investigated. The likely magnitude of any impact was assessed partly according to the number of birds and the proportion of the SPA population for each qualifying species that could be potentially subject to disturbance.

4.3.15 Responses of birds to disturbance are not easily quantified or predicted. They vary between species and according to a number of other factors including sites, seasons and weather conditions. Birds may become habituated to constant levels of relatively predictable disturbance, so activities which represent unpredictable disturbance events are considered more likely to have adverse impacts. The potential impacts of disturbance during construction have been considered under categories of human intrusion, boat movements, noise and light.

Construction

4.3.16 Construction of the Main Crossing and associated approach roads may cause disturbance to estuarine birds through noise, light and visual movement which may alter their ideal foraging, roosting or loafing distribution.

4.3.17 The impacts on, and responses of birds to, disturbance, are complex and difficult to predict. However, in a review by Hill (1990) he summarised the likely responses of waterfowl to disturbance (Table 7).

Table 7: Potential impact of disturbance and likely response by birds (modified from Hill, 1990)

Stimuli	Disturbance	Likely Bird Response
Noise/Visual Movement	Reduction in feeding time	Harassment, birds move elsewhere
Noise/Visual Movement	Reduced feeding area	Risk of predation/mortality by proximity of humans or closeness to structure causes birds to move elsewhere
Artificial light	Increase in feeding time	Birds aggregate at food source stimulated by greater light availability at night
Artificial Light	Interference with migration	Birds disorientate, may lead to mortality (e.g. through collision with a structure)
Noise/Visual Movement and Artificial Light	Interference with roosting	Birds move elsewhere

4.3.18 With the exception of an increase in feeding time all the responses by birds to disturbance (Table 7) are likely to reduce their fitness by increasing energy expenditure through increased flight time (disturbance response) or increased flight distance to alternative habitats. Secondary fitness consequences may be a decrease in energy uptake through reduced foraging efficiency because birds either: spend less time foraging (because of increasing amounts of time exhibiting an alarm behaviour of looking about, not foraging); or displace to non-ideal habitats which might increase intra- and inter-specific competition (reduced feeding time) or reduced food availability due to poor habitat quality (Hill, 1990). For example, studies show that redshank and oystercatcher significantly delay their arrival time at foraging sites (at low tide) and depart earlier if people are present thus reducing the available foraging time (Fitzpatrick & Bouchez, 1998). However, for some species (Oystercatcher; Goss-Custard & Verboven, 1993) reduced feeding time during specific tidal states can be compensated by increasing feeding rates during ebbing or flowing tide or increasing foraging time (Goss-Custard & Verboven, 1993).

4.3.19 The severity of extraneous movement on bird behaviour and potential disturbance is dependent on many factors such as the magnitude and type of activity as well as spatial and temporal variance. It is important to differentiate between disturbance attributed to construction and associated activities and background levels. This is because many bird species are shown to habituate quickly to regular disturbance especially, those found in already heavily urbanised areas. It is abnormal or unpredictable or disturbance events that have the capacity to cause displacement (Logie & Bryant, 1994). The proposed route alignment is currently subject to considerable disturbance from commercial and personal water craft in addition to terrestrial industrial activities and existing bridge structures.

4.3.20 During construction of any large development, in an area frequently utilised by birds, some level of disturbance is likely. The further a source of disturbance is away from the species of interest, the lower the magnitude of the effects is likely to be in terms of changes in behaviour. The response of birds closest to the source of disturbance is an 'escape behaviour when they take flight or move away on foot. A bird's escape behaviour to either anthropogenic (walker) or natural (predator) appears to be similar (Blumstein, 2003) and there are 'energetic costs' from engaging in escape behaviour. These energetic costs are a reduction in net food intake and increase in energy expenditure therefore a bird does not have to stop feeding to starve. Repeated or persistent disturbance to feeding may result in a slow decline in body condition which may lead to increased predation risk or starvation. The response of a bird is therefore a trade-off between avoiding the risk and increased demands on their energy reserves (Stillman & Goss-Custard, 2002). Taken to its natural conclusion birds may face starvation if disturbance levels are so great they spend all their time avoiding risks and not foraging. Beyond the distance at which birds exhibit escape behaviour they show more subtle 'alert behaviours' such as increased head turn and anxiety up to a 'critical distance'. Up to this critical distance birds can be considered to be disturbed (disturbance zone) and beyond, undisturbed.

4.3.21 Midwinter can be an ecological bottle-neck for waterbirds when they have particular difficulty in finding food, especially during periods of harsh weather. At this time, wintering waterbirds from elsewhere in Europe may move to Britain to escape even colder conditions on the continent. This may have two main impacts on the fitness of estuarine birds. Firstly, an increase in energy demands would have to be compensated increased foraging rates and net food intake. Secondly, an influx of birds to coastal regions may increase competition for finite resources.

4.3.22 The magnitude of disturbance and the 'critical distance' up to which it occurs is dependent on a number of factors:

1. **Location** or the distance of the development from the species of interest;
2. **Habituation** of birds to existing disturbance; and
3. **Timing** of the development.

4.3.23 The location of the development, and the density and diversity of birds present is important as bird species vary in their sensitivity to disturbance and respond differently to different kinds of disturbance. Escape behaviour, assessed as mean flight distance, varies within and between species and in response to different sources of disturbance (Table 8). These mean values provide supporting information to identify a series of critical distances against which disturbances can be assessed (Table 9), although it should be noted that mean values do not describe the responses of the most sensitive individuals of a species, or responses at the most sensitive seasons or sites. Accepted practice is to base the most critical distance for disturbance on the most sensitive species (Cutts et al., 2009). However, flight distances in Table 8 ranged from 10m (dunlin/redshank) to 400m (Curlew). In addition there was an inconsistency within species e.g. redshank varied from 10m to 265m. .

Table 8: Mean distance (m) at which escape behaviours of wildfowl was evident in response to disturbances (information taken from Cutts et al., 2009)

Study[2]	Disturbance	Mean flight distance (metre)									
		Bar-tailed godwit	Oystercatcher	Knot	Dunlin	Redshank	Black-tailed godwit	Ringed plover	Grey plover	Shelduck[1]	Curlew[1]
Owens (1977)	Walker						50 to 100				
Wolff et. al. and Smit & Visser (1993)	Walker				163					250	339
Tensen & van Zoest (1983)	Walker					95					95
Glimmerveen & Went (1984)	Walker										102 to 196
Van der Meer (1985)	Walker				71		105	121	124	148	211
Blankensijjn et. al (1986)	Walker										213
Scott (1989)	Walker				10	10 to 15					
Fitzpatrick & Bouchez (1998)	Walker					27					38
Triplet et. al. (1998)	Walker				46	110				145	
Smitt & Visser (1993)	Kayak	200	50	262.5		175				200	237.5
Smitt & Visser (1993)	Wind Surfer	237.5	125	200		265				375	400

1 = Birds classed as 'large' and have an average weight >1000g. All other species are classed as 'small' or <1000g

2 = Table based on summary tables shown in Cutts et. al., 2009

4.3.24 The likelihood that birds might be exposed to disturbance during a development can, at a limited level of accuracy, be predicted (Frid & Dill 2002, West et al. 2002, Drewitt 2007). Disturbance of waterbirds by anthropogenic activities will clearly be influenced by the distances between birds and disturbance sources. The distance at which birds take flight or move away on foot ('escape behaviour'), for example, or show more subtle changes in behaviour as a response to human disturbance is taken to be a 'critical distance' below which birds may be considered to be 'disturbed'. Beyond the critical distance, birds are assumed to be 'undisturbed' or not disturbed sufficiently to affect their fitness, population or distribution. The critical distance may also be termed the 'disturbance distance', while the space between the disturbed bird and the source of disturbance is sometimes called the 'buffer zone' (Rogers & Schwikert, 2002). Choice of an appropriate distance (or distances) is integral to the 'critical distance' approach and yet most published data are species-specific and site-specific. Generic guidelines to extrapolate critical distances to species and circumstances away from study areas are rarely available (Davidson & Rothwell, 1993 a & b; Woodfield & Langston, 2004; Webb & Blumstein, 2005).

4.3.25 Bird assemblage and densities within critical distances of the Main Crossing were used to assess the impacts on Firth of Forth SPA qualifying species. The minimum critical distance where all birds were deemed likely to be disturbed for a impact assessment of the construction and operation of a similar project on the Firth of Forth SPA (the new Clackmannanshire Bridge) was set at 300m (Ader & Bryant, 2003). This was based mainly on experimental walk-up studies of waders' taking-flight from intertidal-flats in NW Europe (Davidson & Rothwell, 1993a & b). However, in adopting this value the authors recognised that the critical distance might be somewhat greater for species more sensitive to disturbance, if the source was above ground level, such as from a bridge or embankment, or if there was more than one cause of disturbance. Equally, critical distances may sometimes be very much greater, such as amongst wild swans reacting to low-flying aircraft, where they can exceed 1km (Rees et al., 2005). Also, at some sites, at some times, critical distances could be lower than 300m, such as where wildfowl or waders habituate to human activity and do not react to routine human traffic (Thomas et al., 2003, Ravenscroft et al., 2007).

4.3.26 Preliminary results from a study of the impacts of the construction of the Upper Forth Crossing (Kincardine Bridge) suggest that 300m represents a minimum critical distance for the suite of waterbird species occurring in this area. The evidence for this statement, albeit not decisive, is that waterbird counts within the 300m buffer zone around the (Clackmannanshire Bridge new crossing) were seen to fall relative to counts outside the buffer zone during the main period of construction activity, 2006-2008 (Dwyer, 2008). They returned to this zone during the less-disturbed post-construction period, in the winter of 2008-09 (D. Bryant, University of Exeter, pers. comm. 2 April 2009). Whether the causative disturbance leading to this temporary partial-exodus (of unknown significance at the population level), was mainly at distances close to the source (i.e. 0-300m), or whether it could have included some disturbance impacts at distances >300m is unclear. Construction-related disturbance events were seen to occur beyond the 300m zone, as in some studies of anthropogenic disturbance elsewhere (Davidson & Rothwell, 1993a & b).

4.3.27 With respect to the FRC, it was considered unlikely that birds would be affected by construction and/or operational disturbance, associated with the Main Crossing, at a distance of >1000m. This assumption is based on the proximity of the Main Crossing to existing infrastructure, including the Forth Road and Rail Bridges, and its industrial setting. The area includes an oil terminal, a naval maintenance dockyard and Rosyth Port and is an area where birds are likely to have habituated to regularly occurring disturbance stimuli (although they may still be disturbed by unpredictable events).

4.3.28 Within 1000m of the main crossing, critical distances at which birds are likely to be disturbed were divided into three zones (Table 9). The magnitude of different disturbances was defined as follows: minimal disturbance deemed only slightly greater than existing disturbance found within the vicinity of the proposed Main Crossing alignment; moderate disturbance constitutes general activities associated with bridge construction works; and exceptional relates to unique disturbance stimuli (examples of disturbance stimuli are given in Table 10).

4.3.29 Based on a review of the scientific literature and consultation with Prof. D. Bryant (University of Exeter, pers. comm. 2 April 2009) 250m was selected as the minimum critical distance for the assessment of potential impacts of the FRC. This takes into account the preliminary results from monitoring during the construction of the Upper Forth Crossing and the fact that the Forth Estuary in the vicinity of the Main Crossing is already subject to considerable anthropogenic disturbance. Within 250m of the proposed Main Crossing all bird species are likely to be disturbed to some extent by construction activities. In addition, further critical distances up to 500m and 1000m were identified to assess disturbance to birds. These areas were identified as zones where more extreme disturbance events such as construction activities which create noise above ambient levels, might cause actual disturbance, and/or more sensitive species might be disturbed; whereas only exceptional disturbance events are likely to disturb all birds up to a kilometre (Table 9). The distribution of waterfowl within these three critical distance zones was used to inform the assessment of the potential impacts of disturbance from the construction of the Main Crossing on the qualifying bird species of the Firth of Forth SPA.

Table 9: Critical distances used to inform the appraisal of disturbance to waterbirds

Zone	Critical Distance up to which birds maybe disturbed	Description of responses within the critical distance	Disturbance type
Zone 1	0-250m	Disturbance likely for all species	Minimal
Zone 2	0-500m	Disturbance possible for the minority of species	Moderate
Zone 3	0-1000m	Disturbance possible for the most sensitive of species	Exceptional

Table 10: Generic descriptions of disturbance types

Disturbance type	Type of disturbance
Minimal	Source is a single pedestrian at ground level (or small party), moving quietly without halting, without a loose dog(s), and with zero ongoing group-recreational, agricultural, industrial or construction activities, events or noises.
Moderate	Source is in elevated position, people are moving irregularly and halting periodically, may be noisy, with loose dog(s), also some construction or other anthropogenic activity is ongoing with periodic and intense noises or movements.
Exceptional	Low-flying aircraft, such as Microlights, Light aircraft (i.e. for Sight-seeing and Training) and Helicopters. Commercial airliners and high-flying aircraft (>1.5km) do not usually cause disturbance to birds within the SPA, some military aircraft may. Assume shortest distance from source to target (i.e. including height for aircraft).

4.3.30 Construction activities such as piling may affect the abundance of invertebrates in intertidal habitats thus potentially making intertidal areas less suitable for feeding. In the intertidal area it piling will be confined to an area of about 0.29 ha (Table 6) which will be temporarily lost to construction sites on the north and south shores of the estuary. This is equivalent to less than 0.01% of the area of the Firth of Forth SPA. While the invertebrate fauna of these areas may be lost or reduced during construction, these losses are not likely to affect the food supply for over-wintering birds and therefore not impacts are predicted on the conservation objectives for any of the SPA qualifying species or the site integrity of the Firth of Forth SPA. Displacement of birds due to disturbance from construction activities is likely to have a greater effect on birds than displacement of food supply. The invertebrate fauna of intertidal areas affected by the construction of a pipeline in Clonakilty Bay, Ireland, was found to recover within 6 months to 1 year after construction (Lewis et al., 2003).

Noise

4.3.31 Disturbance responses of birds to noise are likely to vary between species and for a given species may depend on the levels of ambient noise in the environment they occupy and the extent to which noise levels are increased by a given activity. Species-specific thresholds of disturbance are likely to relate to differences in tolerance, spacing requirements and bioacoustic profiles (frequency and magnitude of perceived noise levels). Activities which result in increases in noise levels above ambient noise may cause disturbance to birds.

4.3.32 In addition, the ecological impact assessment of the potential effects of piling operations on non-migratory fish populations within the Firth of Forth (Jacobs, 2009f, Chapter 11) considered that impacts would be temporary: fish would move away from an area where piling was taking place and re-enter when activities ceased. The distance of any such fish movements would depend on the level of noise, the propagation of noise through water and species specific tolerances.

Light

4.3.33 There are many observations of birds being attracted to and disorientated by lights at night, particularly during conditions of poor visibility. Lights may create a trapping effect whereby

birds entering a lighted area may be hesitant to fly into the darkness beyond. Birds attracted to lights are not only at risk of collision with a structure, but also of exhaustion, starvation and predation (Drewitt & Langston, 2008). A number of instances of seabirds being attracted to lights are cited in Reed et al. (1985), although none of the examples cited are qualifying species of the Firth of Forth SPA. Illuminating a structure with floodlights in an isolated environment may sometimes reduce but also sometimes increase collision risk for birds (Drewitt and Langston, 2008 and references therein).

4.3.34 Waterfowl may feed at night and take advantage of artificial light to extend feeding times, for example, Hill (1990) describes wigeon taking advantage of artificial light to extend the available amount of time for foraging.

Operation

4.3.35 During the operation of the proposed scheme there is potential for traffic noise and lighting associated with the bridge to cause disturbance to qualifying species of the Firth of Forth SPA.

4.3.36 Studies of eight estuarine crossings in Scotland (Logie & Bryant, 1994) indicate that high level bridges do not cause negative impacts on local bird movements, feeding patterns or roosting sites. Generally, research suggests that birds habituate quickly to most new noise sources. It is not considered likely that noise from the proposed new bridge will adversely impact on any of the qualifying species of the Firth of Forth. No assessment has therefore been made of the potential operational impacts of bridge traffic noise on SPA qualifying species.

4.3.37 After the size of a structure, use of lighting is considered to be a key factor affecting the risk that birds will collide with a structure (Drewitt & Langston, 2008). However, it is important to note that at night there is already considerable existing light spill in the vicinity of the proposed scheme area from the settlements on either side of the estuary and the existing Forth Road and Rail Bridge. Therefore any illumination during operation will occur in an area already lit which was taken into account during the assessment process.

4.3.38 A literature search on the reactions of birds to lights was undertaken to inform an assessment of the likely impacts of the proposed lighting arrangements for the proposed scheme on qualifying species of the Firth of Forth SPA.

4.4 Habitat Modification

4.4.1 The potential impacts of habitat modification of existing habitats may cause displacement of birds from their ideal distributions as outlined above (4.3.16), which may reduce energy intake and increase energy expenditure, which have the potential to adversely affect the sites integrity. Significant impacts could potential occur if temporary or permanent habitat loss caused:

- significant adverse impacts on any of the conservation objectives of the site;
- the long-term decline of a species on the site due to increased mortality due to starvation and associated reduction in fitness;
- a reduction of the range of the species within the SPA or SPA connected areas; and/or
- the reduction in size of the habitat used by species within the site (EC, 2002).

4.4.2 Specific factors which may modify habitats are outlined below:

Direct Habitat Loss during Bridge Construction

4.4.3 Habitat loss during the construction of the proposed scheme may result from the following:

- the presence of temporary access roads and bridges associated with the construction of viaduct sections of the main crossing in intertidal areas of the north and south shores of the estuary; and
- the presence in the estuary of piling machinery and concrete batching plants associated with the construction of the north, south and central towers of the bridge.

4.4.4 While they are in place, these structures and plant may exclude SPA qualifying species from areas used for foraging, such as Hopetoun Bank near Port Edgar and tidal races associated with Beamer Rock (Jacobs/Faber Maunsell/AECOM, 2007b).

4.4.5 To assess the impact of loss of foraging habitat during construction of the proposed scheme, a detailed investigation was undertaken based on:

- the distribution of SPA qualifying bird species in this area; and
- information on the location and extent of construction sites and associated structures.

4.4.6 Changes in hydrology and sediment regime of the Forth Estuary resulting from the construction of the bridge may also result in changes in the distribution of inter-tidal and subtidal habitats both within the SPA boundary and adjacent areas connected to the SPA.

4.4.7 Proposals to build temporary access roads/causeways in intertidal areas on the north shores of the estuary during the construction phase will result in the temporary modification of approximately 0.07ha of SPA habitat. Such areas adjacent and connected to the SPA at the southern landfall of the proposed crossing will result in the loss of approximately 0.24ha of intertidal habitat.

4.4.8 Tidal races associated with Beamer rock provide feeding areas for estuarine birds. The presence of a bridge tower on the rock may result in the alteration or loss of this feeding area during construction.

Direct Habitat Loss during Bridge Operation

4.4.9 The permanent habitat loss in shoreline, intertidal and subtidal areas of the Forth Estuary resulting from the main crossing will be very small – effectively comprising the footprint of the three towers supporting the bridge deck and 10 piers supporting the north and south viaduct sections. The footprint of the three towers is small and no SPA habitat will be lost during operation. However, there will be a permanent loss of adjacent intertidal areas connected to the SPA. Although the area impacted is deemed minimal, in relation to the whole of the Forth Estuary (Table 5), the potential of each component of the proposed scheme to impact on the conservation objects will be assessed.

Effect of Bridge Superstructure

4.4.10 The presence of the bridge structure may affect the use made by qualifying species of the SPA of foraging areas which are crossed by the bridge, for example shadowing of the estuary caused by the bridge superstructure has the potential to displace birds from their ideal habitat. Reduced light levels may alter littoral communities affecting food web dynamics and the suitably of habitats to specific bird behaviours i.e. feeding and roosting. Qualifying birds have been observed foraging in the area of the Forth Estuary which will be crossed by the proposed Main Crossing (MBEC, 2007, 2008). If birds avoid foraging close to the proposed scheme this may result in the permanent reduction or loss of these feeding areas for SPA qualifying species.

Alteration to the Hydrology of the Forth Estuary

4.4.11 The water environment of the Forth Estuary is of great importance to the qualifying species and site integrity of the Firth of Forth SPA. In-channel works in the Forth Estuary required for the construction of the bridge, and in the longer term the presence of the bridge piers,

may cause alteration to water flow and the sedimentation regime. Changes in the hydrology and suspended sediments might affect the availability of prey to qualifying species of the Firth of Forth SPA through changes in water quality, in particular turbidity, as well as changes in the deposition and scour of sediment and therefore the extent of different intertidal and subtidal habitats.

4.4.12 A 3D hydrodynamic model of the Forth Estuary was built to investigate the potential impacts of changes to the flow and sedimentation rates during the construction and operation of the bridge.

Pollution Incidents and Risk

4.4.13 Release of pollutants during bridge construction works, post-construction maintenance, or as a result of accidental spillage during construction and/or operation, have the potential to affect all habitats and species present within the Firth of Forth, including the qualifying species of the Firth of Forth.

4.4.14 With respect to pollution, the key issue is the procedures put in place to minimise the risk of contaminants entering the Forth Estuary in sufficient concentrations to cause adverse effects on site integrity. These are discussed further under proposed mitigation (Section 8 below). Calculations of the risk of pollutant spills from traffic using the bridge were used to assess this aspect of the pollution risk (Jacobs Arup, 2009c). The results of the consultation exercise (a list of organisations contacted can be found in Section 5.2) and detailed investigations of the distribution of qualifying species of the SPA in the vicinity of the proposed scheme (methods in Section 5 below) provide information on the areas of greatest sensitivity to pollution.

Table 11: Potential adverse effects of the FRC on the Firth of Forth SPA

Adverse Effect	Potential adverse ecological effect	Likely sources of adverse effect
Disturbance Stimuli	Barriers to bird movement A reduction in bird movements has the potential to disrupt commuting routes between foraging and roosting habitats The proposed bridge has the potential to disrupt winter migration corridors along the Firth of Forth	Construction: Reluctance of bird species to cross the construction footprint of the Main Crossing
		Operation: Reluctance of bird species to cross the Main Crossing
	Effective displacement from feeding and/or roosting distribution Effective habitat loss, due to displacement from preferred habitats, may reduce energy intake (reducing foraging efficiency) and increase energy demands (increased flight time).	Construction: Birds could potentially be excluded from ideal habitats by noise, lighting and visual disturbances Sources of disturbance are: • Loud noises from construction activities such as piling, blasting of Beamer Rock, general construction activities • Lighting of site compounds and construction sites • Vehicle traffic (terrestrial and water craft) and construction personal
		Operation: Excessive light spill may affect normal bird behaviour

Adverse Effect	Potential adverse ecological effect	Likely sources of adverse effect
Habitat Modification	Shading of ideal habitat Effective habitat loss, displacement from preferred habitats, may occur due to the presence of the bridge superstructure. Adverse effects might include reduced energy intake (reducing foraging efficiency) and increase energy demands (increased flight time) due to an increase in the perceived predation risk. The proposed bridge has the potential to disrupt winter migration corridors along the Firth of Forth	Operation: Bridge shadow (shading) has the potential to displace birds from ideal habitats although the height of the bridge is unlikely to promote the effect as it is not observed with other Forth crossings. The presence of 'ambush' vantage points for predators is a consideration. The bridge structure may impede bird movements
	Direct habitat Modification: Modification of habitat due to footprint of construction activities may reduce energy intake (reduce foraging efficiency) and increase energy demands (increased flight time)	Construction Modification of SPA habitat due to construction activities associated with the northern approach viaduct Loss of habitat used by SPA bird populations, but outside the designated SPA boundary, due to construction activities associated with the southern approach viaduct
	Alteration of Forth Estuary hydrology Loss of preferred habitats due to scouring or deposition of sediments may result in ideal habitats being lost and the displacement of birds	Construction: Alteration of suspended sediment concentrations and water velocity (and associated deposition and scouring effects) caused by structures associated with the northern and southern approach viaducts and the removal of rock from Beamer Rock
		Operation: Alteration of sedimentation rates and estuarine currents caused by the bridge tower, viaduct piers and alteration to Beamer Rock
	Pollution Incidents and Risk Contamination of habitats by the pollution incidents may result in ideal habitats being lost and the displacement of birds	Construction: Risk of pollution from incidents
		Operation: Risk of pollution from incidents

4.5 Collision Mortality or Injury

4.5.1 The area of the Forth Estuary to be crossed by the proposed Main Crossing is used as a commuting route, foraging area and migration route by qualifying species of the Firth of Forth SPA. During operation, the presence of the bridge super-structure may affect the use of this area by birds, for example by presenting an obstacle which causes birds to alter flight behaviour, flight paths, or interfering with foraging behaviour. Under some conditions such as stormy weather or poor visibility there may be a risk that birds will collide with the bridge and die. The worst case scenario is that the bridge will create a barrier effect for birds commuting or migrating up or downstream.

4.5.2 A review of bird mortality and bridges (Ove Arup & Partners Hong Kong Ltd, 2002) found no publications documenting bird collisions with or bird mortality due to collisions with bridges or bridge stays. Similarly, a recent review of avian mortality due to collision with man-made structures (Drewitt & Langston, 2008) does not highlight bridges as a source of bird-strike mortality although birds have been recorded colliding with structures which might be considered to have some similarity with bridges in terms of components of the structure (e.g. towers and communication masts). Collisions with moving objects are documented for seabirds, including common and Sandwich terns with wind turbines in Belgium (Everaert & Steinen, 2007).

4.5.3 A review of the effect of bridges on the use of intertidal mudflats found no evidence that the presence of bridge crossings affected local movements of shorebirds within estuaries (Logie & Bryant, 1994). At the bridges studied, the majority of birds (more than 70%) were observed flying underneath the bridge decks and no reference is made to any observations of near collision or collision.

4.5.4 A collision risk assessment was not carried out as a review of the scientific literature provided no evidence that birds collide with bridges and it therefore not considered further in this report (Logie & Bryant, 1994; Ove Arup & Partners Hong Kong Ltd, 2002; and references therein).

5 Methods for Surveys to Inform an Appropriate Assessment of the Effects of the FRC on the Firth of Forth SPA

5.1 Introduction

5.1.1 This section describes the survey design, field methods, and data analysis for surveys to inform the appropriate assessment for the FRC and the Firth of Forth SPA.

5.1.2 The distribution and flight behaviour of the qualifying bird species in the vicinity of the proposed new bridge was investigated to fully understand the potential adverse effects of the Main Crossing on the conservation objectives of the Firth of Forth SPA. Each impact (Table 11) was assessed in the light of information gathered on the behaviour and distribution of qualifying bird species from historical records and surveys carried out between September 2007 and April 2009 (Table 12).

Table 12: Surveys used to assess the potential adverse effects of the Main Crossing on the integrity of the Firth of Forth SPA

Surveys carried out to aid assessment of impacts		Disturbance	Habitat Modification	Collision mortality or injury
	Estuarine Bird Through-the-Tide Counts	✓	✓	
	Estuarine Bird Migration Period Flight Activity Surveys		✓	✓
	Nocturnal Estuarine Bird Count	✓	✓	
	Inland Estuarine Bird Count	✓	✓	
	Historical records	✓	✓	✓

5.2 Consultation

5.2.1 Consultation was undertaken with a number of statutory and non-governmental organisations to investigate historical records of the numbers and distribution of SPA qualifying birds in the Firth of Forth and to provide context for the results of surveys carried out for the appropriate assessment. Consultation was sought with:

- the British Trust for Ornithology (including a request for Wetland Bird Survey (WeBS) data);
- Forth Seabird Group;
- Scottish Natural Heritage;
- RSPB; and
- Scottish Ornithologists' Club.

5.3 Estuarine Bird Through-the-Tide Counts

Aims

5.3.1 Through the tide counts were undertaken to record the numbers, distribution and behaviour of waterbirds (including all qualifying species of the Firth of Forth SPA) present in the Forth estuary (the shoreline, intertidal and open water areas) in the vicinity of the proposed new bridge. The information gathered allowed the identification of areas which are particularly important for migratory bird assemblages during different tide states. The distribution of birds and their use of the estuary informed the assessment of potential adverse effects of displacement in the vicinity of the proposed Main Crossing.

5.3.2 Estuarine bird through-the-tide counts (TTTC) were carried out between September 2007 and April 2009.

Methods

5.3.3 The survey methods were based on the Wetland Bird Surveys (WeBS) core (high tide) and low tide counts (as described in Bibby et al., 2000). Within the survey area, regular counts of birds using the shoreline and the waters of the estuary were carried out at low, mid and high tide. Wetland birds which were recorded included: gulls, terns, divers, grebes, cormorants, herons, swans, geese, ducks, rails, waders and kingfisher, as defined by Wetlands International (Rose & Scott, 1997).

5.3.4 The survey area for through the tide counts is shown on Figure 6. This was divided into a wider survey area, extending between Limekilns and Dalgety Bay on the north shore of the Forth Estuary, and Abercorn Point and Hound Point on the south shore, and a core survey area (survey sectors S2, S3, S4, and N3, N4, N5 and N6) extending between St Margaret's Marsh and Inverkeithing Bay on the north shore and Society Point and the Forth Rail Bridge on the south shore.

5.3.5 Within the wider survey area four replicates of high and low tide counts were carried out each month. In addition four replicates of mid tide counts within the core survey area only were completed each month. Counts therefore covered a range of spring (tides when high water is above the average level and low water below the average level) and neap tide conditions (when tidal ranges are less extreme than average) in the Forth Estuary. (Appendix B).

5.3.6 During each count birds were viewed, with the assistance of binoculars and telescopes, from specific vantage points (VP) along the shoreline, thus enabling the entire shoreline within the survey area to be observed. Surveyors took 'snapshot' scans and recorded the number, location and behaviour of birds on maps of each of the count sectors (refer to Figure 6 and Figure 7 for count sectors used respectively by Jacobs Arup and MBEC). Data were recorded on maps using standard BTO bird species codes (BTO, 2008), with the number of each species recorded in superscript and the related behaviour indicated in subscript text; behaviour codes and descriptions are listed in Table 13 below. Samples of field maps and survey sheets are shown on Figures B3 and B4 of Appendix B. In addition to bird data, weather (wind speed and direction, rainfall, cloud cover and visibility) and sources of potential or actual disturbance to birds were recorded during the counts.

Table 13: Species behaviour codes

Behaviour to be Recorded	Associated Code	Detail / notes
Loafing	L	Bird inactive but observed showing alert behaviour such as head up, head turning
Roosting	R	Bird inactive with no sign of alert behaviour (often with eyes closed or head under wing)
Feeding/Foraging	F	Actively seen feeding on the ground or in the air
Flying	Y	Directly flying / commuting
Carrying Food	O	Bird likely to be carrying food to a nest site

5.3.7 The September 2007 - April 2008, surveys were undertaken by Mackenzie Bradshaw Environmental Consulting (MBEC 2007, 2008).

5.3.8 Surveys carried out by MBEC (2008) between September 2007 and April 2008 were timed so that the mid-point of the survey coincided with the turn of the tide (high or low water). MBEC aimed to survey the whole area four times per calendar month at each tidal state (for a full summary of MBECs detailed survey effort and timings refer to MBEC, 2008).

5.3.9 From May 2008 - April 2009, field surveys were undertaken by Jacobs Arup and some modifications were made to MBEC's survey methodology. Differences between the two survey periods are described below. SNH was informed of these changes (letter from Shirley Henderson, dated 4 July 2008) and advised that it was content (Lachlan Lamont, SNH, pers. comm., 23 July 2008).

5.3.10 Jacobs Arup changed the boundaries of the count sectors to remove overlap between adjacent sectors (Figure 6). Count sectors used by MBEC are shown on Figure 7. The open water sectors used by MBEC (C1-C3; Figure 7) were also removed and instead count sectors N2 – N5 and N7, and S2 - S5 were extended into open water areas roughly half-way across the estuary from the north and south shore respectively, using visible features to demarcate areas where possible.

5.3.11 Jacobs Arup carried out one complete high and low tide count of the wider survey area and one mid tide count of the core area each week between May 2008 and April 2009. Where daylight hours and tidal patterns allowed, high, low and mid-tide counts were synchronised so as to be completed within one tidal cycle on a given day using four surveyors to cover the entire survey area. This provided a 'snapshot' estimate of the total number of birds within the survey area on a given day and tide. Also where possible within each week, high low and mid tide counts were carried out on different days to avoid pseudo-replication (multiple counts carried out in the same area on the same day are likely to record the same birds and are less independent for the purposes of data (statistical) analysis than counts separated by longer periods of time). Within the survey area, surveyors varied the locations at which they began counting on different days so that over the survey period each given count section was visited at a range of different times in relation to the turn of the tide. To avoid observer bias, surveyors rotated between areas on a monthly basis.

5.3.12 High tide counts were carried out over a three hour period, 1.5 hours either side of high water (when minimal or no areas of intertidal flats are exposed), and low tide counts over four hours, two hours either side of low water (when maximum areas of inter-tidal flats are exposed). Mid-tide counts were carried out up to 1.5 hours either side of the time half-way between high and low water (depending on the timing of tides on a particular day) on a falling or rising tide. The mid tide counts were extended to cover the core and wider survey area between November 2008 and January 2009 and during April 2009 (i.e. the periods when migration period flight activity surveys were not ongoing). Detailed survey schedules are shown in Appendix B.

5.4 Estuarine Bird Migration Period Flight Activity Surveys

Aims

5.4.1 The proposed alignment of the new bridge falls in an area regularly used by waterbirds moving between feeding and roosting areas in the inner and outer Forth Estuary. In addition, this area is a flight corridor for migrating waterbirds (e.g. Evans, 1968) and seabirds (e.g. Bryant, 1980; Henty, 1993). Estuarine bird flight activity studies were carried out during spring and autumn passage periods, between autumn 2007 and spring 2009. The aims of the surveys were to record the flight patterns of target bird species and their behavioural interactions with the existing bridges.

5.4.2 Crossing frequency, behaviour and height for a whole suite of bird species was compiled in relation to both existing bridges and the proposed new bridge.

Methods

5.4.3 Estuarine bird flight activity surveys were carried out by MBEC between Autumn 2007 and Spring 2008. Jacobs Arup continued these surveys during the Autumn 2008 and Spring 2009 migration periods. The survey methods used were the same during both periods but different vantage points were adopted as described below. As for the estuarine TTTCs, SNH

was informed of these changes (letter from Shirley Henderson, dated 4 July 2008) and advised that it was content (Lachlan Lamont, SNH, pers. comm., 23 July 2008).

Methods 2008/09

5.4.4 Surveys were carried out from six vantage points: two upstream of the Forth Road Bridge, two between the existing Forth Road and Rail Bridge and two upstream of the Forth Rail Bridge (Table 14, Figure 6). Only one of these, the Port Edgar Harbour Breakwater, was the same as vantage points used in 2007 by MBEC (MBEC, 2007, 2008; Table 2 and Table 3). The MBEC north shore VP to the east of the Forth Rail Bridge (Carlingnose Point) was moved to a site at North Queensferry immediately to the east of the landfall of the Forth Rail Bridge; and the MBEC south shore VP to the east of the Forth Rail Bridge was moved from Whitehouse Point to Long Craig Pier. In each case the rationale was that the proposed new VPs were closer to the Forth Rail Bridge and afforded a better view of the behaviour of birds in the vicinity of the bridge.

5.4.5 An average of 3-5 hours per week was spent surveying at each VP between the end of August and October 2008 and during February and March 2008. Survey periods coincided with peak migration/passage periods. Individual survey sessions were scheduled (where possible) to cover a range of times of day and tidal states. Because of the need to timetable survey work in advance and coordinate flight activity surveys with TTTCs there was little provision for flexibility in the timings so that weather conditions favourable for seabird migration could be selected, as was reported by MBEC (2007). As the survey effort was intensive, no more than three hours of recording were normally undertaken by a surveyor on a given day.

Table 14: Vantage point locations for bird migration flight activity surveys

VP Locations			
1. North shore, beneath road bridge	IRB Station N Queensferry	312552	680510
2. West of road bridge, south shore	Port Edgar Harbour Breakwater	311945	679158
3. Between bridges, north	North Queensferry Town Pier	313058	680165
4. Between bridges, south	South Queensferry Harbour	313029	678536
5. East of rail bridge, north	Under rail bridge north landfall	313438	680159
6. East of rail bridge, south	Long Craig Pier	314437	678883

5.4.6 During each survey period, weather and tide conditions were recorded on an hourly basis. Surveyors prioritised recording the flight paths of target species. Primary target species, including all qualifying species of the Firth of Forth SPA, were swans, geese, ducks, grebes, gannets, cormorants, skuas, sandpipers and allies, plovers including lapwings, oystercatchers, auks and Schedule 1 raptors of the Wildlife and Countryside Act 1981 (e.g. goshawk, hen harrier, hobby, honey buzzard, red kite and osprey). Other secondary target species comprised all other raptors, waders, wildfowl not listed above and 'notable' gull and tern movements (i.e. not localised and foraging/commuting).

5.4.7 At each VP when a target species was observed the bird was followed using binoculars or a telescope until it flew out of sight or landed. Once the flight activity survey was complete the flight path and other details were recorded on survey sheets. These details comprised: the bird species, number of birds, sex, age, start time, length of time that the bird was followed, initial flight height and whether the target bird crossed the road and/or rail bridge. If the bird crossed a bridge its crossing behaviour was recorded in one of the following categories: no change (NA); height change (HC); direction change (DC); abort AB; flare (FL); near collision (NC); and collision (C). HC and DC were classed as 'soft' behavioural changes because they generally did not cause gross changes in flight behaviour or flight energetics and were apparently a response to the presence of the bridge superstructure. FL, and NC were classed as 'hard' changes as these infer that birds were unaware of the bridge superstructure until they were very close. Crossing flight height above the water surface was also recorded in one of the following categories: 0-2m, 2-10m, 10-50m, 50-170m, 170-250m

and above 250m. Immediately after a flight path watch was completed, each flight path was also drawn on a map of the survey area (horizontal plane) and a schematic diagram of the bridges (vertical plane).

Survey Methods 2007/08

5.4.8 MBEC (2008) carried out migration period flight activity surveys between August and November 2007 and February to April 2008 from three VPs shown in Table 15 below. The survey methods and recording were the same as those described above (1.4.7 and 1.4.8) with one small modification, bird flight heights were recorded in five rather than six height bands (0-10m (VL), 10-50m (L), 50-170m (M), 170-250m (H) and >250m (VH); MBEC 2008, 2007).

Table 15: Vantage point locations for estuarine bird migration period flight activity surveys

Vantage Point	Grid Reference (6 figure)	Equivalent Jacobs Arup VP
MBEC 1 East of Rail Bridge, North Shore Carlingnose Point	NT 135 806	VP1
MBEC 2 East of Rail Bridge, South Shore Whitehouse Point	NT 119 793	VP6
MBEC 3 W of Road Bridge, South Shore Port Edgar Harbour Breakwater	NT 125 805	VP2

5.5 Nocturnal Estuarine Bird Count

5.5.1 Jacobs Arup carried out nocturnal low tide counts within the core survey area in October 2008 and January/February 2009, using the same methodology as described above for daytime tidal counts. Trial surveys carried out in May 2008 indicated that throughout much of the survey area there was sufficient light 'pollution' to enable birds using the shoreline and areas of open water close to the shore to be identified using conventional binoculars and telescopes. High powered torches were used as required to aid identification and where ambient light levels were not sufficient.

5.6 Inland Estuarine Bird Counts

5.6.1 Surveys of areas adjacent to estuary shores were carried out to determine whether some of the qualifying bird species of the Firth of Forth SPA made use of these areas for feeding and/or roosting. The survey area comprised agricultural fields and other areas of open habitat (excluding wooded and urban/industrial areas) within 1km of the north and south shore of the estuary. The eastern and western limits of the study area were the same as those of the wider survey area for estuarine birds (i.e. on the north shore from Limekilns to Donibristle Bay, and on the south shore from Abercorn Point to Hound Point). Bi-monthly counts of these inland areas were carried out between November 2008 and April 2009. Counts were carried out at high tide, as this is the time when estuarine birds were considered most likely to make use of inland areas, and covered a range of spring and neap tidal conditions throughout the survey period.

5.7 Disturbance

5.7.1 Disturbance to birds was recorded during the TTTC surveys. Surveyors recorded the scale of disturbance to birds in response to disturbance stimuli according to the behavioural responses described in Table 16.

Table 16: Behaviour used to assess the scale of disturbance to birds

Disturbance Magnitude	Description
Low Disturbance	Alert behaviours observed such as head raised, head turning
Moderate Disturbance	Birds exhibited avoidance response (flight or walk) but remain within the vicinity of the survey sector boundary
High Disturbance	Birds fly out with the survey sector boundary

5.8 3D Hydrodynamic Model of the Forth Estuary

5.8.1 A hydrodynamic model of the Forth has been built using the MIKE 3 3D software package. The model was calibrated and validated for baseline conditions in the estuary (Jacobs Arup 2009a). The model was used to predict flow direction, velocities, water levels and suspended sediments and to identify potential changes in these parameters during construction and operation of the proposed scheme. As a 3D model, predictions of velocities, phasing and directions have been made at different water depths which provides a more realistic representation of conditions than a 2D model. It also provided a better description of flow regimes in tidal waters consisting of strong inflow of low salinity fluvial water and the more saline brackish water from the sea.

5.9 Noise Monitoring

5.9.1 Surveys of ambient noise at North Queensferry and Port Edgar were carried out on Thursday 19 March 2009. The aim was to assess levels of ambient noise in the vicinity of Long Craig Island and Port Edgar. The location of monitoring stations is shown in Table 17: Measurements at each location were taken for 10 minutes during daylight hours.

Table 17: Location of noise monitoring stations

Grid reference (approx)	Location	Position no.
NT 124 814	Cult Ness	20
NT 126 806	North shore under landfall of Forth Road Bridge	21
NT 128 803	North Queensferry railway pier	22
NT 119 793	West breakwater, Port Edgar	23

5.10 Data Management and Analysis of Results

Estuarine Bird Through the Tide Counts

5.10.1 Field data were compiled in Microsoft Access 2000. This database provided a platform to calculate queries and digitised data for analysis in ESRI® ArcCatalog™ 9.2 and figures created in ESRI® ArcMap™ 9.2 Geographical Information System (GIS).

5.10.2 Data input was undertaken by a team of experienced and trained ecologists.

5.10.3 Data collected by Jacobs Arup was digitised and mapped to a grid aligned with that used by MBEC (2008). This grid employed cells of 200x200m for areas greater than 500m from the shore, and 100x100m for areas on land and within 500m of the shore. The difference in grid square sizes with distance from the shore allows for a lower accuracy in terms of the mapping of birds at greater distances from a shore-based observer (i.e. on and close to the estuary shore it is likely that an observer can pinpoint birds to the nearest 100m, but further away, and especially in open water areas, observers are likely to identify bird locations with

lower accuracy). Polygons of bird flocks which overlapped more than one square were proportionately assigned to appropriate grid squares during the data input stage.

5.10.4 Due to fundamental differences between processes for digitisation of bird data between MBEC and Jacobs Arup, spatial distribution maps of peak count data for selected species (or species groups) are only shown for data collected by Jacobs Arup. Monthly peaks and mean peak values are calculated using both MBEC and Jacobs Arup data.

5.10.5 Data collected between May 2008 and April 2009 were used to calculate peak monthly counts for the wider study area. For each species this represents the highest total recorded from all coordinated high and low tide counts within the wider study area during a given month. Peak counts provide an estimate of the maximum number of birds of a given species using the study area in a given month and are a standard measure used to assess the national and international importance of waterbird populations (Austin et al., 2008).

5.10.6 Bird data was presented for each species (or species groups) in the following ways for data collected between May 2008 and April 2009:

- Peak Count - the maximum number of birds observed in specified area during the whole survey period
- Monthly Peak Count – the maximum number of birds within a calendar month observed during a single survey of the whole area
- Winter Mean Peak Count - the mean of all the monthly peak counts between November and March

5.10.7 Peak monthly counts are considered to represent the best estimate of the population of birds of individual species using the wider study area and were compared against that cited in the SPA. They represent the 'worst case scenario' in terms of the maximum number of birds likely to be affected. In addition, it is important to note that due to the nature of these surveys bird numbers are generally underestimated due to the inherent variably in bird count numbers (see Table 23 and Table 25). For a comparison against the most recent population estimates we referred to five year winter peak mean WeBS data collected between 2002/03 and 2006/07 for the Firth of Forth SPA. The WeBS data for winter peak means are collected between November and March.

5.10.8 It was not possible to calculate similar peak counts for the period September 2007 to March 2008, because surveys of the wider study area were not carried out in a synchronised manner. During this time, weekly counts of the survey area for a given tide state were not carried out on a single day but over a number of days during which time birds may have moved between sectors resulting in double-counting. For this period a mean count for each species and each survey sector within the wider study area was derived, based on all high and low tide counts of that sector carried out within a given month. Mean counts for each sector were then added together to give an estimated population for each species for the entire study area in a given month. Mean counts for each sector were used rather than maximum counts because the latter might over-estimate the numbers of birds present if birds move between sectors counted on different days. For the data collected between September 2007 and March 2008, comparing population estimates for the wider study area from mean and maximum counts per sector with actual count data for selected species, suggested that mean counts per sector provided a more robust estimate of the population of each species within the wider study than maximum counts per sector. For data collected between September 2007 and April 2008, the Cumulated Mean Monthly Count therefore represents the mean number birds seen in each survey sector totalled for a single month for the whole survey area and is considered to provide the best estimate of the population of each species within this area.

5.10.9 Birds recorded in direct flight were excluded from these totals. Direct flying birds might be commuting between areas within or out with the survey boundary or passing through on migration. TTTC surveys aims to take 'snapshot' observations of birds which best represent

the population which actively utilises the site for: foraging, breeding, roosting or loafing. By definition direct flying birds are transitory in nature and their use of the site is unclear. In addition, there was a potential to double count birds already recorded else where during the survey. Migratory (and direct flying) bird populations were observed during the Flight Activity surveys and any adverse effects on these flights were assessed against the relevant conservation objectives.

5.10.10 Due to differences in survey strategies, data entry and digitisation a direct amalgamation and comparison of MBEC and Jacobs Arup data was not possible. A modified dataset supplied by MBEC (15 March 2009) provided a sum of each bird species in each survey sector for each visit. From this data monthly counts for the survey area were calculated by adding together the mean number of birds (of each species) seen in each survey sector each month. Please refer to MBEC (2007, 2008) for a full description of their methods.

Important Areas for Estuarine Birds

5.10.11 Important areas for estuarine birds within the survey area were identified from digitised count data for on the basis of at least two abuting grid squares with peak counts of >50 of qualifying bird species (See Section 6.2; Figure 10 and Figures C1-C24; Appendic C) for locations). .The assessment was only applied to data between May 2008 and April 2009 as this information was collected systematicly and most accuralty refected the distribution of qualifing features within the Forth Esturay. It is important to note that key locations represent only that a qualifing feature was observed at a site at least once and does not provide information on the frequency the site was utilised.

Zonal Distribution of Waders and Wildfowl in Relation to the Main Crossing

5.10.12 Data collected between May 2008 and April 2009 was used to calculate the number of birds within three zones (0-250m, 0-500m and 0-1000m; Table 9) of the Main Crossing alignment to provide information on the magnitude of any adverse effect that might be caused by various disturbance stimuli. The peak count for species within each zone is based on the accumulation of values within each grid square from the Main Crossing alignment to the specified distance either side of the Main Crossing. Distances were measured from the centre of the route alignment to the centroid of each grid square (Figure 8).

Winter Passage Migration Surveys

5.10.13 Flight line data for Autumn 2008 and spring 2009 were, digitised onto a base map of the survey area using ArcMap™ 9.2 Geographical Information System (GIS) provided by Environmental Systems Research Institute (ESRI®). Each flightline was digitised along with information relating to time and date of survey, bird species, crossing points and other characteristics unique to each flight path. B y manipulating this data using SQL queries distributions and patterns could be identified based on a number of variables taken from the attribute data.

5.10.14 A modified data set of MBEC flight activity data was used to assess the flight behaviour of Firth of Forth SPA qualifying birds in relation to the existing Forth crossing bridges. To facilitate the analysis data collected by Jacobs Arup for bird flight lines between 0-2m and 2-10m were combined to match that used by MBEC (0-10m).

5.10.15 For the purposes of interpretation, analysis of the survey data was combined with information from other studies on the relationship between birds and bridges. This was used to inform the potential impacts of the FRC and direct the design of possible mitigation measures and strategies.

Nocturnal Bird Surveys

5.10.16 During nocturnal bird surveys, care was taken not to disturb birds. This, combined with restricted visibility, due to limited light capture by the optical equipment, meant that accurate

counts could not be undertaken over long distances. Therefore only species lists are provided for nocturnal surveys.

Inland Estuarine Bird Surveys

5.10.17 Field data was digitised data for analysis in ESRI® ArcCatalog™ 9.2 as point data and figures created in ESRI® ArcMap™ 9.2 GIS.

5.11 Quality Control and Assurance

5.11.1 Details of quality assurance for 2007/8 field surveys for estuarine tidal counts and migration period flight activity surveys are provided in MBEC (2007, 2008).

5.11.2 Quality assurance measures employed by Jacobs Arup for their surveys and data entries carried out from May 2008 onwards include;

- All fieldworkers involved in surveys of estuarine birds for the proposed scheme were experienced in ornithological survey techniques and bird identification and were provided with training and mentoring in the specific methods employed on this project as appropriate.

- Data input was undertaken by a team of experienced ecologists who were provided with training in the specific requirements for the project.

- All data entered were subject to a 100% cross-check by another member of the data input team. A further 10% sample of data was then cross-checked by a suitably experienced ecologist not directly involved in the project. Further quality control checks were carried out throughout out the analysis, for example checks were made with field maps and data sheets if particular data values appeared anomalous.

5.11.3 SNH were consulted over changes in survey count sectors and modifications to survey methods (Jacobs Arup, 2008; letter from Shirley Henderson, dated 4 July 2008).

6 Survey Results

6.1 Estuarine Through-the-Tide Counts

Waterfowl, Wildfowl and Wader Population Trends – September 2007 to April 2009

6.1.1 Analysis of waterfowl, wildfowl and waders show seasonal trends in bird abundance within the survey boundary (Figure 9) from September 2007 through to April 2009. Due to differences in data collection and digitisation methods, absolute values can not be directly compared between the surveys carried out by MBEC (September 2007 to April 2008) and Jacobs Arup (May 2008 to April 2009), but the underlying trends can be compared.

6.1.2 Total waterfowl assemblages exhibited a bimodal peak during each winter survey period (2007/08 and 2008/09). The initial peak represents the autumn and the second the spring passage periods when migratory flocks of many bird species use the Forth Estuary as a staging site during their migration (Evans, 1968; Elkins and Williams, 1972; Pienkowski and Clark, 1979; Summers et. al., 1975; Figure 9). The slight dip between the autumn and spring migration represents the overwintering bird population.. The number of birds present during peak periods provides an indication of the relative importance of the survey area for each qualifying feature.

6.1.3 Wading birds represented the largest component of the total waterfowl assemblage within the survey area (Figure 9). Wader distribution mirrored that of the waterfowl and was the main cause of the bimodal peaks during the estuarine bird surveys over the winter months (Figure 9). Between September 2007 and mid-March 2008 and consistently between October 2008 and March 2008 the abundance of waders was greater than 1% of the wader component of the waterfowl qualifying assemblage as stated in the Firth of Forth SPA citation (refer to Appendix A, 50,000 waders). Again this indicates the relative importance of the survey area for waders. The lowest number of waders was recorded during the summer months (minimum number was 61 in May 2008) but, it is noted that all SPA qualifying species are protected all year round.

6.1.4 There was less variation in wildfowl numbers throughout out the survey period although slight increases were observed during the winter months. The numbers present exceeded 1% of the wildfowl component of the waterfowl assemblage for which the whole SPA was classified (refer to Appendix A, 45,000 wildfowl) only once in November 2007 (n = 468, Figure 9). Therefore the study area for the FRC surveys supports only a small proportion of the total populations of wildfowl within the SPA.

6.1.5 Sandwich terns were present between May and November, with peak numbers between July and September, during their autumn passage migration through the Firth of Forth (Figure 9).

6.1.6 The survey area is of importance to wading birds and whilst the wildfowl component of the whole waterfowl assemblage was relatively small, qualifying bird species are protected all year round and specific sites within the survey area might be of importance to individual species.

Firth of Forth SPA Qualifying Bird Assemblages – September 2007 to May 2008

6.1.7 Cumulated mean monthly counts of qualifying bird species between September 2007 and May 2008 showed wide variation between species and months (Table 18) within MBECs survey boundary (Figure 7). During this period every SPA qualifying species was observed at least once (Table 18). Only two of the 11 qualifying species of waders were never recorded in numbers greater than 1% of their cited SPA population within the survey area for any given month; these were golden plover and grey plover. However, during this period of study, six of the 17 qualifying wildfowl species were not recorded in any month in numbers >1% of their cited population. These species were; pink-footed goose, shelduck, scaup, long-tailed duck, common scoter and velvet scoter.

6.1.8 The greatest diversity of SPA qualifying species (n = 24) in the whole survey area was recorded in January 2008 and the largest total of individual birds (of all species combined) in February 2008 (n = 2378). Wader populations peaked in February (Table 18 and Figure 9). Wildfowl records peaked in November 2008 January/February 2008 (Table 18 and Figure 9).

Table 18: Cumulated mean monthly counts for qualifying bird species of the Firth of Forth SPA within the wider survey area between September 2007 and April 2008.

Species	Cumulated Mean Monthly Counts (Individual Birds)								Cumulated Mean Monthly Count[4]	Percentage of SPA qualifying population	Winter Peak mean[1]	Percentage of current population[2]
	Sep' 07	Oct' 07	Nov '07	Dec '07	Jan ' 08	Feb '08	Mar' 08	Apr' 08				
Bar-tailed Godwit	1	113	130	66	256	269	102	0	**269**	**13.6**	**164.6**	**12.4**
Turnstone	8	57	62	53	55	56	58	49	**62**	**7.2**	**56.8**	**7.3**
Knot	125	90	238	2	291	564	150	0	**564**	**6.1**	**249**	**4.5**
Redshank	144	245	268	200	261	203	190	89	**268**	**6.2**	**224.4**	**4.9**
Golden Plover	22	2	0	0	1	1	0	0	**22**	**0.7**	**0.4**	**<0.1**
Oystercatcher	149	254	259	270	270	311	224	138	**311**	**4.0**	**266.8**	**3.9**
Ringed Plover	7	49	57	44	36	27	14	15	**57**	**17.4**	**35.6**	**13.0**
Grey Plover	1	0	0	0	0	0	0	0	**1**	**0.1**	**<0.1**	**<0.1**
Dunlin	0	85	177	372	362	366	91	28	**372**	**3.9**	**273.6**	**3.4**
Curlew	125	158	137	154	135	187	126	76	**187**	**9.7**	**147.8**	**5.1**
Lapwing	81	243	40	42	123	14	0	1	**243**	**5.9**	**43.8**	**1.5**
Red-throated Diver	1	23	19	15	12	2	2	5	**23**	**25.6**	**10**	**13.9**
Slavonian Grebe	0	0	0	1	4	1	1	1	**4**	**4.8**	**1.4**	**2.1**
Great Crested Grebe	10	30	60	24	22	12	17	25	**60**	**8.3**	**27**	**15.4**
Pink-footed Goose	1	1	0	1	1	1	0	0	**1**	**0.0**	**0.6**	**<0.1**
Shelduck	0	9	16	14	18	37	27	28	**37**	**0.1**	**22.4**	**2.0**
Cormorant	35	23	51	21	18	19	28	8	**51**	**7.5**	**27.4**	**6.3**
Scaup	0	0	0	0	0	0	0	3	**3**	**0.7**	**<0.1**	**<0.1**
Eider	96	54	90	89	171	114	178	229	**229**	**2.4**	**128.4**	**2.5**
Long-tailed Duck	0	1	1	0	1	0	0	0	**1**	**0.1**	**0.4**	**0.1**
Common Scoter	0	4	6	6	5	5	0	3	**6**	**0.2**	**4.4**	**0.2**
Velvet Scoter	0	0	0	0	1	0	0	0	**1**	**0.2**	**0.2**	**0.0**
Goldeneye	0	22	14	20	31	30	20	13	**31**	**1.0**	**23**	**2.2**
Red-breasted Merganser	5	33	38	39	32	26	34	5	**39**	**5.8**	**33.8**	**7.6**
Wigeon	2	75	107	105	89	101	76	13	**107**	**5.0**	**95.6**	**4.4**
Mallard	39	51	66	54	43	32	14	3	**66**	**2.6**	**41.8**	**3.3**
Sandwich Tern[1]	126	22	0	0	0	0	0	1	**126**	**7.8**	**0**	**<0.1**

1 = Winter peak means calculated from values recorded between November and March

2 = Current population estimates refer to five year winter peak mean WeBS data collected between 2002/03 and 2006/07 for the Firth of Forth SPA.

3 = Autumn Peak Means were used for Sandwich tern current WeBS populations

4 = Cumulated peak means are based on surveys at high and low tide only

Population Estimates for Firth of Forth SPA Qualifying Bird Assemblages – May 2008 to April 2009

6.1.9 Monthly peak counts for Firth of Forth SPA qualifying bird species between May 2008 and April 2009 found 25 species were recorded on at least one occasion within the survey boundary (Table 19). Two qualifying species that were not seen are: grey plover and Slavonian grebe. Three wader species were present within the survey area in numbers equivalent to over 10% of their cited SPA population: bar-tailed godwit, curlew and ringed plover (Table 19). Cormorant and red-breasted merganser were observed in numbers exceeding 5% of their SPA cited population with several other species observed in peak numbers exceeding 2% (Table 19). A comparison between peak monthly counts and their most recent five year winter peaks means (based on WeBS count data for the Firth of Forth SPA) is shown in Table 19.

Table 19: Monthly peak counts for Firth of Forth SPA qualifying bird species within the wider survey area between May 2008 and April 2009.

Species	Monthly Peak Counts (Individual Birds)												Peak Monthly Count[4]	Percentage of SPA qualifying population	Winter Peak mean[1]	Percentage of current population[2]
	May' 08	Jun '08	Jul '08	Aug '08	Sept '08	Oct '08	Nov '08	Dec '08	Jan '09	Feb '09	Mar '09	Apr '09				
Bar-tailed Godwit	0	0	5	30	22	19	196	211	228	60	25	23	228	11.6	144.0	10.9
Turnstone	0	0	16	15	67	57	49	34	41	35	38	35	67	7.8	36.6	4.7
Knot	0	0	0	18	0	0	26	185	3	11	1	0	185	2.0	45.2	0.8
Redshank	2	10	130	220	182	300	234	238	261	158	194	150	300	6.9	217.0	4.7
Golden Plover	0	0	0	0	0	38	42	1	0	25	0	0	42	1.4	13.6	0.5
Oystercatcher	63	147	152	331	274	307	380	476	334	731	327	216	731	9.3	449.6	6.6
Ringed Plover	3	4	28	41	9	19	36	51	51	45	15	6	51	15.5	39.6	14.5
Grey Plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Dunlin	0	0	0	3	0	8	251	141	100	179	144	8	251	2.6	163.0	2.0
Curlew	20	60	138	177	131	190	264	189	260	319	269	122	319	16.5	260.2	9.0
Lapwing	0	52	50	78	146	82	190	0	40	38	0	0	190	4.6	53.6	1.9
Red-throated Diver	0	0	0	0	2	7	4	2	0	1	0	1	7	7.8	1.4	1.9
Slavonian Grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Great Crested Grebe	11	1	9	19	32	16	15	44	26	15	13	7	44	6.1	22.6	12.9
Pink-footed Goose	0	0	0	0	0	0	1	0	1	0	0	0	1	0.0	0.4	0.0
Shelduck	26	30	52	4	12	12	13	9	18	27	32	28	52	0.1	19.8	1.7
Cormorant	14	16	36	73	61	67	43	37	47	47	43	12	73	10.7	43.4	10.0
Scaup	0	0	0	0	3	0	2	2	0	0	0	0	3	0.7	0.8	1.5
Eider	335	229	252	140	238	88	142	223	253	202	323	413	413	4.4	228.6	4.4
Long-tailed Duck[2]	0	0	0	0	0	0	0	0	1	0	0	1	1	0.1	0.2	0.1
Common Scoter	0	0	0	0	0	0	1	0	1	1	0	0	1	0.0	0.6	0.0
Velvet Scoter	0	0	0	0	0	0	1	2	2	1	0	0	2	0.3	1.2	0.1
Goldeneye	0	0	0	0	0	15	14	19	39	42	14	1	42	1.4	25.6	2.4

Species	Monthly Peak Counts (Individual Birds)												Peak Monthly Count[4]	Percentage of SPA qualifying population	Winter Peak mean[1]	Percentage of current population[2]
	May' 08	Jun '08	Jul '08	Aug '08	Sept '08	Oct '08	Nov '08	Dec '08	Jan '09	Feb '09	Mar '09	Apr '09				
Red-breasted Merganser	3	1	2	1	21	15	70	61	41	53	80	45	80	11.9	61.0	13.7
Wigeon	0	0	0	0	36	72	130	127	135	115	146	10	146	6.8	130.6	6.0
Mallard	3	7	2	15	30	40	70	59	53	98	20	11	98	3.8	60.0	4.7
Sandwich Tern[3]	5	35	157	110	111	17	0	0	27	0	0	7	157	9.7	5.4	0.2

1 = Winter peak means calculated from values recorded between November and March

2 = Current population estimates refer to five year winter peak mean WeBS data collected between 2002/03 and 2006/07 for the Firth of Forth SPA.

3 = Autumn Peak Means were used for Sandwich tern current WeBS populations

4 = Monthly peak counts are based on surveys at high and low tide only

Comparison of Through-the-Tide Surveys of Firth of Forth SPA Qualifying Species found within the Survey Area carried out from September 2007 to April 2008 and May 2008 and April 2009

6.1.10 All 27 qualifying species of the Firth of Forth SPA were observed on at least one occasion between September 2007 and May 2009. Comparing peak numbers of different species observed with the populations within the Firth of Forth SPA, indicated that five qualifying features were consistently present in numbers exceeding 5% of their cited SPA population in both surveys (ringed plover, bar-tailed godwit, curlew, cormorant and red-breasted merganser; compare Table 18 and Table 19). It is important to remember that, based on a comparison between the most recent five year winter peak mean counts for the Firth of Forth SPA (WeBS data 2002/03 to 2006/07) and the population estimates on the SPA citation (mixed dates between 1992 and 1998), that many species have exhibited a general decrease (Table 4).

6.1.11 There were differences between the data from the two survey periods including the number of species observed (Table 20) and the peak numbers of each species; monthly peak counts for the period September 2007 to April 2008 tended to be higher than those for May 2008 to April 2009 (compare Table 18 – cumulated mean monthly counts – and Table 19 – peak monthly counts). There are many reasons why this may have occurred: most likely is the inherent natural variation in bird numbers, which is often, reported e.g. compare population estimates for the Firth of Forth at classification and from the most recently available WeBS data in Table 4). Another explanation could relate to over estimation of bird populations during the earlier period due to a lack of synchrony of tidal counts throughout the study area and possible double counting of birds moving between count sectors between different surveys (refer to Section 5.10). Acknowledging these differences between survey methods, a more detailed investigation of the distribution of bird populations within the survey area was undertaken using data collected between May 2008 and April 2009 only.

Table 20: Firth of Forth SPA qualifying species that were observed on at least one occasion between September 2007 and April 2009.

Bird Species	Wildfowl Observed		Bird Species	Wildfowl Observed	
	Sept 2007 to April 2008	May 2008 to April 2009		Sept 2007 to April 2008	May 2008 to April 2009
Red-throated Diver	✓	✓	Mallard	✓	✓
Slavonian Grebe	✓	None	Sandwich Tern	✓	✓

Bird Species	Wildfowl Observed		Bird Species	Wildfowl Observed	
	Sept 2007 to April 2008	May 2008 to April 2009		Sept 2007 to April 2008	May 2008 to April 2009
Great Crested Grebe	✓	✓	Bar-tailed Godwit	✓	✓
Pink-footed Goose	✓	✓	Golden Plover	✓	✓
Shelduck	✓	✓	Knot	✓	✓
Cormorant	✓	✓	Redshank	✓	✓
Scaup	✓	✓	Turnstone	✓	✓
Eider	✓	✓	Oystercatcher	✓	✓
Long-tailed Duck	✓	✓	Ringed Plover	✓	✓
Common Scoter	✓	✓	Grey Plover	✓	None
Velvet Scoter	✓	✓	Dunlin	✓	✓
Goldeneye	✓	✓	Curlew	✓	✓
Red-breasted Merganser	✓	✓	Lapwing	✓	✓
Wigeon	✓	✓			

6.2 Important Areas for Estuarine Birds

All Qualifying Features

6.2.1 Key locations for waterfowl, within the boundary of Jacobs Arup survey area, between May 2008 and April 2009 are listed below (refer to Figures 10 and 11). Key locations are areas where at least 50 individuals of qualifying bird species were observed in two abuting grid squares. The relative importance for each species is discussed below:

- Limekilns;
- North Queensferry Harbour;
- Inverkeithing Bay;
- Abercorn Point;
- Hopetoun Bank;
- Port Edgar;
- Hound Point and tanker berths; and
- Dalmeny Estate Shore.

Waders

6.2.2 Waders (refer to Table 21 for list of species) were consistently recorded along the entire shoreline of the survey area with the exception of St. Margaret's Marsh and within Rosyth Dockyards (Figure 12). Seven areas exhibited high densities of usage: Limekilns, North Queensferry Harbour, Inverkeithing Bay, Hound Point, Port Edgar, Hopetoun Bank and Abercorn Point. All these sites with the exception of Hopetoun Bank are part of the Firth of Forth SPA with peak counts of over 100 birds during the period of study for all behaviours combined except direct flying birds. These seven locations are at times used by large numbers (peak counts >50 individuals) of roosting waders (Figure 13) and foraging (Figure 14) and to a lesser extent loafing birds (Figure 15). Each key location was utilised by a different suite of species for each behavioural activity (Table 21) e.g. Port Edgar is an important site for both foraging and roosting redshank and Hound Point is used by oystercatcher and bar-tailed godwits for roosting.

Table 21: Species and their behaviour at key locations within the whole survey area

Key Location	Species found at key locations and their corresponding behaviour		
	Foraging	**Loafing**	**Roosting**
Limekilns	Turnstone Ringed plover	Lapwing Golden plover Curlew Dunlin	Lapwing Golden plover Curlew (Rosyth) Turnstone Ringed plover Oystercatcher (Rosyth) Redshank Dunlin
Long Craig Island	Oystercatcher	Oystercatcher	Oystercatcher
North Queensferry Harbour	Redshank	Redshank	Redshank
Inverkeithing Bay	Redshank Oystercatcher Lapwing Dunlin	Redshank Oystercatcher Lapwing	Lapwing Oystercatcher Redshank Dunlin
Hound Point	Bar-tailed godwit	Oystercatcher Bar-tailed godwit	Knot Bar-tailed godwit Oystercatcher
Port Edgar	Redshank Dunlin	Redshank Knot Dunlin	Redshank Dunlin
Hopetoun Bank	Redshank Curlew Dunlin	Redshank Curlew	Curlew Redshank
Abercorn Point	Oystercatcher Curlew	Curlew	Curlew Oystercatcher
Dalgety Bay	Turnstone		Turnstone
South Queensferry Harbour			Oystercatcher

Wildfowl

6.2.3 Wildfowl (refer to Table 22 for list of species) were more ubiquitously spread throughout the whole survey area (both littoral areas and open water) with only three main aggregations (peak count >50 individuals) at Limekilns, Inch Garvie Island and off Hound Point and several subsidiary sites (compare distribution on Figure 17 to Figure 19). With the exception of a few eider and cormorants (Peak Count <25 individuals) very few wildfowl were seen near the main crossing of the proposed scheme (Figure 16).

Table 22: Species and their behaviour at key locations within the whole survey area

Key Location	Species found at key locations and their corresponding behaviour		
	Foraging	**Loafing**	**Roosting**
Limekilns	Wigeon	Wigeon	Mallard Wigeon
Inch Garvie Island		Eider Cormorant	Cormorant
Hound Point	Eider	Eider	
Abercorn Point	Wigeon	Wigeon	

6.2.4 Roosting wildfowl aggregations were located predominantly at Hound Pont and by the Tanker Berths, Inch Garvie Island, Whitehouse Point and Limekilns during the survey period (Figure 17). Minimal wildfowl foraging activity was observed throughout survey area with small aggregations at Hound Point, Limekilns and Abercorn Point (Figure 18). Loafing wildfowl exhibited a similar distribution pattern to roosting wildfowl (compare Figure 17 and 19) at Limekilns, Hound Point and Inch Garvie Island with occasional additional loafing flocks along the coast from Hopetoun Bank to Abercorn Point.

6.2.5 Species which contributed the most individuals to specific behaviours at key locations are summarised in Table 22 above.

Sandwich Terns

6.2.6 Sandwich terns frequently foraged throughout the whole survey area and roosted around Port Edgar marina (especially the floating breakwater at the entrance of the harbour) and Long Craig Island (Figure 20).

Summary

6.2.7 Overall, wildfowl numbers were low near the Main Crossing alignment with Sandwich terns the only species to utilise areas likely to be disturbed at Port Edgar and Long Craig Island. Sandwich terns are also a qualifying species of the Forth Islands SPA and were the focus of specific detailed studies as part of the report to inform an Appropriate Assessment for this site (Jacobs Arup, 2009).

6.3 Zonal Distribution of Waders and Wildfowl in Relation to the Proposed Scheme

Overview

6.3.1 Please refer to Section 4.3 (Table 9 and associated text) for a rationale of the following analysis of waterfowl distribution within critical distances of the Main Crossing alignment at which disturbance may occur. If a qualifying species of the SPA was observed within 250m of the Main Crossing alignment then 'minimal' levels of disturbance may have a significant adverse effect on the bird populations. This was further extended to 500m and 1000m where only 'moderate' and 'exceptional' disturbances were assessed to have the potential to affect bird populations. This information was used to underpin the assessment of the likely impacts of disturbance.

Waders

6.3.2 With the exception of golden, ringed and grey plover all the qualifying species were observed within 1000m of the Main Crossing and could potentially be disturbed during construction (Table 23). Large numbers of foraging, roosting and loafing waders were present around the proposed southern landfall of the Main Crossing, at Port Edgar floating breakwater, tern rafts and mudflats, and dispersed along the rocky shore line at Hopetoun Bank (Figure 12). Within 500m and 1000m either side of the Main Crossing respectively six and nine species of waders are likely to be disturbed by 'moderate' or 'exceptional' disturbance events respectively (Table 23). A full summary of individual species is shown below and distribution maps for all species are shown in Appendix C.

<u>Bar-tailed Godwit</u>

6.3.3 Bar-tailed godwits were seen within 250m of the Main Crossing in September and December 2008 and February 2009, with a maximum of three individuals in December 2008 around the west breakwater at Port Edgar. Within 1000m of the Main Crossing birds were seen in every month except May and June 2008 with a maximum of 23 individuals in April 2009. This probably shows the use of this area by staging birds during their spring migration (Table 23). The key location of bar-tailed godwits within the wider survey area was at Hound Point with occasional flocks seen at Abercorn Point (Appendix C; Figure C1).

<u>Turnstone</u>

6.3.4 Between September 2008 and January 2009 turnstones were consistently seen within 250m of the Main Crossing (maximum = 9) (Table 23). Roosting and foraging turnstones were

observed on the rocks directly under the proposed Main Crossing footprint at the high water mark at Hopetoun Bank, the floating breakwater and wooden tern rafts at Port Edgar Marina, Hopetoun Bank and North Queensferry Harbour (Table 23). Within 1000m either side of the Main Crossing a maximum of 20 individuals was observed in September 2008. However, key locations for this species within the wider survey area were at Limekilns and Dalgety Bay; both of which are a considerable distance from the Main Crossing (Appendix C; Figure C22).

Knot

6.3.5 A single large flock of knot was observed on the floating breakwater at Port Edgar in December 2008 (160 birds) (Table 23). However, knot were only seen on two additional occasions; a solitary bird within 250m of the Main Crossing in November 2008 and a flock of 18 in August 2008 again on the floating breakwater (Table 23). During 2008/09 a winter peak mean of 32 birds was recorded within 1000m of the Main Crossing, representing 0.6% of the five year winter peak mean for the Firth of Forth SPA based on the most recently available WeBS data (Table 23). Knot were also seen infrequently seen within the wider survey boundary with occasional flocks recorded on the southern shoreline (Appendix C; Figure C10).

Redshank

6.3.6 Redshank were seen in considerable numbers within 250m of the main crossing (Table 23). Large numbers of roosting redshank use the littoral zone at Hopetoun Bank directly under the proposed Main Crossing footprint with additional roost sites present on the floating breakwater and tern rafts within Port Edgar. Mudflats within Port Edgar Marina and are also frequently used by large numbers of foraging redshank in addition to areas along the shore adjacent to Hopetoun Bank. The peak month for redshank numbers within 250m of the main crossing was February 2009 (n=88). The winter peak mean for redshank within 250m of the Main Crossing was 40 birds or 2% of the five year winter peak mean for the Firth of Forth SPA, based on the latest WeBS data; this percentage increased to 3% for the numbers recorded within 1000m of the scheme (Table 23). Large numbers of redshank were also seen at North Queensferry and Inverkeithing within the survey boundary (refer to Appendix C; Figure C17).

Golden Plover

6.3.7 Golden plover were not observed within 1000m of the Main Crossing between May 2008 and April 2009. Golden plover were only observed at Limekilns within the boundary of the wider survey area (Appendix C; Figure C9)

Grey Plover

6.3.8 Grey plover were not observed within the survey boundary between May 2008 and April 2009.

Oystercatcher

6.3.9 The number of oystercatchers within 250m of the Main Crossing peaked between November and December 2008 (Table 23). Small groups of oystercatcher used the shoreline adjacent to Hopetoun Bank to forage, under the footprint of the southern approach viaduct. Oystercatchers were also observed foraging and roosting on Long Craig Island. Within 1000m of the Main Crossing a peak of 123 birds or 1.6% of the population cited at SPA classification was recorded in January 2009 (Table 23). The winter peak mean of 75 birds represents 1.8% of the most recent population estimate for the SPA (Table 23). Elsewhere within the wider survey area oystercatchers were observed at Limekilns, Inverkeithing Bay, Hound Point, Abercorn Point and South Queensferry Harbour (Table 21 and Appendix C; Figure C14).

Ringed Plover

6.3.10 No ringed plover were observed within 1000m of the Main Crossing. Their key location within the survey boundary was at Limekilns (Appendix C; Figure C19).

Dunlin

6.3.11 In November 2008 a peak count of 175 dunlin, representing 1.8% of the population cited at SPA classification, was observed within 250m of the Main Crossing route alignment (Table 23). Within 1000m of the Main Crossing the winter peak mean was 116 birds which is approximately 3% of the five year winter peak mean count for this species within the SPA, based on the most recently available WeBS data (Table 23). Aggregations of roosting dunlin were recorded on the floating breakwater and tern rafts within Port Edgar marina (>1000m from the main crossing) and at Limekilns and Inverkeithing in the wider survey area (Appendix C; Figure C5).

Curlew

6.3.12 Curlew were regularly observed within 250m of the Main Crossing between July 2008 and March 2009 with a maximum of 110 individuals in January 2009, equivalent to 5.7% of the cited population at SPA classification (Table 23). Aggregations of foraging and roosting curlew were observed on the rocks on the south shore adjacent to Hopetoun Bank. Elsewhere within the wider survey area, curlews were seen all along the shoreline (with the exception of St. Margaret's Marsh) with aggregations at Limekilns, Abercorn Point, Hound Point and Hopetoun Bank (Appendix C; Figure C3). The winter peak mean within 1000m of the Main Crossing was 100 birds which is approximately 4% of the most recent five year winter peak mean count within the SPA (Table 23).

Lapwing

6.3.13 Lapwings were never seen within 1000m of the Main Crossing and within the wider survey area were only recorded at two sites: Inverkeithing Bay and Limekilns (Appendix C; Figure C11).

Table 23: Monthly peak counts of qualifying wader species of the Firth of Forth SPA within 0-250m, 0-500m, and 0-1000m of the Main Crossing.

Species	Zone	Monthly Peak Counts (Individual Birds)												Peak Count	% of SPA cited population	Winter Peak Mean[1]	% of current population estimate[2]
		May '08	Jun '08	Jul '08	Aug '08	Sept '08	Oct '08	Nov '08	Dec '08	Jan '09	Feb '09	Mar '09	Apr '09				
Bar-tailed Godwit	0-250	0	0	0	0	1	0	0	3	0	2	0	0	3	0.2	1.0	0.2
	0-500	0	0	1	0	1	0	0	3	1	2	0	0	3	0.2	1.2	0.2
	0-1000	0	0	1	1	1	1	1	3	3	2	14	23	23	1.2	4.6	1.7
Turnstone	0-250	0	0	0	0	2	2	3	2	9	0	0	0	9	1.0	2.8	1.2
	0-500	0	0	4	6	10	3	5	6	9	5	0	2	10	1.2	5.0	1.3
	0-1000	0	0	4	6	20	5	5	6	13	7	5	2	20	2.3	7.2	2.6
Knot	0-250	0	0	0	0	0	0	1	0	0	0	0	0	1	0.0	0.2	0.0
	0-500	0	0	0	18	0	0	1	160	0	0	0	0	160	1.7	32.2	2.9
	0-1000	0	0	0	18	0	0	1	160	0	0	0	0	160	1.7	32.2	2.9
Redshank	0-250	0	0	53	62	82	47	23	43	22	88	22	0	88	2.0	39.6	1.9
	0-500	1	8	76	64	91	151	98	73	64	88	121	50	151	3.5	88.8	3.3
	0-1000	2	8	98	137	122	152	116	105	118	116	124	68	152	3.5	115.8	3.3
Oystercatcher	0-250	0	1	22	21	23	26	39	35	33	21	21	15	39	0.5	29.8	0.6
	0-500	5	6	22	35	65	32	42	39	76	21	33	18	76	1.0	42.2	1.1
	0-1000	9	16	34	39	65	75	69	47	123	90	47	42	123	1.6	75.2	1.8
Dunlin	0-250	0	0	0	0	0	0	175	0	0	35	0	0	175	1.8	42.0	2.1
	0-500	0	0	0	0	0	8	175	88	40	106	103	0	175	1.8	102.4	2.1
	0-1000	0	0	0	0	0	8	236	88	40	108	106	0	236	2.5	115.6	2.9
Curlew	0-250	1	1	22	25	17	26	50	60	110	61	30	7	110	5.7	62.2	3.8
	0-500	2	1	22	31	18	26	50	62	110	65	64	7	110	5.7	70.2	3.8
	0-1000	4	5	27	59	41	77	105	110	112	84	89	24	112	5.8	100.0	3.9

1 = Winter peak means calculated from values recorded between November and March

2 = Current population estimates refer to five year winter peak mean WeBS data collected between 2002/03 and 2006/07 for the Firth of Forth SPA (see Table 4).

Roosting Waders

6.3.14 Redshank, curlew and dunlin utilise the rocky outcrop along the shore adjacent to Hopetoun Bank (Figure 10) as a roost site and this area is directly under the footprint of the southern landfall of the Main Crossing. The number of roosting waders (Table 24) varied between and within months within an area 250m either side of the southern landfall of the Main Crossing within 250-500m of the mean high water spring tide mark.

6.3.15 Redshanks were only observed roosting on ten occasions at high tide between the 4 November 2008 and 18 March 2009, within 250m of the Main Crossing. A maximum of 81 individuals was recorded on the 11 March 2009 (Table 24).

6.3.16 Curlews were seen roosting within 250m of the Main Crossing on 10 occasions between 3 December 2008 and 11 March 2009 (Table 24). A maximum of 84 roosting birds was seen on 30 January 2009.

6.3.17 Dunlins were recorded roosting within 250m of the Main Crossing on three occasions between 4 November 2008 and 11 March 2009 (Table24) . A maximum of 101 roosting birds was seen on 3 December 2008.

Table 24: Numbers of roosting curlew, dunlin and redshank within 250m either side of the Main Crossing at the southern landfall within 500m of the mean high water spring tide between May 2007 and December 2008.

Species	Number of times waders observed roosting	Sum	Mean (Standard Error)	Maximum
Curlew	10	351	35.1 (7.3)	**84**
Dunlin	3	148	49.3 (26.7)	**101**
Redshank	10	275	27.5 (8.5)	**81**

Wildfowl

6.3.18 On three occasions three separate species were seen in significant numbers within 250m of the Main Crossing (red-throated diver, cormorant, wigeon) and within 500m a single additional species was observed (red-breasted merganser) (Table 25). However, overall between May 2008 and April 2009 very few wildfowl were seen within 1000m of the Main Crossing (Table 25).

Red-throated Diver

6.3.19 A single red-throated diver was observed foraging in open water along the alignment of the Main Crossing in October 2008. Another individual was observed during November 2008, within 500m of the Main Crossing (Table 25, Appendix C; Figure C16).

Great-crested Grebe

6.3.20 Great-crested grebes were regularly seen within 250m of the Main Crossing between May and September 2008 and January and April 2009. A maximum of four individuals was reported in May 2008 (Table 25). A winter peak of 1.2 birds was observed within 1000m of the Main Crossing, representing 0.7% of the most recent population estimate for this species within the SPA (Table 25). Within the wider survey boundary the greatest aggregations were observed at Dalgety Bay (Appendix C; Figure C7).

Slavonian Grebe

6.3.21 No Slavonian grebes were seen within the survey boundary between May 2008 and April 2009.

Pink-footed Goose

6.3.22 Pink-footed geese were rarely seen within 1000m of the Main Crossing, with a single observation in November 2008 within 500m, and another solitary bird in January 2009 within 1000m (Table 25, Appendix C; Figure C15).

Shelduck

6.3.23 Between May 2008 and April 2009 shelduck were regularly observed in small numbers (Table 25). Maximum numbers within 1000m of the crossing were observed in April 2009. Peak observations within the wider survey boundary were recorded at Limekilns and Inverkeithing Bay (Appendix C; Figure C21).

Cormorant

6.3.24 In October 2008 a peak of eight cormorants was observed within 250m of the Main Crossing which represented roosting individuals using Beamer Rock. Reflecting their ubiquitous distribution within the survey boundary (with the exception of a concentration on Inch Garvie Island), the numbers of cormorants recorded increased with increasing distance from the Main Crossing (Table 25 and Appendix C; Figure C2). The winter peak mean for cormorants within 1000m of the Main Crossing was 1.2% of the most recent WeBS winter five year mean for the Firth of Forth SPA.

Scaup

6.3.25 Two scaup were recorded to the west of the eastern breakwater at Port Edgar in November 2008 (Table 25 and Appendix C; Figure C23).

Eider

6.3.26 Eiders were seen throughout the survey period and monthly peaks were greatest during the spring and summer months (Table 25). The peak count of 74 birds during April 2009 represents 0.8% of the population quoted on the SPA citation. Although birds occasionally rafted around Beamer Rock the large majority of peak observations were seen downstream of the Forth Rail Bridge at Inch Garvie Island, Hound Point and the Tanker Berth (Appendix C; Figure C6).

Long-tailed Duck

6.3.27 Long-tailed ducks were not seen within 1000m of the Main Crossing between May 2008 and April 2009. Only two single observations were made during the survey period (both at mid-tide) at the Tanker Berth off Hound Point and Dalgety Bay (Table 19, Appendix C; Figure C12).

Common Scoter

6.3.28 Within the wider study area, common scoter observations were limited to the estuary downstream of the Forth Railway Bridge (Table 19, Appendix C; Figure C4) and not within 1000m of the Main Crossing.

Velvet Scoter

6.3.29 Two single observations of a velvet scoter were recorded within 1000m of the Main Crossing alignment (Table 25 and Appendix C; Figure C23) in November 2008 and February 2009 (Table 19).

Goldeneye

6.3.30 Goldeneye were observed throughout the wider survey boundary in relatively low numbers and a maximum of two individuals was recorded within 250m of the Main Crossing (Table 25 and Appendix C; Figure C8).

Red-breasted Merganser

6.3.31 Numbers of red-breasted mergansers increased from the late summer through to the winter, peaking in March 2009 when 39 individuals were observed within 1000m of the Main Crossing, representing 5.8% of the SPA cited population of this species (Table 25). In general lower numbers of birds were recorded close (within 250m) to the Main Crossing with a maximum of 6 birds in October 2008. Within 1000m a winter peak mean of 19.4 birds was recorded which represents 4.3% of the most recent WeBS winter five year mean for this species (Table 25). In general red-breasted mergansers were more frequently observed in large flocks off the northern shoreline (Appendix C; Figure C18).

Wigeon

6.3.32 The number of wigeon peaked between January and March 2009. A peak count of 33 wigeon was observed in March 2009 within 250m of the Main Crossing and a maximum of 46 birds within 1000m in February 2009 (Table 25). Unlike most of the Firth of Forth qualifying species, within the wider study area wigeon tended to congregate upstream of the existing Forth Bridges, between Hopetoun Bank and Abercorn Point on the south shore and at Limekilns on the north shore (Appendix C; Figure C24).

Mallard

6.3.33 Few mallard were observed within 1000m of the Main Crossing with a peak count of 16 in January 2009 (Table 25). The key location for this species within the wider survey area was at Limekilns (Appendix C; Figure C13).

Sandwich Tern

6.3.34 Sandwich tern numbers peaked in July 2008 with a maximum of 18 individuals within 250m of the Main Crossing (Table 25) equivalent to 1.1% of the SPA cited population of this species. Most Sandwich tern records were loafing flocks at Long Craig Island and the floating breakwater at Port Edgar. Large numbers of Sandwich terns are known to roost overnight on Long Craig Island and at Port Edgar Marina and peak counts of roosting Sandwich terns from roost surveys carried out between August and October 2008 (see Jacobs Arup, 2009e for more details of these surveys) are shown in Table 26. The data from the estuarine bird surveys indicated an influx of birds into the Forth estuary in the vicinity of the Main Crossing (Figure 20) between May and November (Figure 9).

Table 25: Monthly peak counts of selected Firth of Forth SPA qualifying wildfowl species and Sandwich tern within 0-250m, 0-500m, and 0-1000m of the Main Crossing.

Species	Zone (meters)	Monthly Peak Counts (Individual Birds)												Peak Count	% of cited SPA population	Winter Peak Mean[1]	% of current population estimate[2]
		May '08	Jun '08	Jul '08	Aug '08	Sept '08	Oct '08	Nov '08	Dec '08	Jan '09	Feb '09	Mar '09	Apr '09				
Red-throated diver	0-250	0	0	0	0	0	1	0	0	0	0	0	0	1	1.1	0.0	0
	0-500	0	0	0	0	0	1	1	0	0	0	0	0	1	1.1	0.2	1.4
	0-1000	0	0	0	0	0	1	1	0	0	0	0	0	1	1.1	0.2	1.4
Great crested grebe	0-250	4	1	2	3	2	0	0	0	2	2	2	1	4	0.6	1.2	0.7
	0-500	4	1	2	3	4	2	0	0	2	2	2	1	4	0.6	1.2	0.7
	0-1000	4	1	5	3	4	3	0	0	2	2	2	4	5	0.7	1.2	0.7
Pink-footed goose	0-250	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	0-500	0	0	0	0	0	0	1	0	0	0	0	0	1	0.0	0.2	0.0
	0-1000	0	0	0	0	0	0	1	0	1	0	0	0	1	0.0	0.4	0.0
Shelduck	0-250	0	2	4	2	2	0	0	2	2	2	2	3	4	<0.1	1.6	0.1
	0-500	2	5	5	4	2	1	2	2	2	2	2	7	7	0.2	2.0	0.2
	0-1000	3	5	6	4	2	1	2	2	3	3	4	8	8	0.2	2.8	0.2
Cormorant	0-250	2	1	6	3	6	8	2	3	4	1	5	1	8	1.2	3.0	0.7
	0-500	3	4	7	4	8	12	10	4	4	2	5	2	12	1.8	5.0	1.1
	0-1000	6	4	11	10	10	16	10	4	5	2	6	2	16	2.3	5.4	1.2
Eider	0-250	52	15	24	25	17	2	3	4	35	18	42	32	52	0.6	20.4	0.4
	0-500	64	32	32	32	17	14	4	4	43	24	51	43	64	0.7	25.2	0.5
	0-1000	67	44	65	35	22	14	8	14	50	31	63	74	74	0.8	33.2	0.6
Goldeneye	0-250	0	0	0	0	0	0	1	0	2	1	0	0	2	0.1	0.8	<0.1
	0-500	0	0	0	0	0	0	1	0	2	3	0	0	3	0.1	1.2	0.1
	0-1000	0	0	0	0	0	0	2	0	3	3	2	0	3	0.1	2.0	0.2
Scaup	0-250	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	0-500	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	0-1000	0	0	0	0	0	0	2	0	0	0	0	0	2	0.5	0.4	0.7
Velvet scoter	0-250	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	0-500	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0

Species	Zone (meters)	Monthly Peak Counts (Individual Birds)												Peak Count	% of cited SPA population	Winter Peak Mean[1]	% of current population estimate[2]
		May '08	Jun '08	Jul '08	Aug '08	Sept '08	Oct '08	Nov '08	Dec '08	Jan '09	Feb '09	Mar '09	Apr '09				
	0-1000	0	0	0	0	0	0	1	0	0	1	0	0	1	0.2	0.4	<0.1
Red-breasted merganser	0-250	0	1	1	1	1	6	4	1	2	4	1	2	6	0.9	2.4	0.5
	0-500	0	1	1	1	3	6	7	7	16	7	3	5	16	2.4	8.0	1.8
	0-1000	0	1	1	1	4	6	8	9	19	22	39	8	39	5.8	19.4	4.3
Wigeon	0-250	0	0	0	0	0	1	0	0	14	6	33	10	33	1.5	10.6	0.5
	0-500	0	0	0	0	0	1	0	0	14	24	33	10	33	1.5	14.2	0.7
	0-1000	0	0	0	0	0	1	2	0	22	46	36	10	46	2.2	21.2	1
Mallard	0-250	0	0	0	0	0	6	4	0	12	10	4	0	12	0.5	6.0	0.5
	0-500	0	0	0	0	0	6	4	0	12	10	6	0	12	0.5	6.4	0.5
	0-1000	0	0	0	0	0	6	4	0	12	16	6	0	16	0.6	7.6	0.6
Sandwich tern	0-250	0	2	18	3	4	2	0	0	0	0	0	0	18	1.1	N/A	N/A
	0-500	0	2	69	57	79	15	0	0	0	0	0	0	79	4.9	N/A	N/A
	0-1000	0	4	143	79	92	15	0	0	0	0	0	0	143	8.8	N/A	N/A

1 = Winter peak means calculated from values recorded between November and March

2 = Current population estimates refer to five year winter peak mean WeBS data collected between 2002/03 and 2006/07 for the Firth of Forth SPA (see Table 4).

Table 26: Peak counts of roosting Sandwich terns at Port Edgar and Long Craig Island. Taken from Jacobs, 2009e

Year	Peak Count			Peak roost count as % of SPA population*		
	Long Craig Island	Port Edgar	Long Craig and Port Edgar combined	Long Craig Island	Port Edgar	Long Craig and Port Edgar
2008	180	249	429	11%	16%	27%
2007	500	256	596	31%	16%	37%

6.4 Estuarine Bird Migration Period Flight Activity Surveys

6.4.1 Focused flight activity surveys, involving observations of birds flying across the Forth Road and Forth Rail Bridges, were carried out to coincide with spring and autumn passage migrations. In Autumn 2007 and Spring 2008 observations were carried out by MBEC and during the 2008 autumn and 2009 return spring migration by Jacobs Arup. In total 1443 flight events (2879 birds) were observed involving qualifying species of the Firth of Forth SPA (Table 27). More flight events were observed crossing the Forth Rail Bridge than the Forth Road Bridge.

Table 27: Summary of flight events that crossed the Forth Road Bridge, Forth Rail Bridge or both bridges.

Survey	Bridge Crossing	Number of flight events	Number of birds
Autumn 2008 and Spring 2009	Forth Rail Bridge	747	1114
	Forth Road Bridge	492	870
	Forth Road and Rail Bridge	106*	611
	Total	**1345**	**2595**
Autumn 2007 and Spring 2008	Forth Rail Bridge	61	153
	Forth Road Bridge	27	56
	Forth Road and Rail Bridge	10*	75
	Total	**98**	**284**
Total	Forth Rail Bridge	808	1267
	Forth Road Bridge	519	926
	Forth Road and Rail Bridge	116*	686
	Total	**1443**	**2879**

* = Each flight event crossed both the Forth Road and Forth Rail Bridge and these flights are not included in the individual bridge totals

6.4.2 Very few birds crossed either bridge at a height greater than the bridge superstructure (a maximum of 170m for the Forth Road Bridge) whereas 96% of all the bridge crossing events were below the existing deck heights, approximately 50 metres above sea-level, and the majority of these were between 0-10m above sea-level with no sign of a behavioural change (refer to Table 28). During the period of study no behavioural change was observed for 89% of all flight events. Only 10.1% of flight events involved some kind of alteration in flight behaviour when crossing a bridge and 0.8% of flight paths were aborted (Table 28). Behavioural changes were observed more frequently within the 51-170m height band when over half were affected (55%). This zone is between the road and rail bridge deck and the top of the existing bridge superstructure (compare the behaviours recorded in row 51-170m with the other height ranges in Table 28).

6.4.3 During the period of study no behavioural change was observed for 89% of all flight events. Only 10.2% of flight events involved some kind of alteration in flight behaviour when crossing a bridge and 0.8% of flight paths were aborted (Table 28.). Behavioural changes were observed more frequently within the 51-170m height band when over half were affected

(55%). This zone is between the road and rail bridge deck and the top of the existing bridge superstructure (compare the behaviours recorded in row 51-170m with the other height ranges in Table 28

Table 28: Flight height and behaviour of qualifying bird species of the Firth of Forth SPA crossing the Forth Road and Rail Bridges.

Height Band \ Behaviour	No Change	Height Change	Direction Change	Height/ Direction Change	Total flights with height and/or direction change	Aborted
>251m	1	0	0	0	**0**	
171-250m	16	1	0	0	**1 (5.9%)**	
51-170m	13	6	1	9	**16 (55.2%)**	
11-50m	348	28	5	5	**38 (9.8%)**	
0-10m	1010	75	21	7	**103 (9.3%)**	
Total	**1388**	**110**	**27**	**21**	**158**	**13**
% of Total	**89.0**	**7.1**	**1.7**	**1.3**	**10.1**	**0.8**

The totals represent the number of flight events observed. Where a single flight line crossed both bridges each crossing was classed as a separate flight event. A flight event may represent a single bird or a flock. Total number of flight events = 1559

6.4.4 The most frequently seen change in bridge crossing behaviour was a change in flight height followed by a change in flight direction. No collisions or flares were observed for qualifying species of the Firth of Forth during the survey period.

6.4.5 In total, for the four migration periods, 13 flight paths were observed to abort crossing either the Forth Road Bridge or Forth Rail Bridge. This consisted of five species: cormorant, curlew, eider, red-throated diver and turnstone. The height band at which each flight aborted was recorded for 11 of the 13 observations.

6.4.6 Four individual cormorants aborted their flight paths. Three flight events were aborted at the Forth Rail Bridge: two at the 0-10m height band and one at 10-50m. One cormorant aborted within the 0-10m height band at the Forth Road Bridge. This represents <0.5% of the total flight paths recorded for this species (Table 29). A single curlew aborted crossing the Forth Road Bridge within the 0-10m height band and a single eider flight event (a total of nine birds) was observed to abort crossing the Forth Rail Bridge also within the 0-10m height band. For both species, aborted flights represented only a small percentage of the total flight events and birds observed (Table 29). During the study, five red-throated diver flight events (19 birds) representing 39% of those observed, aborted crossing the Forth Rail Bridge (Table 29). Observers' recorded four aborted red-throated diver flight events within the 10-50m height band. Only three turnstone flight paths were observed crossing the Forth Rail Bridge; one aborting (17 birds), a single unchanged flight crossing and five birds exhibiting a directional change (Table 29).

6.4.7 A total of 16 of the Firth of Forth SPA qualifying species were recorded during flight activity surveys. Cormorant flight paths were observed most frequently, followed by oystercatchers and eider (Table 29). All three of these species have a characteristic flight behaviour skimming just above the water level often flying in a straight path (compare crossing behaviour and height columns in Table 29) crossing the bridges without any 'gross' changes.

6.4.8 Curlews, a large wader, appear to slightly modify their behaviour when crossing bridges (Table 29). Over a quarter of their flight events or (30.7% of birds) exhibited a change in height, direction or both when crossing either the Forth Road or Rail Bridge - the most out of any species with a reasonable sample site (>10 flight events).

6.4.9 Common scoter, dunlin, great-crested grebe, mallard and redshank were all observed crossing either the Forth Road or Rail Bridge and were not observed to change their flight behaviour (Table 29).

6.4.10 The remaining species in Table 29 were observed in low numbers and it is hard to identify any significant trends. However overall, 10.4% of the total number of flight events that crossed the bridge exhibited some degree of change (height, direction or either) that may increase flight distance and associated energy requirements.

Table 29: Behaviour and flight height of Firth of Forth SPA qualifying birds which crossed either the Forth Road or Forth Rail Bridges

Species	No. flights/ birds	Total	Aborted (% total)	Crossed (% total)	Behavioural Change (% of total crossed)	Forth Road and Rail Bridge Crossing Behaviour				Crossing height (metres)				
						No change	Height change	Direction change	Height & direction change	0-10	11-50	51-170	171-250	>251
Cormorant	Number of flight events	838	4 (<0.5)	834 (99.5)	96 (11.5)	738	70	17	9	629	192	12	1	0
	Number of birds	1007	4 (<0.5)	1003 (99.6)	112 (11.2)	891	76	18	18	760	217	24	2	0
Curlew	Number of flight events	62	1 (1.6)	61 (98.4)	16 (26.2)	45	7	2	7	41	12	8	0	0
	Number of birds	76	1 (1.3)	75 (98.7)	23 (30.7)	52	10	2	11	48	15	12	0	0
Common Scoter	Number of flight events	1	0	1	0	1	0	0	0	1	0	0	0	0
	Number of birds	1	0	1	0	1	0	0	0	1	0	0	0	0
Dunlin	Number of flight events	2	0	2	0	2	0	0	0	0	0	0	2	0
	Number of birds	23	0	23	0	23	0	0	0	0	0	0	23	0
Eider	Number of flight events	207	2 (1.1)	205 (98.0)	12 (6.6)	193	9	3	0	153	52	0	0	0
	Number of birds	439	9 (70.4)	430 (97.9)	26 (6.0)	404	22	4	0	330	100	0	0	0
Great-crested grebe	Number of flight events	1	0	1	0	1	0	0	0	1	0	0	0	0
	Number of birds	1	0	1	0	1	0	0	0	1	0	0	0	0
Goldeneye	Number of flight events	7	0	7	1 (14.3)	6	0	0	1	2	4	1	0	0
	Number of birds	14	0	14	2 (14.3)	12	0	0	2	4	8	2	0	0
Mallard	Number of flight events	3	0	3	0	3	0	0	0	3	0	0	0	0

Species	No. flights/ birds	Total	Aborted (% total)	Crossed (% total)	Behavioural Change (% of total crossed)	Forth Road and Rail Bridge Crossing Behaviour				Crossing height (metres)				
						No change	Height change	Direction change	Height & direction change	0-10	11-50	51-170	171-250	>251
	Number of birds	6	0	6	0	6	0	0	0	6	0	0	0	0
Oystercatcher	Number of flight events	275	0	275	18 (6.5)	257	15	2	1	208	64	3	0	0
	Number of birds	625	0	625	39 (6.2)	586	36	2	1	397	82	146	0	0
Pink-footed goose	Number of flight events	9	0	9	1 (11.1)	8	1	0	0	0	0	2	7	0
	Number of birds	1028	0	1028	16 (1.6)	1012	16	0	0	0	0	18	1010	0
Red-throated diver	Number of flight events	13	5 (38.5)	8 (61.5)	2 (25)	6	1	0	1	1	1	0	5	1
	Number of birds	27	19 (70.4)	8 (29.6)	2 (25)	6	1	0	1	1	1	0	5	1
Redshank	Number of flight events	8	0	8	0	8	0	0	0	6	2	0	0	0
	Number of birds	25	0	25	0	25	0	0	0	22	3	0	0	0
Red-breasted merganser	Number of flight events	105	0	105	7 (6.7)	98	6	0	1	59	44	1	1	0
	Number of birds	218	0	218	9 (4.1)	209	8	0	1	123	92	2	1	0
Shelduck	Number of flight events	15	0	15	2 (13.3)	13	1	0	1	6	6	2	1	0
	Number of birds	25	0	25	3 (12.0	22	2	0	1	11	10	3	1	0
Sandwich tern	Number of flight events	10	0	10	2 (20.0)	8	0	2	0	1	9	0	0	0
	Number of birds	27	0	27	4 (14.8)	23	0	4	0	4	23	0	0	0
Turnstone	Number of flight events	3	1	2	1	1	0	1	0	2	0	0	0	0

Species	No. flights/ birds	Total	Aborted (% total)	Crossed (% total)	Behavioural Change (% of total crossed)	Forth Road and Rail Bridge Crossing Behaviour				Crossing height (metres)				
						No change	Height change	Direction change	Height & direction change	0-10	11-50	51-170	171-250	>251
			(33.3)	(66.7)	(50.0)									
	Number of birds	23	17 (73.9)	6 (26.1)	5 (83.3)	1	0	5	0	6	0	0	0	0
Total	Number of flight events	1559	13 (0.9)	1546 (99.1)	158 (10.4)	1388	110	27	21	1113	386	29	17	1
	Number of birds	3565	50 (1.4)	3515 (98.6)	241 (6.9)	3274	171	35	35	1714	551	207	1042	1

6.4.11 In total 116 flight events were observed to cross both bridges representing seven qualifying species. The majority of these were cormorants followed by eider, red-breasted merganser, oystercatchers, pink-footed geese, goldeneye and red-throated diver (refer to Table 30 and Table 31). Approximately 90% of flight lines crossed both bridges with no observable change in behaviour and at a flight height below the existing bridge decks (0-50m). Only curlew and eider were observed to alter their flight behaviour crossing either of the bridges. A single eider flight event involved an alteration of flight direction when crossing the Forth Road Bridge whereas cormorants sometimes altered their behaviour in response to both bridges (Table 30). There was no significant difference in the crossing behaviour of birds between the two bridges when both are crossed (Wilcoxon Singed Ranks Test: z = -2.92, p = .771). Crossing heights for flight events crossing both bridges followed a similar trend to those of single bridge crossings with the majority flying below the existing deck height (Table 31).

Table 30: Crossing behaviour of species that crossed both the Forth Road and Rail bridges.

Behaviour / Species	No Change		Height Change		Direction Change		Height/Direction Change		Total
	Forth Road Bridge	Forth Rail Bridge	Forth Road Bridge	Forth Rail Bridge	Forth Road Bridge	Forth Rail Bridge	Forth Road Bridge	Forth Rail Bridge	
Cormorant	72	72	7	4	0	2	1	2	80
Eider	19	20	0	0	1	0	0	0	20
Goldeneye	1	1	0	0	0	0	0	0	1
Oystercatcher	5	5	0	0	0	0	0	0	5
Pink-footed goose	3	3	0	0	0	0	0	0	3
Red-throated diver	1	1	0	0	0	0	0	0	1
Red-breasted merganser	6	6	0	0	0	0	0	0	6
Total	**107**	**108**	**7**	**4**	**1**	**2**	**1**	**2**	
Percentage of total	**92.2**	**93.1**	**6.0**	**3.4**	**0.9**	**1.7**	**0.9**	**1.7**	

Table describes the total number of flight events that crossed both the Forth Road and Rail bridges = 116

Table 31: Flight heights of species which crossed both the Forth Road and Rail bridges.

Crossing Height / Species	0-10m		11-50m		51-170m		171-250m		Total
	Forth Road Bridge	Forth Rail Bridge	Forth Road Bridge	Forth Rail Bridge	Forth Rail Bridge	Forth Road Bridge	Forth Rail Bridge	Forth Road Bridge	
Cormorant	72	57	5	22	3	1	0	0	80
Eider	20	13	0	7	0	0	0	0	20
Goldeneye	1	0	0	1	0	0	0	0	1
Oystercatcher	4	3	0	1	1	1	0	0	5
Pink-footed goose	0	0	0	0	0	0	3	3	3
Red-throated diver	0	0	0	0	0	0	1	1	1
Red-breasted merganser	6	5	0	1	0	0	0	0	6
Total	**103**	**78**	**5**	**32**	**4**	**2**	**4**	**4**	
Percentage of total	**88.8**	**67.2**	**4.3**	**27.6**	**3.4**	**1.7**	**3.4**	**3.4**	

Table describes the total number of flight events that crossed both the Forth Road and Rail bridges = 116

6.5 Nocturnal Bird Surveys

6.5.1 In October 2008 and January/February 2009 eight Firth of Forth SPA qualifying bird species were recorded within the survey boundary during the nocturnal bird surveys (Table 32). Both large (body mass >1000g) and small waterfowl were observed (Dunlin: 48g to Mallard: 1200g). However, due to difficulties observing birds with distance, numbers and location >100m could not be recorded accurately. Most of the observations were of disturbed birds flying away from the surveyors so records of behaviour in the absence of this disturbance are not available.

Table 32: List of species observed during nocturnal surveys of the Northern and Southern sections of the wider study area

Northern Section	Southern Section
Curlew	Curlew
Oystercatcher	Oystercatcher
Redshank	Redshank
Turnstone	Dunlin
Ringed plover	Shelduck
Mallard	Turnstone
	Ringed plover

6.6 Inland Estuarine Bird Surveys

6.6.1 Three species of wader and one species of duck were observed in the fields adjacent to the Firth of Forth SPA within the boundary of the inland survey area (Table 33 and Figure 21). Curlew were the only species seen in significant numbers (18.8% of their SPA cited population in February 2009, Table 33) but at a considerable distance from the alignment of the Main Crossing in the fields adjacent at Society Point, Rosyth, Limekilns, Inverkeithing and within Dalmeny Estate (Figure 21).

Table 33: Monthly peak counts of waterfowl at high tide at fields adjacent to the Firth of Forth SPA boundary within the survey area

	Monthly Peak Count[1]			
Month	Curlew	Lapwing	Oystercatcher	Mallard
Dec 2008	7 (0.4)	3 (0.1)	0	0
Feb 2009	362 (18.8)	1 (<0.1)	40 (0.5)	0
March 2009	267 (13.8)	24 (0.6)	27 (0.3)	2 (0.1)
April 2009	15 (0.8)	21 90.5)	21 (0.3)	0

1 = percentage of SPA population shown in parenthesis

6.7 Disturbance

6.7.1 Information on the source and magnitude of disturbance stimuli on estuarine birds was recorded as part of the TTTC counts. In rank order in both the number and percentage of surveys where birds were observed to be disturbed, walkers (17.9%), dogs (13.0%) and powered boats (8.9%) were recorded most frequently (Table 34). Overall, a disturbance of some kind was observed just over 50% of the surveys highlighting the already established levels of disturbance in the Forth Estuary (Table 34).

Table 34: Sources of disturbance and frequency of occurrence during through-the-tide counts

Level of Disturbance	Number and % of surveys where disturbance was recorded [1]	Disturbance Stimuli																
		Aircraft	Anglers	Bat diggers	Dogs	Jet skis	Powered boats	Shell fisher	Unpowered boats	Vehicles	Walkers	Windsurfers	Drill-rigs	Peregrine falcon	Industrial related noise	Surveyors	Other	Total
High	N	0	0	2	15		11	2	3	1	25	0	2	0	0	0	0	61
	%	0.0	0.0	0.1	0.9	0.0	0.7	0.1	0.2	0.1	1.5	0.0	0.1	0.0	0.0	0.0	0.0	3.7
Moderate	N	0	4	6	64		16	5	11	5	67		4	1	14	4	2	203
	%	0.0	0.2	0.4	3.9	0.0	1.0	0.3	0.7	0.3	4.1	0.0	0.2	0.1	0.9	0.2	0.1	12.5
Low	N	7	9	15	133	2	118	7	50	34	199	2	0	0	10	20	5	611
	%	0.4	0.6	0.9	8.2	0.1	7.2	0.4	3.1	2.1	12.2	0.1	0.0	0.0	0.6	1.2	0.3	37.5
Total	N	7	13	23	212	2	145	14	64	40	291	2	6	1	24	24	7	875
	%	0.4	0.8	1.4	13.0	0.1	8.9	0.9	3.9	2.5	17.9	0.1	0.4	0.1	1.5	1.5	0.4	53.7

1 = Total number of surveys 1628