11 Estuarine Ecology

This chapter presents the ecological impact assessment (EcIA) of the proposed scheme on estuarine species, communities and habitats, and is generally focused on the Main Crossing. Assessment was carried out in accordance with all relevant legislation and guidelines, with the approach based on DMRB and Institute of Ecology and Environmental Management (IEEM) guidance.

The study area comprises intertidal and subtidal environments which includes migratory and non-migratory fisheries, benthic habitats, marine mammals and estuarine birds.

Where potential impacts to habitats are assessed as significant, mitigation measures, both generic and specific, are applied with the aim to reduce the level of impact on the ecological receptor. Key mitigation measures include an Ecological Clerk of Works (ECoW) to be present during excavation and piling activities and the use acoustic deterrents at appropriate frequency during key construction periods to deter sensitive species from entering the area.

Significant residual impacts on migratory and non-migratory fish are predicted to result from the excavation of Beamer Rock. Similarly, significant residual impacts on benthic habitats, fish and marine mammals are also predicted for chemical spillage events although with specific mitigation in place the probability of this occurring is extremely unlikely.

11.1 Introduction

11.1.1 This chapter presents an ecological impact assessment of the proposed scheme on estuarine ecology in the Firth of Forth. The chapter is supported by the following appendices, which are cross-referenced in the text where relevant:

- Appendix A11.1: Estuarine Ecology - Legislation;
- Appendix A11.2: Detailed Estuarine Survey Methods;
- Appendix A11.3: Detailed Estuarine Baseline Information; and
- Appendix A11.4: Detailed Estuarine Ecology Impacts and Mitigation.

11.1.2 As noted in Chapter 10 (Terrestrial and Freshwater Ecology), Appendix A10.1 lists key members of the ecology team.

11.1.3 As the chapter focuses on the estuarine environment, impacts are generally related to construction or operation of the Main Crossing (Chapter 4: The Proposed Scheme) and maybe permanent or temporary, direct or indirect, and/or cumulative.

11.1.4 Impacts on terrestrial and freshwater species and habitats are described in Chapter 10 (Terrestrial and Freshwater Ecology) and includes consideration of the St. Margaret's Marsh Site of Special Scientific Interest (SSSI). St. Margaret's Marsh SSSI is therefore not reassessed in this chapter. Chapters 9 (Water Environment), 12 (Landscape) and 13 (Visual) also contain information pertinent to this chapter.

11.1.5 Impacts on Natura 2000 sites Firth of Forth SPA, Forth Islands SPA, Imperial Dock Lock, Leith SPA and River Teith SAC are summarised in Section 11.7. Fully detailed assessments of these sites are provided in the Reports to Inform an Appropriate Assessment (RIAAs) (Jacobs Arup, 2009a-c).

Aims

11.1.6 The aims of this assessment are to:

- identify the presence and status of habitats, flora and fauna of conservation significance within the study area through consultation, desk-based research and field surveys;
- evaluate the importance of ecological receptors in terms of their nature conservation value;

- identify anticipated potential impacts on habitats, flora and fauna of conservation significance;
- propose mitigation to avoid or reduce the identified potential impacts; and
- assess the residual impacts following the successful implementation of mitigation.
- Approach and Methods

11.2 Approach and Methods

Overview of Approach

11.2.1 The Ecological Impact Assessment (EcIA) has been undertaken through interpretation of baseline data, literature reviews, legislation, consultation and professional judgement and in accordance with guidelines produced by DMRB, Volume 11, Section 3, Part 4: Ecology and Nature Conservation (The Highways Agency et al., 1993) and IEEM (2006). The principles and approach of IEEM have been followed as far as possible and standard impact assessment terms have been used where appropriate to provide consistency with the other assessments reported in this ES.

11.2.2 IEEM (2006) provides a framework for identifying which ecological features or resources (receptors) within the study area are both of sufficient value to be included in the assessment and vulnerable to significant impacts arising from a project, as follows:

- identification of ecological receptors;
- identification of key attributes of the receptor;
- identification of the level of importance of the receptor;
- identification of legal protection offered to the receptor;
- identification of activities in the proposal that may impact on the receptors;
- characterisation of the potential impacts;
- assessing the significance of the impact to the nature conservation of the receptor;
- outlining the proposed mitigation measures; and
- assessing the residual impacts of the proposals.

11.2.3 The ecological impact assessment of the proposed scheme has been carried out in accordance with the above guidelines, with the following exceptions or clarifications to ensure consistency with this ES and with DMRB guidance:

- the Zone of Influence referred to in IEEM guidelines has been defined in accordance with DMRB study area guidelines where applicable; and
- the definition of threshold values to determine ecological receptors to be included within the scoping of ecological surveys and assessment was not used. The scope was determined during consultation with SNH and SEPA, and also informed by DMRB guidance and by information obtained during the general EIA consultation (Chapter 6: Scoping and Consultation).

Legislation, Conservation Status and Biology

11.2.4 Appendix A11.1 (Estuarine Ecology - Legislation) provides full descriptions of all relevant legislation and statutory and non-statutory environmental designations; all relevant policy is documented in Chapter 20 (Policies and Plans).

11.2.5 The legislation relevant to the estuarine environment has been used in Table 11.1 to define ecological value.

Consultation and Literature Review

11.2.6 An extensive literature review and consultation process was undertaken to generate baseline information on the estuarine ecology in the area and to identify key issues. Statutory bodies' view on the proposed scheme is provided in Appendix A6.3 (Summary of Key Issues). With regard to estuarine ecology, the majority of consultees provided baseline information and/or ecological records rather than offering a view on the scheme proposals. The main exception to this was SNH, with whom there was ongoing close liaison throughout the progression of the proposed scheme design and the ecological assessment. Their input and views are summarised below:

- The scope of the ecology assessment, which included field survey methods, was agreed through consultation with SNH throughout 2008.
- The scope of RIAAs for Firth of Forth Ramsar Site, Firth of Forth SPA, Forth Islands SPA, Imperial Dock Lock, Leith SPA and River Teith SAC was agreed in consultation with SNH.
- SNH identified the following concerns, which were considered and addressed in the assessment and the proposed mitigation:
  i. the need to provide detailed mitigation for European Protected Species;
  ii. the impact of noise and water quality on species such as salmon and lamprey;
  iii. potential lighting impacts on roseate terns on Long Craig Island and birds utilising the Firth of Forth;
  iv. although unlikely to be a major concern, the impact of Main Crossing construction on grey and common seals;
  v. piling and blasting time constraints for Main Crossing construction programme during sensitive periods. This was considered and discussed further with SNH, and agreement reached on approach; and
  vi. provision of marine mammal observers during certain construction activities.

11.2.7 The following data sources have been used in the preparation of this chapter, with detailed appendices providing supporting information to each section (see paragraph 11.1.1):

Site Designations

- SNH – protected site citations;
- Joint Nature Conservation Committee (JNCC) – protected site citations; and
- Jacobs Arup (2008a) and Jacobs Arup (2008b) - Ecological Scoping Reports.

Fisheries

- SEPA – Fisheries trawling data 1977 – 2006, screen catches at Longannet Power Station 2001 -2006;
- Marine Scotland (formerly Fisheries Research Services) and Scottish Fisheries Protection Agency (SFPA) – commercial catch statistics;
- Forth District Salmon Fisheries Board (FDSFB);
- Scottish Government (Marine Directorate, Sea Fisheries Management Division); and
- Elliott & Taylor (1989), Elliott et al. (1990) and Greenwood & Hills (2003) and Greenwood (2008) – fisheries research data.

Benthic Ecology

- SEPA and Forth River Purification Board – benthic baseline reports; and
- Bennet & McLeod (1998), Elliot & Kingston (1987) and McLusky (1987).

Marine Mammals

- Sea Watch Foundation (SWF);
- Lothian Wildlife Information Centre (LWIC);
- Forth Seabird Group (FSG);
- SNH (Isle of May Reports);
- British Divers Marine Life Rescue (BDMLR); and
- Sea Mammal Research Unit (SMRU).

Estuarine Birds

- SNH;
- Forth Seabird Group;
- East of Scotland Tern Group;
- Scottish Wildlife Trust; and
- Faber Maunsell and AECOM (2007), Jacobs/Faber Maunsell/AECOM (2007), Environmental Resource Management (ERM) (1996), and Mackenzie Bradshaw Environmental Consulting (MBEC) (2008) – estuarine bird survey data.

Study Area

11.2.8 The geographical extent of this study takes account of the migratory ranges and routes for interest species of designated sites within the Firth of Forth and pathways by which potential impacts could affect these.

11.2.9 The study area was also determined through consultation with statutory and non-statutory bodies, review of existing data and consideration of potential impacts and pathways on species, habitats and communities and by which these could potentially affect interest features of designated sites (see Appendix A11.1 for relevant designations).

11.2.10 In addition to the use of existing baseline data, detailed ecological surveys were undertaken by Jacobs Arup to generate additional baseline data on the Firth of Forth on which impacts could be assessed. Figures 11.1 and 11.3 shows the geographical extent of these baseline surveys. The following habitats were surveyed:

- benthic intertidal and subtidal habitat surveys; the survey area ranged between 4km upstream and downstream of the Main Crossing;
- estuarine intertidal and subtidal fisheries surveys; the survey area ranged between 2km upstream and 3km downstream of the Main Crossing; and
- marine mammal data collection; desk studies and incidental sightings. Data within 50km from the Main Crossing are detailed in the ES whilst Appendix A11.3 (Detailed Estuarine Baseline Information) contains data beyond this range, from Arbroath in the north to Bamburgh in the south and up to 24km offshore.

11.2.11 Surveys for estuarine birds were undertaken over a two-year period by Faber Maunsell and MBEC between 2007/2008 and Jacobs Arup between 2008 and 2009 over a survey area that ranged between 5km up- and downstream of the Main Crossing. It was agreed with SNH that one year's survey data would be adequate for the EcIA, with the RIAAs for the Firth of Forth SPA and the Forth Islands and Imperial Dock Lock, Leith SPAs reporting on data from two years. Examination of the second year's data within the RIAAs, confirmed compatibility between both years. For the EcIA reported in this ES, the data gathered by Faber Maunsell and MBEC were used to inform the assessment of impacts to estuarine birds.

Survey Methods

11.2.12 Appendix A11.2 (Detailed Estuarine Survey Methods) provides detailed survey methodologies, these methods are briefly summarised below. No surveys were undertaken for marine mammals as baseline data were obtained from a range of consultees.

Benthic Sampling Methodology

11.2.13 The survey design incorporated intertidal and subtidal components. The subtidal survey area extended up to 4km upstream and downstream of the Main Crossing. A total of 35 sample sites were selected with eight sites (four either side) positioned across the Firth of Forth in close proximity to the Main Crossing. The remaining 27 sites were appropriately spaced throughout the study area, following consultation with SEPA. In the intertidal area on the north shore the study area extended approximately 1km upstream and downstream of the Main Crossing, whilst on the south shore surveys were conducted up to 2km either side of the Main Crossing. Sampling site locations are presented on Figure 11.1.

11.2.14 Owing to the range of different habitat types, a number of sampling techniques were adopted for the intertidal areas. Where hard substrate was found, biotope mapping was undertaken using Marine Nature Conservation Review (MNCR) intertidal methodologies (as per Hiscock, 1996). Where soft substrate was found, a hand corer was deployed. Sediment samples for physico-chemical analyses were taken directly from undisturbed surface sediment.

11.2.15 Biotopes were assigned to all biological communities according to Joint Nature Conservation Committee (JNCC) marine habitat classification scheme (Connor et al., 2004). All taxa were identified to the lowest taxonomic level practicable. Generally, fauna were enumerated while the abundance of plant species was expressed as percentage cover.

11.2.16 Sediments were analysed for a range of materials including metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).

Fisheries Sampling Methodology

11.2.17 A survey study area of approximately 4km^2 was chosen following consultation with SEPA, extending from a transect between Rosyth church and Hopetoun Point in the west, to a transect line between Downing Point and Hound Point in the east. The survey area encompassed the Forth Road Bridge and Forth Rail Bridge, large areas of heterogeneous intertidal area and a mosaic of subtidal habitats, including the deep water shipping channel. This provides sufficient spatial coverage of fish communities that would be directly affected by the Main Crossing, whilst allowing an assessment of baseline fish community structure in the Firth of Forth. Data derived from these surveys were supplemented by historic data collated from a range of organisations up to 10km up- and downstream from the Main Crossing.

11.2.18 Several fishing methods were used to adequately sample the fisheries populations. These methods were in accordance with Water Framework Directive (WFD) and JNCC methods and incorporated both intertidal and subtidal fishing techniques. Subtidal and intertidal fishing sites are shown on Figure 11.3. The fishing techniques used were:

- intertidal seine netting using a 5mm centre mesh;
- intertidal push netting using a 5mm mesh cod end liner;
- intertidal fyke netting fitted with a 14mm mesh liner;
- subtidal beam trawls using a 1.8m beam and 5mm cod end; and
- subtidal otter trawls using a 4mm cod end.

11.2.19 To allow accurate comparisons between sites, the baseline fisheries data were corrected for fishing effort (catch per unit effort, CPUE) for otter trawls, or area (catch per unit area, CPUA) for beam trawls. These calculations allow the catch data for each fishing method to be compared within and between sites and seasons despite the variable lengths of each replicate trawl. Full statistical analysis of datasets is presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Estuarine Birds Sampling Methodology

11.2.20 Surveys for non-breeding coastal birds and passage migrants were developed and undertaken by MBEC from October 2007 to April 2008 and were agreed with SNH through consultation.

11.2.21 The breeding and passage migrant tern surveys were developed and undertaken by Jacobs/Faber Maunsell from April-October 2007 and were agreed with SNH through consultation.

Coastal Birds

11.2.22 The study area for coastal birds covered the area between Abercorn Point and Hound Point on the southern shore of the Firth of Forth and Limekilns and Donibristle Bay on the northern shore. The study area was divided into 18 survey sectors following geographic boundaries (where possible); nine on the northern shore and six on the southern shore (N1 to N9 and S1 to S6 respectively). In addition, three core sectors (C1 to C3) were established to cover the mid-water areas (Figure 11.6).

11.2.23 Coastal birds were surveyed using a modified version of the Wetland Bird Survey (WeBS) (Gilbert et al., 1998). Systematic counts were undertaken throughout a range of tide states, i.e. high, low and on ebbing and flooding tides. Counts were postponed or curtailed when visibility was judged to be less than 1km.

11.2.24 Approximately four high, mid and low tide counts were undertaken each month at each sector. Count dates were selected to include both neap and spring tides and timed so that the mid-point of the survey would be synchronised with the turn-of-the-tide (i.e. high water or low water).

Breeding Terns

11.2.25 At fixed, frequent and constant timed intervals all active i.e. fishing/foraging and loafing/roosting terns were counted within a count sector from April to October 2007.

11.2.26 A survey grid covering 500m either side of the Main Crossing was divided along the main channel axis of the Firth of Forth. The grid was divided into count sub-sectors and each count sub-sector was 300m x 250m.The count sectors to the north and south of the central channel axis were referred to as Area NQ and Area SQ which were sub-divided into 16 count sectors and 20 count sectors respectively.

11.2.27 Distinctive landmark features (such as the two cable towers on the existing Forth Road Bridge and terrestrial geographic features) were used as guides to aid differentiation of each respective sector (Figures 11.6a and 11.6b).

11.2.28 Two vantage points (VPs) were used for this survey (Figures 11.6a and 11.6b).

- Vantage Point 1 (VP1) was located close to the lifeboat station at North Queensferry, underneath the Forth Road Bridge (NT 12551 80514).
- Vantage Point 2 (VP2) was located approximately 500m west of Port Edgar near to The Fisheries (NT 11281 78804).

11.2.29 Surveys took account of the distinct tidal races, and used the easily monitored tern colony at Port Edgar as an indicator of the tern breeding season.

Passage Migrants

11.2.30 The study area for passage migrants was located between Whitehouse Point (east of the Forth Rail Bridge at NT 14796 79256) and Port Edgar Harbour Breakwater (west of the Forth Road Bridge at NT 11781 78878) on the southern shore of the Firth of Forth and Carlingnose Point (east of the Forth Rail Bridge at NT 135 806) on the north shore of the estuary (Figures 11.6a and 11.6b).

11.2.31 Within the study area, timed watches from strategic vantage points (VPs) were undertaken in order to record waterbird flight activity in relation to the existing Forth Rail and Road Bridge structures and the location of the Main Crossing as it crosses the estuary.

11.2.32 Three VPs were established to provide visibility of the Main Crossing and also the area to the east of the Forth Rail Bridge. These were at White House Point, Carlingnose Point and Port Edgar west breakwater.

11.2.33 A total of 80 observations, each comprising three-hour watches was completed, providing a total of 240 hours of observation for all VPs, from October 2007 to April 2008.

11.2.34 As noted in Section 1.2 of Appendix A11.2 (Detailed Estuarine Survey Methods) vantage point surveys are unable to cover the whole survey area but the use of multiple vantage points ensured that sufficient coastline was visible during the surveys to provide adequately robust data for the assessment.

Criteria Used to Evaluate Ecological Receptors

11.2.35 In undertaking the evaluation of baseline conditions, the following definitions are used:

- an ecological receptor is the habitat, species or community within the receiving environment that might be influenced by the change; and
- the value or sensitivity of the ecological receptor refers to its importance in terms of its nature conservation value and susceptibility to impact.

11.2.36 The value or sensitivity of an ecological receptor was determined by consultation, literature review and desk-based studies, field survey information, legal protection/conservation status and professional judgement. Reference was also made to the Ratcliffe Criteria, where applicable, as used in the selection of biological SSSIs (Ratcliffe, 1977).

11.2.37 In accordance with IEEM, the determination of ecological value involved professional judgement informed by available guidance and information, together with advice from experts who know the locality of the project and the distribution and status of the species or features that are being considered. Ecological receptors were assigned into the framework shown in Table 11.1.

Table 11.1: Criteria used to evaluate ecological receptors

Ecological Value	Attributes of Ecological Receptor
International European	**Habitats** • An internationally designated site or candidate site i.e. SPA, provisional SPA (pSPA), SAC, candidate SAC (cSAC), Ramsar site, Biogenetic/Biosphere Reserve, World Heritage Site or an area which meets the published selection criteria for such designation. • A viable area of a habitat type listed in Annex I of the Habitats Directive, or smaller areas of such habitat that are essential to maintain the viability of a larger area. **Species** • Any regularly occurring population of an internationally important species, which is threatened or rare in the UK, i.e. a UK Red List species or listed as occurring in 15 or fewer 10km squares in the UK (Categories 1 and 2 in the UK Biodiversity Action Plan (BAP) or of uncertain conservation status or of global conservation concern in the UK BAP. • A regularly occurring, nationally significant population/number of any internationally important species.

Ecological Value	Attributes of Ecological Receptor
National Scottish	**Habitats** • A nationally designated site i.e. SSSI, Areas of Special Scientific Interest (ASSI), NNR, Marine Nature Reserve, or a discrete area, which meets the published selection criteria for national designation (e.g. SSSI selection guidelines). • A viable area of a priority habitat identified in the UK BAP, or of smaller areas of such habitat that are essential to maintain the viability of a larger whole. **Species** • A regularly occurring, regionally or county significant population/number of an internationally/nationally important species. • Any regularly occurring population of a nationally important species which is threatened or rare in the region or county. • A species identified as a priority species listed in the UK BAP. • A species listed on 1994 or 2001 International Union for the Conservation of Nature (IUCN) criteria as at least Near Threatened or at least Rare on the Red List based on pre-1994 IUCN guidelines; species listed as Nationally Scarce, Nationally Notable A or Notable B (rare and scarce species not based on IUCN criteria.
Regional Kingdom of Fife (Fife) and Edinburgh & Lothians	**Habitats** • Sites which exceed the county-level designations but fall short of SSSI selection criteria. • Viable areas of key habitat identified in the Regional BAP or smaller areas of such habitat that are essential to maintain the viability of a larger area. • Viable areas of key habitat identified as being of regional value in the appropriate SNH Natural Heritage Future area profile. **Species** • Any regularly occurring, locally significant population of a species listed as being nationally scarce which occurs in 16-100 10km squares in the UK or in a regional BAP or relevant SNH Natural Heritage Future area on account of its regional rarity or localisation. • A regularly occurring, locally significant population/number of a regionally important species. • Sites maintaining populations of internationally/nationally important species that are not threatened or rare in the region or county. • Species listed as Indeterminate or Insufficiently Known on the Red Listing pre-1994 IUCN guidelines or species listed on the 1994 IUCN guidelines as Data Deficient or species listed on the 2001 Red Listing as Lower risk – least concern.
Authority Area City of Edinburgh, West Lothian Council and Fife Council	**Habitats** • Sites that are recognised by local authorities e.g. Sites of Interest for Nature Conservation (SINC) and District Wildlife Sites (DWS). • County/District sites that the designating authority has determined meet the published ecological selection criteria for designation, including Local Nature Reserves (LNR). • A viable area of habitat identified in county/district BAP or in the relevant SNH Natural Heritage Future area profile. **Species** • Any regularly occurring, locally significant population of a species that is listed in a county/district BAP on account of its regional rarity or localisation. • A regularly occurring, locally significant population of a county/district important species (particularly during a critical phase of its life cycle). • Sites supporting populations of internationally/nationally/regionally important species that are not threatened or rare in the region or county, and are not integral to maintaining those populations. Sites/features that are scarce within the county/district or which appreciably enrich the county/ district habitat resource.
Local Kirkliston, South Queensferry, North Queensferry, Inverkeithing and Rosyth	**Habitats** • Areas of habitat considered to appreciably enrich the habitat resource e.g. marshes, grasslands etc. **Species** • Populations/assemblages of species that appreciable enrich the biodiversity resource within the local context. • Sites supporting populations of county/district important species that are not threatened or rare in the region or county, and are not integral to maintaining those populations.

Impact Assessment

Identification of Impacts

11.2.38 The activities that could have a potential ecological impact were reviewed and assessed for each ecological receptor individually. Professional judgement by experienced ecologists was used to identify those activities associated with the Main Crossing that could impact on a particular receptor.

11.2.39 To aid consistency and readability, a standard list of potential areas of concern was developed, derived from a review of the likely Main Crossing construction and operational activities (refer to Chapter 4: The Proposed Scheme) that could impact on a receptor, such as excavation of Beamer Rock, piling and dredging etc. These include:

- noise and vibration;
- habitat loss;
- water pollution;
- sediment loading;
- re-suspension of sediment-bound contaminants;
- light pollution;
- changes to hydrology; and
- severance of juvenile fish migration routes, physical barriers.

11.2.40 The list shown in paragraph 11.2.39 was considered with respect to all construction and operational activities.

Impact Magnitude

11.2.41 For the purposes of this assessment, the term 'impact magnitude' is taken to represent the overall characterisation of positive or negative impacts in accordance with IEEM including:

- scale/extent;
- direct or indirect impact;
- reversibility of impact;
- frequency of impact (single event, recurring or constant);
- duration of impact (short term, medium term, long term or permanent); and
- likelihood of occurrence (certain/near certain, probable, unlikely or extremely unlikely).

11.2.42 Impact magnitude was identified as shown in Table 11.2 as negligible, low, medium or high, taking into account IEEM impact characterisation approach as listed in paragraph 11.2.41.

Table 11.2: Impact characterisation translated into impact magnitude

Impact Character	Impact Magnitude
A permanent or long-term effect on the distribution and/or abundance of a habitat, species assemblage/community or population. If negative this would have implications for the integrity of the receptor and its conservation status, and if positive would result in an improvement to the conservation status of the receptor.	High
A permanent or long-term effect on the distribution and/or abundance a habitat, species assemblage/community or population. If negative this would have negligible implication for the integrity of the receptor or its conservation status and if positive would not alter the conservation status of the receptor.	Medium
A short-term reversible effect on the distribution and/or abundance of a habitat, species assemblage/ community or population and within normal fluctuations observed within the ecology of the receptor.	Low
A short-term reversible effect on the distribution and/or abundance of a habitat, species assemblage/community or population unlikely to be detectable by monitoring.	Negligible

Impact Significance

11.2.43 Once potential impacts were understood and receptor value determined, professional judgement and scientific evidence were used to focus the assessment on impacts that would require mitigation. Therefore for example, an impact on a receptor valued at a national level would progress through the assessment process and if assessed as significant would require mitigation measures.

11.2.44 IEEM (2006) states that *'if an ecological resource or feature is likely to experience a significant impact, the consequences in terms of development control, policy guidance and legislation will depend on the level at which it is valued. Significant impacts on features of ecological importance should be mitigated (or compensated for) in accordance with guidance derived from policies applied at the scale relevant to the value of the feature or resource. Any significant impacts remaining after mitigation (the residual impacts), together with an assessment of the likelihood of success in the mitigation, are the factors to be considered against legislation, policy and development control in determining the application*'.

11.2.45 In accordance with IEEM (2006) a significant impact is an impact (negative or positive) on the integrity of a defined site or ecosystem and/or the conservation status of habitats and/or species Conservation (Natural Habitats, &c.) Regulations 1994 as amended). In the context of reporting in this Chapter, the specific impacts described in Section 11.4 (Potential Impacts) contain information regarding all potential impacts considered to be significant. A summary of potential impacts assessed as insignificant is also provided in Section 11.4 (Potential Impacts) and described in detail in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation).

Mitigation and Residual Impacts

11.2.46 A hierarchical approach to mitigation has been adopted for the proposed scheme, which seeks to avoid adverse impacts in the first instance through an iterative approach to design (e.g. informing road alignment to avoid sensitive receptors where possible). In areas where avoidance is not possible, measures are proposed to prevent or reduce potentially significant negative impacts. Measures to compensate the negative impacts at specific sites may also be required (e.g. habitat creation to offset the local, site-specific impacts associated with habitat loss and fragmentation).

11.2.47 Although all significant potential impacts require mitigation, most would be addressed using generic mitigation including the application of best practice guidance, and specific mitigation was therefore only developed where generic mitigation would be inappropriate, ineffective or insufficient.

11.2.48 Where there would still be a significant impact after mitigation this is reported in Section 11.6 (Residual Impact).

11.2.49 Mitigation was identified following a hierarchical approach and to meet the requirements outlined in the Environmental Impact Assessment (Scotland) Regulations 1999 which requires '*a description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment*' to be provided.

Limitations to Assessment

11.2.50 Potential limitations to assessment related to baseline data are explained in Appendix A11.2 (Detailed Estuarine Survey Methods).

11.3 Baseline Conditions

11.3.1 The Firth of Forth is the estuary of the River Forth and stretches approximately 100km from its tidal limit at Stirling to the harbour limits, the latter being a transect from Bass Rock to Crail. There are a number of towns which line the shores, as well as the petrochemical complex at Grangemouth, the commercial docks at Leith, oil rig construction yards at Methil, the ship-breaking facility at Inverkeithing, the Longannet Power Station near Kincardine on the Firth of Forth and the Rosyth dockyard.

11.3.2 The Kincardine Bridge, the Forth Road Bridge, the Forth Rail Bridge and the Clackmannanshire Bridge (previously known as the Upper Forth Crossing), currently carry traffic across the Firth of Forth.

11.3.3 The Firth of Forth contains a number of habitats typical of British estuaries including:

- mudflats and sandflats;
- saltmarsh;
- boulder and rocky habitats; and
- intertidal creeks and lagoons.

11.3.4 The following section summarises the baseline conditions which are used in the assessment of impacts. Appendix A11.2 (Detailed Estuarine Survey Methods) details full survey methods and Appendix A11.3 (Detailed Estuarine Baseline Information) details full baseline results.

Benthic Habitats Baseline

Existing Baseline Data

11.3.5 The subtidal benthic fauna of the Firth of Forth was extensively surveyed by the Forth River Purification Board and much of this work was summarised by Bennett & McLeod (1998). The results of these studies indicated that sediments throughout the estuary were comprised primarily of sand and muds with some coarser material and that benthic communities in the lower estuary were polychaete dominated while in the upper estuary oligochaetes were dominant. A greater number of benthic marine taxa were present in the lowermost part of the estuary.

11.3.6 The subtidal environments of the mid and lower Firth of Forth were extensively investigated by Elliott & Kingston (1987). This study indicated that sediments in the vicinity of the current survey area were predominantly fine with varying proportions of coarser material with silt and clay representing >60% of material at most sites. The authors identified four faunal associations of which the supra-estuarine and impoverished supra-estuarine associations were present in the area covered by the present study. The supra-estuarine association was characterised by the polychaetes, *Dodecaceria concharum* and *Neoamphitrite figulus* and the bivalve, *Abra alba* and occurred in the middle and southern parts of the study area and between the Forth Road Bridge and the Forth Rail Bridge. The impoverished supra-estuarine association was similar but with reduced abundance and number of taxa. This association was found in the northern part of the study area upstream of the Main Crossing. It is likely that the impoverished fauna reflects dredging

activity in the navigational approach to Rosyth Dockyard and the associated spoil grounds to the west of Beamer Rock.

11.3.7 Several studies have been conducted on the intertidal sedimentary habitats of the Firth of Forth which indicate that the distribution of macroinvertebrates follows a salinity gradient, which is additionally influenced by the underlying sedimentary and tidal characteristics. Species diversity is reduced in the upper estuary where the narrow intertidal area is organically enriched; the greatest biomass occurs in the middle estuary, while the lower estuary supports the greatest diversity (McLusky, 1987).

11.3.8 Much of these intertidal studies have concentrated on the mudflats in the vicinity of the petrochemical complex at Grangemouth where communities are clearly influenced by industrial contamination although conditions have consistently improved since the 1970s (McLusky & Martins, 1998; McLusky et al., 1993). Where upper and middle estuary communities were dominated by pollution tolerant taxa, particularly oligochaetes, as conditions have improved, the number of taxa has increased while the abundance of pollution tolerant taxa has greatly reduced.

Benthic Baseline Survey Results (2008)

Substrate Composition

11.3.9 A mixture of sediment types were found across the sampling area, although subtidal sediments were predominantly sandy muds with some coarser material identified at deeper sites (Figures 11.2a and 11.2b).

11.3.10 Intertidal soft sediments were consistently sandy muds. There is known patchiness to the sediments of the Firth of Forth, they have been found to consist of sands and muds with shells, clinker, fly-ash and other debris. Elliott & Kingston (1987) also found the sediment to include the remains of tubes from the polychaete, *Sabellaria* spp., which were also found surrounding Port Edgar in this present study. Subtidal sediments were predominantly sandy muds throughout the survey area, although some coarser material occurred at deeper sites; intertidal soft sediments were consistently sandy muds (Figures 11.2a and 11.2b).

11.3.11 Chemical analysis compared the chemical concentrations with the threshold effects limits (TEL) and probable effects limits (PEL). The TEL represents the concentration below which adverse effects on benthic fauna are expected to occur only rarely. The PEL represents the threshold above which adverse effects are expected to occur frequently.

11.3.12 Levels of sediment-bound zinc, cadmium, mercury, lead and arsenic were elevated above background levels throughout the study area, although concentrations of these and other metals were similar to those previously reported from the Firth of Forth and other major UK estuaries (Table 11.3). Sediment-bound mercury concentrations exceeded the relevant PEL at a number of sites. The majority of concentrations of copper, lead, arsenic and nickel were between the relevant TELs and PELs, while the majority of zinc, cadmium and chromium concentrations were below the relevant TEL. The majority of sediment-bound concentrations were between Action Levels 1 and 2 for all metals with none exceeding the relevant Action Level 2 concentration (Appendix A11.3: Detailed Estuarine Baseline Information).

11.3.13 High levels of polycyclic aromatic hydrocarbons (PAHs) were present in sediments in the vicinity of the Forth Road Bridge and Forth Rail Bridge and at the western end of the survey area. The majority of concentrations were greater than the relevant TEL for all PAHs and several values also exceeded the PEL, although the PEL for total PAH was not exceeded at any site. Levels of total PAH were analogous with those from other major UK estuaries although lower than those in dredge material from Rosyth.

11.3.14 Polychlorinated Biphenyls (PCB) levels were all below the minimum reporting value (MRV) from which it is inferred that total PCB levels were below the Sediment Action Level 1.

Table 11.3: Sediment-bound metal (mg kg^{-1}) and PAH (µg kg^{-1}) concentrations from the Firth of Forth and other major UK estuaries. The TEL and PEL values have also been provided for comparison

Metal	Copper (Cu)	Zinc (Zn)	Cadmium (Cd)	Mercury (Hg)	Lead (Pb)	Arsenic (As)	Chromium (Cr)	Nickel (Ni)	Source	Individual PAH Range	Total PAH Range	Source
TEL	18.7	124	0.7	0.13	30.2	7.24	52.3	15.9	-	-	-	-
PEL	108	271	4.2	0.7	112	41.6	160	42.8	-	-	-	-
Location	-	-	-	-	-	-	-	-	-	-	-	-
Firth of Forth (offshore)	25.9	105	0.11	0.63	51	24.5	83	12.6	FRS/SEPA (1997)	<0.01 - 20.9	37.8	FRS/SEPA (1997)
Firth of Forth	62.1	193	1.13	1.4	128	16.3	66.6	37	FRS Unpublished data	-	4400 - 25000	FRS Unpublished data
Clyde	31.4	187	0.15	0.31	107	39.9	141.8	30.5	FRS/SEPA (1997)	<0.01 - 134.2	854	FRS/SEPA (1997)
Tyne	92	421	2.17	0.92	187	24.8	46	34	Burt et al. (1992)	<17 - 2417	236 - 10720	Sheahan (2006)
Mersey	84	379	1.15	3.01	124	-	-	29	Burt et al. (1992)	<5 - 1242	6 - 5236	Sheahan (2006)
Thames	48	120	0.36	0.35	55	13	96	31	NMMP site 455 data	13 - 1071	597 - 5350	Sheahan (2006)
Firth of Forth	25.6	107	0.23	0.59	52.3	20.4	40.2	24.8	Current study	3 - 1400	64 - 5909	Current study

Subtidal Faunal Analysis

11.3.15 The area sampled for this baseline study was in the transitional area between the lower estuary and the inlet of the sea (see Figure 11.1 for location of sampling sites). Species found across the whole area sampled were predominated by marine species. The sublittoral sediments were as expected from the area, with a typical bivalve-annelid community. The communities were dominated by two highly abundant species, the bivalve (*Abra alba*) and polychaete (*Scalibregma inflatum*). The other predominant species present in this study but not in such high numbers were; juvenile common mussels (*Mytilus edulis*), the oligochaete (*Tubificoides* spp.) and polychaete species (*Mediomastus fragilis*, *Ophelina acuminata*, *Levensenia gracilis*, *Scoloplos armiger*, *Nephtys* juveniles, *Lumbrineris gracilis*, *Pholoe* sp. and *Chaetozone gibber*). Although the majority of stations showed a relatively uniform community, there was some patchiness in species abundance and dominant species present.

11.3.16 In total 198 infaunal taxa were identified in the samples from 26,421 individuals. A total of 18 epifaunal species were also recorded. Of the fauna recorded, 110 species were annelids, accounting for 55.6% of the total species. The Arthropoda were represented by 45 species (22.7%), the Mollusca by 30 species (15.2%) while the echinoderms, flatworms, phoronids, priapulids, anthozoans, nemerteans and sipunculans accounted for the remaining 6.5% of the total species. Table 11.4 shows the dominant species present at each site.

Table 11.4: Three dominant species present at each site in order of abundance

Note: (P- Polychaeta, B- Bivalvia, C- Crustacea, O- Oligochaeta, Ph- Phoronida).

Site	Dominant spp	Site	Dominant spp
FS01	*Microphthalmus* spp. (P)	FS02	*Mediomastus fragilis* (P)
	Abra alba (B)		*Scoloplos armiger* (P)
	Glycera lapidum agg. (P)		*Melinna palmata* (P)
FS03	*A. alba (B)*	FS04	*A. alba* (B)
	Scalibregma inflatum (P)		*Ophelina acuminata* (P)
	M. fragilis (P)		*Tubificoides amplivisatus* (O)
FS05	*Streptosyllis bidentata* (P)	FS06	*A.alba* (B)
	Protodorvillea kefersteini (P)		*M.fragilis* (P)
	Microphthalmus sp. (P)		*S.armiger* (P)
FS07	*A. alba* (B)	FS08	*Ophelina acuminata* (P)
	S. armiger (P)		*A. alba* (B)
	O. acuminata (P)		*Nemertea*
FS09	*Exogone naidina* (P)	FS10	*Polydora* spp. (P)
	Chaetozone gibber (P)		*A. alba* (B)
	Galathowenia oculata (P)		*Diastylis rathkei* (C)
FS11	*Phoronis muelleri* (Ph)	FS12	*A. alba* (B)
	S. inflatum (P)		*S. inflatum* (P)
	A. alba (B)		*Levensenia gracilis* (P)
FS13	*A. alba* (B)	FS14	*Mytilus edulis* # juv. (B)
	S. inflatum (P)		*A. alba* (B)
	M. fragilis (P)		*S. inflatum* (P)
FS15	*Mytilus edulis* # juv. (B)	FS16	*A.alba* (B)
	A.alba (B)		*S.inflatum* (P)
	M.fragilis (P)		*Melinna palmata* (P)
FS18	*A.alba (B)*	FS19	*A.alba* (B)
	Mytilus edulis # juv. (B)		*S.inflatum* (P)

Site	Dominant spp	Site	Dominant spp
	S.inflatum (P)		*M.fragilis* (P)
FS20	*Nephtys #* juv. (P)	FS21	*S.inflatum (P)*
	M.fragilis (P)		*A.alba* (B)
	A.alba (B)		*Chaetozone gibber* (P)
FS22	*A.alba* (B)	FS24	*S.inflatum* (P)
	S.inflatum (P)		*T.amplivisatus* (O)
	M.fragilis (P)		*Levensenia gracilis* (P)
FS25	*M.edulis #* juv. (B)	FS26	*T.swirencoides* (O)
	S.inflatum (P)		*S.inflatum* (P)
	A.alba (B)		*T.amplivisatus* (O)
FS27	*Levensenia gracilis* (P)	FS28	*Microphthalmus sp.* (P)
	T.amplivisatus (O)		*A.alba* (B)
	Melinna palmata (P)		*M.edulis #* juv. (B)
FS29	*A.alba* (B)	FS30	*A.alba* (B)
	S.inflatum (P)		*S.inflatum* (P)
	Barnea candida (B)		*T.swirencoides* (O)
FS31	*A.alba* (B)	FS32	*A.alba* (B)
	S.inflatum (P)		*S.inflatum* (P)
	Prionospio fallax (P)		*T.swirencoides* (O)
FS33	*A.alba* (B)	FS34	*A.alba* (B)
	Pholoe inornata (P)		*S.inflatum* (P)
	Protodorvillea kefersteini (P)		*Prionospio fallax* (P)
FS35	*A.alba* (B)		
	S.inflatum (P)		
	M.edulis # juv. (B)		

11.3.17 Univariate analysis of the community at each station is shown in Appendix A11.3 (Detailed Estuarine Baseline Information), and shows the number of taxa ranged from 5 to 68 per station; the total abundance of individuals varied greatly, owing to patchiness of some dominant species, ranging between 6 and 2,913 per station ($0.1m^2$). Stations FS02, FS33, FS34 and FS35 had the highest numbers of species present, whereas FS10, FS11 and FS12 had the least number of species. FS14 and FS30-32 had the highest numbers of individuals and FS10, FS05 and FS12 had the least number of individuals.

11.3.18 The results of multivariate analyses of subtidal community data are provided in Appendix A11.3 (Detailed Estuarine Baseline Information). The results indicate that over the majority of the survey area the community characteristics are relatively consistent with any differences observed related to sediment type and depth.

11.3.19 The dry weight of fauna was calculated from the wet weight using conversion factors described by Eleftheriou & Basford (1989). The biomass of the sublittoral fauna by station ranged from $0.0008g^{-1}m^2$ (FS10) to $4.39g^{-1}m^2$ (FS32). The fauna across all stations had a total biomass of 22.82g, more than half of which was made up of polychaetes (14.85g) and a significant proportion of molluscs (6.31g).

11.3.20 No correlations between the communities and the metallic and non-metallic contaminants were found, while the environmental parameters governing the distribution of the communities were found to be depth and sediment granulometry. Elliott & Kingston (1987) also found community size and diversity to be related to depth and sediment type. However, whilst the patchy communities observed can be explained by parameters such as depth and sediment granulometry, it is also likely these communities are highly influenced by industrial influences, dredging and the depositing

of dredge spoil in the area. Elliott & Kingston (1987) found that in general, the benthos of the coastal areas had a greater variability dependent on anthropogenic stresses superimposed on sedimentary effects.

11.3.21 The subtidal benthos around the study area is typical for the region, and includes no unusual or unexpected species, nor any taxa or habitats of conservation concern.

11.3.22 The quality status of the subtidal communities was assessed using the Infaunal Quality Index (IQI) and *W* statistic, details of which are given in Appendix A11.3 (Detailed Estuarine Baseline Information). IQI results indicate that the quality status of the benthos throughout the survey area ranged between moderate and high with the majority of sites returning good or high status. Similarly, values for the *W* statistic indicate predominantly undisturbed conditions throughout the study area.

Intertidal Faunal Analysis and Biotopes

11.3.23 The area surveyed extended over approximately 4km of the south shore of the Firth of Forth from Society Point in the west to Hawes Pier in Queensferry in the east and over 1.5km of the north shore (see paragraph 11.2.13). Full details of the species identified in the intertidal zones are given in Appendix A11.3 (Detailed Estuarine Baseline Information) whilst the main species and habitats are described below.

11.3.24 The complex array of intertidal environments found within the survey area, allied to the influence of tidal height, results in a wide variety of biological communities with 11 different biotopes (ecological communities) identified. These biotopes and the dominant species are described below with the relevant code in parentheses:

- lichens or small green algae on supralittoral rock (LR.FLR.Lic);
- *Enteromorpha* spp. (green algae) on freshwater-influenced and/or unstable upper-eulittoral rock (LR.FLR.Eph.Ent);
- fucoids (brown algae) in variable salinity conditions (LR.LLR.FVS);
- shingle and gravel shores (LS.LCS.Sh);
- species-rich, mixed sediment shores (LS.LMx.Mx);
- *Pelvetia canaliculata* (brown algae) on sheltered littoral fringe rock (LR.LLR.F.Pel);
- oligochaetes in variable salinity littoral mobile sand (LS.LSa.MoSa);
- *Semibalanus balanoides* (barnacles), *Patella vulgata* (limpets) and *Littorina* spp. (molluscs) on exposed to moderately exposed or vertical sheltered eulittoral rock (LR.HLR.MusB.Sem.Sem); and
- *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock (LR.MLR.BF.PelB).

11.3.25 Habitat biotope maps are provided as Figure 11.8.

Fisheries Baseline

Existing Baseline Data

11.3.26 Fish communities within the Firth of Forth have been studied since the 1970s to examine the functioning of the fish communities, effects of anthropogenic influence and in response to EU Directives. To date, 38 fish species have been identified in the Firth of Forth by SEPA (Appendix A11.3: Detailed Estuarine Baseline Survey Information), ranging from freshwater species with no estuarine requirement, to marine species with an estuarine requirement. Certain species use the estuary as a nursery area or seasonally as adults. Other species, such as salmon (*Salmo salar*),

river lamprey (*Lampetra fluviatilis*), sea lamprey (*Petromyzon marinus*) and eel (*Anguilla anguilla*) migrate through the estuary to spend parts of their lifecycle in fresh or salt water.

11.3.27 The Firth of Forth acts as an important nursery ground for dab (*Limanda limanda*), plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*) and cod (*Gadus morhua*), and an important over-wintering ground for sprat (*Sprattus sprattus*) and herring (*Clupea harengus*) (Elliott et al., 1990). Flounder (*Platyichthys flesus*) use the upper estuary as a nursery ground after spawning in the coastal areas (Elliott et al., 1990). The highest abundances of flounder occur in the subtidal and intertidal areas of the lower estuary in summer and in the upper estuary in winter (Elliott & Taylor 1989).

11.3.28 The intertidal mudflats at Skinflats and Kinneil are utilised by a variety of species including flounder, plaice, whiting, gobies, viviparous blenny (*Zoarces viviparous*), cod, pogge (*Agonus cataphractus*) and dab (Elliott & Taylor, 1989).

11.3.29 Longannet Power Station is situated on the north bank of the Firth of Forth approximately 18km upstream from the Forth Road Bridge. Sampling results have been obtained since 1999 and show 40 species of fish have been impinged on fish screens, installed at the entrance to the cooling water intake (see Table 11.5). This data are a good indication of the species present in the Firth of Forth and include all species identified by SEPA during routine trawling surveys. Herring and sprat represented 40% of all species impinged at Longannet (SEPA, 2008).

Table 11.5: Species collected from the cooling water intake of Longannet Power Station from January 1999 to December 2000 (Greenwood, 2008)

Species (common name)	
Atlantic herring	Gobies
Atlantic mackerel	Greater sandeel
Atlantic salmon	Grey gurnard
Bib / pout	Haddock
Boreal pearlsides (pearlside)	Lesser sandeel
Butterfish or gunnel	Lesser weever
Cod	Ling
Common dab	Pipefish
Common dragonet	Pogge
Common sole	Pollack
Eelpout / viviparous blenny	River lamprey
European eel	Saithe/coley
European perch	Sand smelt
European plaice	Sea snail
European sea bass	Sea trout
European smelt	Silvery cod (silver pout)
Fatherlasher (short-spined sea scorpion or bull-rout)	Sprat
Five-bearded rockling	Thick-lipped grey mullet
Flounder	Three-spined stickleback
Fourteen-spined stickleback [*sic*]	Whiting

11.3.30 Eleven species of fish caught at Longannet have conservation status and therefore are of conservation value. River lamprey is listed in Annex II and V of the Habitats Directive. Atlantic salmon (Salmo salar) is also an Annex II species and a UKBAP listed species. Eel, smelt (*Osmerus eperlanus)*, sea trout (*Salmo trutta*), cod, herring, plaice, sole (*Solea solea*), lesser sandeel (*Ammodytes marinus*) and whiting are UKBAP listed species.

11.3.31 Data from Longannet indicated a decline in total fish abundance between 2001 and 2006 with a reduction in herring and juvenile flounder. Adult flatfish species, cod, whiting and sprat have all shown increases in abundance from 2005.

11.3.32 The Firth of Forth lies in the IVb ICES fishing area. Annual commercial landings from the two local ports; Eyemouth and Pittenweem are recorded by the Scottish Government. The total landings by UK vessels from 2003-2007 are displayed in Table 11.6. The total tonnage of demersal and pelagic fish landed during this period peaked in 2004.

Table 11.6: Live weight of commercial landings by UK vessels from 2003- 2007 at ports Eyemouth and Pittenweem (SG, 2008)

Site		2003	2004	2005	2006	2007
		Tonnes				
Eyemouth	Demersal	1882	2472	1776	1123	437
	Pelagic	-	1	0	0	17
	Shellfish	1002	1295	1235	1965	2403
	Total	**2884**	**3768**	**3010**	**3088**	**2858**
Pittenweem	Demersal	24	103	5	16	7
	Pelagic	0	0	0	0	1
	Shellfish	892	1313	1444	1631	1824
	Total	**916**	**1416**	**1449**	**1648**	**1832**

11.3.33 Elliott et al. (1990) estimated fish population size (Table 11.7) and reported that the Firth of Forth supports 0.54%, 0.45% and 0.05% of the total North Sea stocks of similar sized plaice, cod and herring respectively. These species have been identified as being close to their Safe Biological Limit (SBL) and are therefore vulnerable to a fishery collapse if excessive exploitation occurs (UKBAP, 2007).

Table 11.7: Fish population size estimated for the Firth of Forth (by Elliott et al. 1990)

Species	Maximum population estimate for Firth of Forth (x106)
Sprat	6.04
Herring	2.72
Plaice	1.34
Common dab	5.95
Cod	1.13
Whiting	4.56
Viviparous blenny	6.43

11.3.34 In the outer Firth of Forth there is significant trawling activity for Norway Lobster (*Nephrops norvegicus*), although this does not extend westwards as far as the existing Forth Road Bridge. Crab, lobster, whelk and clams are also landed commercially within the Firth of Forth (SFPA consultation).

11.3.35 A single vessel is known to operate out of Port Edgar, fishing sixty creels for whelk. There are no data currently available on this fishery.

Fisheries Baseline Survey Results (2008)

11.3.36 A detailed description of sites selection, survey methodologies and results are presented in Appendix A11.2 (Detailed Estuarine Survey Methods) and Appendix A11.3 (Detailed Estuarine Baseline Information). Sampling site locations are shown on Figure 11.3.

Intertidal Baseline Conditions

11.3.37 In total 3,045 fish (22 species) were caught during intertidal fish surveys in spring and autumn 2008 (Table 11.8).

Table 11.8: Species recorded during 2008 intertidal fisheries surveys (methods combined)

Species		
Plaice (MA)	Pogge (MA)	Weaver fish (MA)
Flounder (MJ)	Viviparous blenny (ER)	Common goby (MA)
Herring (MS)	Sandeel spp (MA)	Dab (MA)
Greater pipefish (MA)	Three-spined stickleback (FW)	Brill (MA)
Sand goby (MA)	Cod (MA)	Snake pipefish (MA)
Scorpion fish (MA)	Lumpsucker (MA)	Nilsson's pipefish (MA)
Juvenile clupeid (MA)	Pollack (MJ)	
Eel (DA)	Whiting (MA)	

Note: ecological guild in brackets – see Appendix A11.3 (Detailed Estuarine Baseline Information) for description.

11.3.38 Three species dominated the catch across all sites and seasons with juvenile plaice, sand goby (*Pomatoschistus minutus*) and herring dominating 91% of the total catch (54%, 23% and 14% respectively). Dab, sandeel (*Ammodytidae* spp.) and scorpion fish (*Taurulus bubalis*) were numerically dominant over the remaining species.

11.3.39 Five species of conservation value (Table 11.11) were recorded. The four dominant species were plaice, herring, cod and whiting and constituted 54%, 23%, 0.2% and 0.1% of the total catch respectively; a single eel was recorded from the soft mud margins at North Queensferry. The majority of plaice were less than 40mm (total length) in spring and less than 60mm (total length) in autumn, indicating that the intertidal areas are a nursery area. St. Margaret's Marsh and Society Point were the most important areas for species of conservation concern.

11.3.40 Three commercially important species were identified in the intertidal surveys; dab, brill (*Scophthalmus rhombus*) and flounder. These are in addition to the species of conservation value described above.

11.3.41 Site utilisation by intertidal fish species was highly variable, with the north shore sites of St. Margaret's Marsh, Port Laing and St. David's contributing most fish to total catch observed. Large numbers of juvenile plaice characterised the fish communities at these sites, with peaks in abundance in autumn at St. Margaret's Marsh and Port Laing whilst more plaice were observed in spring at St. David's. Sand gobies were also prevalent at these three sites, predominantly during the autumn survey.

11.3.42 Port Laing demonstrated the highest marine diversity of all surveyed sites with 15 species recorded. Whiting, brill, lesser weaver fish (*Echiichthys vipera*), snake pipefish (*Entelurus aequoreus*), Nilsson's pipefish (*Syngnathus rostellatus*) and the three-spined stickleback (*Gasterosteus aculeatus*) were only recorded at Port Laing. The presence of so many different species indicates the importance of the intertidal areas for fish populations. The extensive kelp beds observed immediately below low water might affect the number and diversity of fish observed as they provide shelter from predators and environmental diversity.

11.3.43 During the intertidal fish surveys (push and seine nets) a range of invertebrates was recorded. These incidental sightings are detailed in Appendix A11.3 (Detailed Estuarine Baseline Information).

Subtidal Baseline Conditions

11.3.44 During the subtidal surveys 7,490 fish were recorded, represented by 22 species (Table 11.9). The otter trawls were dominated by herring and whiting, whilst flatfish species and gobies dominated the beam trawls (paragraph 11.2.19).

Table 11.9: Presence of fish species (shaded boxes) at each site and season surveyed for subtidal fish

Species	SPRING				AUTUMN			
	East		West		East		West	
	Otter	Beam	Otter	Beam	Otter	Beam	Otter	Beam
Cod								
Dab								
Dover sole								
Dragonet								
Flounder								
Grey gurnard								
Gunnel								
Herring								
Juvenile gadoid								
Long rough dab								
Long-spined sea scorpion								
Mackerel								
Painted goby								
Plaice								
Pogge								
River lamprey								
Sand goby								
Sandeel spp.								
Sea snail								
Snake pipefish								
Viviparous blenny								
Whiting								

11.3.45 Seven species of conservation value were recorded during the subtidal surveys in 2008; river lamprey, plaice, Dover sole, herring, whiting, mackerel (*Scomber scombrus*) and cod. Three river lamprey were recorded in the spring beam trawl, and three in the spring otter trawl west of the Forth Road Bridge. Lamprey is a listed feature of the upstream Teith SAC, and use the lower estuary as a feeding area while they mature before migrating back to freshwater to spawn. A number of commercially important species was also recorded including flounder and dab. The presence of these species reinforces the results from consultation, which indicated that the Firth of Forth is an important nursery and feeding ground for commercially important species in the adjacent open sea area.

11.3.46 The CPUA and CPUE data for species of conservation and commercial value are presented in Table 11.10.

Table 11.10: Mean, standardised fish catch data for species of conservation and commercial value caught in subtidal trawls

Fish species	Otter (Catch Per Unit Effort, CPUE) (fish/100m)				Beam (Catch Per Unit Area, CPUA) (fish/100m^2)			
	Spring		Autumn		Spring		Autumn	
	East	West	East	West	East	West	East	West
Herring	0.37	0.02	42.42	-	-	-	-	-
Cod	-	0.05	4.7	4.8	-	-	0.28	0.1
Whiting	-	0.43	47.66	27.86	0.36	-	0.52	2.45
Plaice	0.63	0.56	0.93	4.04	1.18	0.34	2.01	2.68
Dover sole	-	-	-	0.02	-	-	-	-
River lamprey	-	0.07	-	-	-	0.05	-	-
Mackerel	-	-	0.02	-	-	-	-	-
Flounder	0.03	0.25	0.2	5.18	-	0.07	-	0.4
Dab	0.03	-	0.29	0.17	0.1	0.02	0.72	0.07

Marine Mammals Baseline

Existing Baseline Data

11.3.47 The data presented within the study were collated from a number of sources, via internet searches, existing literature and from a variety of statutory and non-governmental organisations as listed in paragraph 11.2.6.

11.3.48 A detailed description of the data collation and analysis are presented in Appendix A11.3 (Detailed Estuarine Baseline Information). Figure 11.4 shows key haul out sites for seals and Figures 11.5a, 11.5b and Plot 11.1 presents marine mammal sightings within the Firth of Forth with distances from the proposed location of the Main Crossing shown.

11.3.49 As discussed in paragraph 11.2.12, only marine mammal sightings within the Firth of Forth are assessed, as the conservation status and marine mammal populations outside of the estuary would not be affected by the Main Crossing.

Cetaceans

11.3.50 The southeast coast of Scotland is a moderately rich area for marine mammals compared to the UK but species diversity is relatively low. Seventeen species have been seen in the Firth of Forth and it is regarded by MacLeod (2007) as an important habitat for both resident and transient populations of cetaceans.

11.3.51 Distributional data displayed on Figures 11.5a and 11.5b indicate four species frequently occur in the estuary: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), white-beaked dolphin (*Lagenorhynchus albirostris*) and the minke whale (*Balaenoptera acutorostrata*).

11.3.52 The harbour porpoise was the most frequently recorded species and, being the species that penetrates the furthest upstream, most often sighted near the Main Crossing. Sightings were recorded year round for this species, indicating the importance of this area for this species.

11.3.53 The bottlenose dolphin has a predominantly coastal range, with sightings close to the northern and southern coastline however the species is known to frequent the Firth of Forth. Studies undertaken by Stockin et al. (2006) and Weir & Stockin (2001) reveal evidence suggesting that the animals from the Moray Firth population exploit various feeding grounds over 200km. The bottlenose

dolphins observed in the Firth of Forth are likely to belong to the Moray Firth population and the regular sightings indicate that the Firth of Forth is an important habitat for this species.

11.3.54 The minke whale exploits estuarine, coastal and offshore waters, occurs regularly within 10km of the Main Crossing and is found throughout the Firth of Forth. Minke whale sightings have been recorded within 1km of the Main Crossing, including an incidental sighting near Beamer Rock during ecology surveys for the proposed scheme.

11.3.55 The white-beaked dolphin is an occasional visitor to the Firth of Forth. Carwardine (1995) states this species to be resident in British waters year round, but it is known to have seasonal inshore-offshore movements. High abundances of white-beaked dolphin occurred in the northern North Sea (SCANS-II, 2008) and they may enter the Firth of Forth to exploit various feeding grounds.

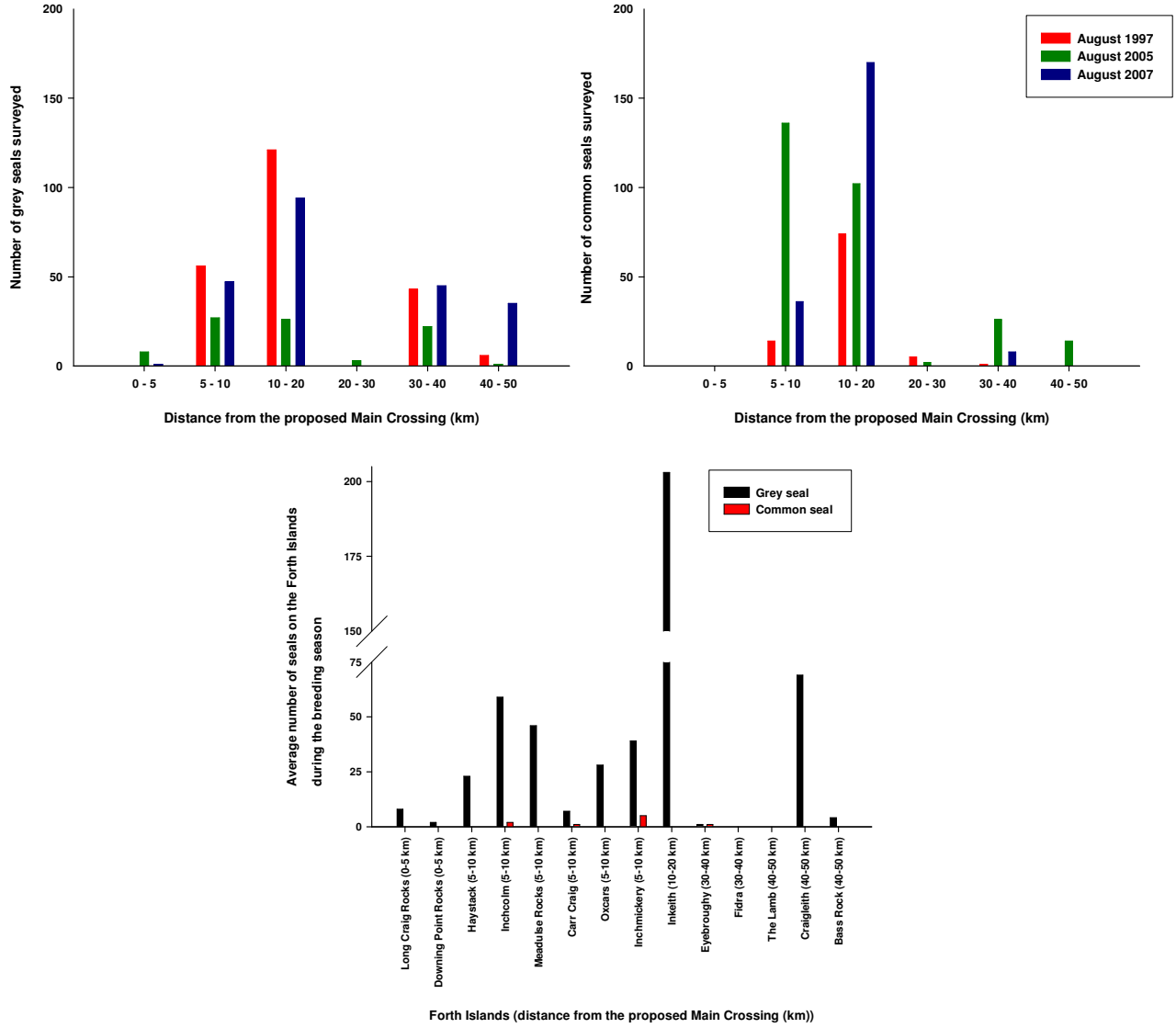
11.3.56 Other cetacean species (including the long-finned pilot whale (*Globicephala melas*), killer whale (*Orcinus orca*), short-beaked common dolphin (*Delphinus delphis*) and Atlantic white-sided dolphin (*Lagenorhynchus acutus*) are regarded as occasional visitors to the Firth of Forth and rarer species (such as the fin whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), beluga (*Delphinapterus leucas*) and striped dolphin (*Stenella coeruleoalba*)) usually occur in the coastal waters to the north and south of the estuary (Figure 11.5b).

Pinnipeds

11.3.57 Plot 11.1 illustrates the number of grey seals (top left) and common seals (top right) counted at various distances from the proposed location of the Main Crossing on one day in August 1997, 2005 and 2007 (data adapted from SMRU (2008)). The lower graph shows the average number of grey and common seals recorded on the Forth Islands during the breeding season between 2002 and 2007 inclusive (data obtained from Forth Seabird Group (FSG) reports 2002-2007).

11.3.58 Both the grey (*Phoca vitulina*) and common seals (*Halichoerus grypus*) frequent the Firth of Forth throughout the year. Plot 11.1 provides a snapshot of pinniped distribution during the moulting season that occurs during August. The numbers of grey and common seals were comparable with the majority of sightings occurring within 20km of the Main Crossing. In general, whilst common seals are sighted in the Firth of Forth, the data obtained from FSG (2002-2007) indicate that they are only occasional visitors to the area.

11.3.59 Grey seals are a rare species globally and individuals in the UK make up a total of 40% of the global population and 95% of the European population. Grey seals breed within 10km of the Main Crossing on the islands of Inchmickery, and Inchcolm, here small numbers of pups have been recorded on a regular basis.



Plot 11.1: Distribution of grey and common seals during the breeding season, at various distances from the Main Crossing

11.3.60 Plot 11.1 indicates that during the breeding season grey seals may be present on the majority of the Islands surveyed with common seals found in low numbers on a few of the Forth Islands including Inchcolm, Inchkeith and Inchmickery.

11.3.61 Many of the Forth Islands are used as haul-out sites for grey seals. This behaviour is not unusual because whilst many migrate long distances to feed in pelagic waters, some seals forage seasonally in waters close to their colonies (Reeves et al., 2002).

11.3.62 A number of incidental sightings of grey and common seals have been made during the surveys undertaken by Jacobs Arup (a full list can be found in Appendix A11.3: Detailed Estuarine Baseline Survey Information) with sightings at Port Edgar, North Queensferry and on Beamer Rock.

Estuarine Birds Baseline

Existing Baseline Data

11.3.63 Consultation was undertaken by MBEC and Faber Maunsell in 2007 & 2008 with a range of statutory and non-statutory consultees regarding previous survey data for the study area and proposed survey methods.

11.3.64 A desk study was undertaken Jacobs Arup to establish the presence of statutory and non-statutory designated sites and bird species within and adjacent to the estuarine bird study areas. Scientific names of bird species recorded are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

11.3.65 A full description of baseline information is presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Coastal Birds

11.3.66 Wetland birds recorded included gulls, terns, divers, grebes, cormorants, herons, swans, geese, ducks, rails, waders and kingfisher as defined by Wetlands International (Rose and Scott, 1997).

11.3.67 A description of the legal and conservation status of birds is provided in Appendix A10.2, Section A10.2.5.

Core Bird Count Sectors

11.3.68 Red list species are those that are globally threatened according to IUCN criteria, those whose population or range has declined rapidly in recent years, and those that have declined historically and not shown a substantial recent recovery. Amber list species are those with an unfavourable conservation status in Europe, those whose population or range has declined moderately in recent years, those whose population has declined historically but made a substantial recent recovery; rare breeders, and those with internationally important or localised populations. Species that fulfil none of the criteria are green listed.

11.3.69 Twenty-eight species of bird were recorded within the three core sector areas comprising eleven species of wildfowl (ducks, divers and geese), six species of gull/petrel and four species of wader. The remaining seven were species of auk, cormorant (*Phalacrocorax carbo*) and tern, together with a single raptor species. The majority of individual birds recorded were species of gull (76%) with wildfowl species accounting for 12% and waders only 2%.

11.3.70 Of the 28 species recorded, two were recorded on the JNCC 'Red' list and 23 were recorded on the JNCC 'Amber' list (JNCC, 2008) while four were also a UK or local BAP species (great crested grebe (*Cristatus Podiceps*), herring gull (*Larus argentatus*), redshank (*Tringa totanus*) and scaup (*Aythya marila*)). Three species are protected by European and national legislation, either Birds Directive Annex 1 or on WCA Schedule 1 or both (peregrine (*Falco peregrinus*), red-throated diver (*Gavia stellata*), scaup). Five species had no conservation classification i.e. green listed.

11.3.71 The average number of species recorded in each sector was similar at 11-13 and lower than the number recorded in the southern and northern sectors. More species were recorded in October than other months. Peak bird numbers were recorded in January-April (263-414) with most in February. Numbers were lower in the September-December period (58-115) with the least number of birds recorded in September.

11.3.72 Full results of the coastal bird surveys for the core sectors are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Northern Bird Count Sectors

11.3.73 In total 55 species were recorded, the majority of which were wildfowl (25 species), waders (12 species) and gulls (seven species). There were also three species auk, three species of cormorants and herons, two species of swans, one raptor (peregrine) and two other species (kingfisher (*Alcedo atthis*) and raven (*Corvus corax*)). Wildfowl accounted for 19% of all bird records, while waders accounted for 34% and gulls accounted for 42%.

11.3.74 Of the 55 species recorded, 13 are protected by European and national legislation including: black-throated diver (*Gavia arctica*), common scoter (*Melanitta nigra*), great northern diver (*Gavia immer*), Greenland whitefronted goose (*Anser a. flavirostris*), kingfisher, peregrine, purple sandpiper (*Calidris maritima*), red-throated diver, scaup, Slavonian grebe (*Podiceps auritus*), velvet scoter (*Melanitta fusca*), whimbrel (*Numenius phaeopus*) and whooper swan (*Cygnus cygnus*).

11.3.75 Forty of the recorded species are also on the JNCC Amber list with five species on the Red list (common scoter, dunlin (*Calidris alpina*), herring gull, lapwing (*Vanellus vanellus*), scaup and whimbrel). Seven of these are also UK or local BAP species (common scoter, great crested grebe, herring gull, kingfisher, lapwing, redshank and scaup) and one species (great crested grebe) was a local BAP species only. A further nine recorded species had no conservation classification.

11.3.76 The average number of species recorded was 17 but the number varied between sectors (6-24). Numbers of birds were generally greatest in the October-February period with most in October (367). The least number of birds recorded was in September (156).

11.3.77 Full results of the coastal bird surveys for the northern sectors are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Southern Bird Count Sectors

11.3.78 A total of 48 bird species were recorded including 18 wildfowl species, 13 waders and six gull species. There were also two species of auk, three species of cormorant and heron, two species of swan, a raptor (peregrine) and three other species and amalgams (kingfisher and raven) and 'gulls'. Wader numbers accounted for 57% of all bird records, whilst 29% were gulls and 12% were wildfowl.

11.3.79 Of the 48 species recorded, nine are protected by European and national legislation (black-tailed godwit (*Limosa limosa*), common scoter, greenshank, kingfisher, peregrine, red-throated diver, Slavonian grebe, whimbrel, whooper swan). Of those recorded, 34 species are on the JNCC Amber list with six species on the Red list (black-tailed godwit, common scoter, dunlin, herring gull, lapwing and whimbrel). Six species are also UK or local BAP species (black-tailed godwit, common scoter, great crested grebe, herring gull, lapwing and redshank). Four species had no conservation classification.

11.3.80 The average number of species recorded in the southern sectors was 18 with a range of 16-21. In general, more species were recorded in October-January and less were recorded in April. More birds were recorded in the southern sectors than in the core or northern sectors.

11.3.81 Full results of the coastal bird surveys for the southern sectors are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Breeding Terns

Common Terns

11.3.82 Two common tern (*Sterna hirundo*) (a Birds Directive Annex 1 and JNCC Amber List species) colonies supporting between 90-100 breeding pairs were recorded within the study area at Long Craig Island and an artificial tern breeding raft within Port Edgar, adjacent to the west breakwater.

Roseate Terns

11.3.83 A pair of roseate terns (*Sterna dougallii*) with fledged young were observed within the study area at the end of the 2007 breeding season. Roseate tern is a Birds directive Annex 1 and JNCC Red List species.

Other Tern Species

11.3.84 No evidence of any other nesting tern species was recorded throughout the study area.

11.3.85 Post breeding aggregations of adult and juvenile sandwich terns (*Sterna sandvicensis*) (a Birds Directive Annex 1 and JNCC Amber List species) from nests out with the study area (such as the Isle of May) used Long Craig Island as a nursery/loafing/roosting area.

11.3.86 Full results of the tern surveys are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Passage Migrants

11.3.87 Ten species of passage migrant, comprising gulls, terns and skuas were observed from the three vantage points. In general, more species and more birds were recorded from VP1 than the other vantage points. The lowest bird numbers were recorded at VP3.

11.3.88 In addition, gannet (*Morus bassanus*) and four species of skua were recorded during the passage period by the sector surveys. Arctic skua (*Stercorarius parasiticus*) is a JNCC Red List species while gannet, great skua (*Catharacta skua*), arctic tern (*Sterna paradisaea*), kittiwake (*Rissa tridactyla*), little gull (*Larus minutus*) and manx shearwater (*Puffinus puffinus*) are JNCC Amber List species.

11.3.89 Full results of the passage migrant surveys are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

Criteria Used to Evaluate Ecological receptors

11.3.90 Baseline data were examined to identify species or habitats with a biodiversity value recognised through legislation or through conservation plans. For the assessment of importance, receptors have been categorised into designated sites, habitats, communities and species. Table 11.11 summarises all receptors identified and their overall ecological value, and provides justification for their selection.

Table 11.11: Summary of identified ecological receptors and justification for their evaluation

Receptor	Value	Justification
Designated Sites		
Teith SAC	International	The River Teith is designated an SAC owing to the significant populations of the three British lamprey species. Atlantic salmon (Annex II species) is also a qualifying feature of this SAC. Species migrate up and down the Firth of Forth to reach the SAC and therefore past the proposed location of the Main Crossing.
Firth of Forth SPA and Forth Islands SPA (including Ramsar site)	International	SPA designation supporting internationally important over-wintering and breeding birds which potentially feed on fry and juvenile fish.
Firth of Forth SSSIs	National	SSSI designation supporting nationally important species which may feed on juvenile fish.
Communities		
Migratory fish species	International	Migratory fish species include salmon, sea trout, sea and river lamprey and European eel (detailed below).
Non migratory fish species	National	Non migratory fish species include important commercial species and species of conservation concern. Fisheries enrich local biodiversity and are important for local recreational fishing (commercial species are addressed individually below). Pelagic and demersal trawling indicated the presence of a range of UKBAP species; plaice, herring, cod, whiting, mackerel and sole. Fisheries enrich local biodiversity and are important for local recreational fishing.
Cetacean populations	International	Consisting of the Annex II species of harbour porpoise and bottle nose dolphins (including SAC populations of the Moray Firth) of international importance and other cetaceans of regional importance.
Pinniped populations	International	Consisting of grey seals of international importance and common seals of national importance, belonging to the designated SAC population situated in the Firth of Tay and Isle of May SAC.
Intertidal benthic communities	Regional	Intertidal benthic communities provide value food resources for a number of key species.
Subtidal benthic communities	Regional	Subtidal benthic communities provide value food resources for a number of key species.
Coastal bird assemblage	International	An assemblage of 60 coastal species, 26 considered to be of international ecological value, nine of national value, three of regional value, 16 of authority area importance and six of local value. Taken together, the coastal bird assemblage is assessed to be of international value. A full detailed list of the species making up this assemblage is given in Appendix A11.3 (Detailed Estuarine Baseline Information).
Breeding terns assemblage	International	All species of terns in this assemblage (common, roseate and sandwich) are considered to be of international value and therefore the tern assemblage is correspondingly evaluated to be of international value. A full detailed list of the species making up this assemblage is given in Appendix A11.3 (Detailed Estuarine Baseline Information).
Passage migrant assemblage	National	Consisting of 10 species, the gannet of national value and all other passage migrant species of regional importance / value. The passage migrant assemblage is therefore evaluated to be of national importance / value. A full detailed list of the species making up this assemblage is given in Appendix A11.3 (Detailed Estuarine Baseline Information).
Species of Conservation/Commercial Value		
Salmon	National	Only Annex II in freshwater environs. In marine environs salmon is a UKBAP species. Salmon is an interest feature of the Teith SAC.
Sea trout	National	Have protection under the Salmon and Freshwater Fisheries Act.
Sea lamprey	International	Annex II, UK BAP.
River lamprey	International	Annex II, UK BAP. River lamprey is associated with the Teith SAC and as such receives protection throughout its migration corridor through the Firth of Forth. River lamprey is common in the upper estuary feeding on herring and sprat. This species requires unimpeded access to spawning grounds and the maintenance of satisfactory adult habitats.
European eel	National	UK BAP species.

Receptor	Value	Justification
Herring	National	UK BAP species and commercially important.
Plaice	National	UK BAP species and commercially important.
Whiting	National	UK BAP species.
Cod	National	UK BAP species, OSPAR and a vulnerable on the IUCN red list.
Mackerel	National	UK BAP and recreational fishery.
Sole	National	UK BAP and commercial species with stocks below safe biological limits.
Harbour porpoise	International	Annex II species of international importance resident in UK waters and occurs regularly in the Firth of Forth.
Bottlenose dolphin	International	Annex II species of international importance and occurs in the region. Those present in the Firth of Forth are likely to belong to the protected SAC population of the Moray Firth.
Grey seal	International	An internationally important species and one which is regularly sighted within the region and is a population that is of significant national importance.
Common seal	National	This species is of national importance and is sighted in the region. Those occurring in the Firth of Forth are likely to belong to the designated SAC population situated in the Firth of Tay.

11.4 Potential Impacts

Introduction

11.4.1 The following section describes the potential impacts that would occur during construction and operation of the Main Crossing, in the absence of mitigation. Each impact is described in turn, with assessments made of the potential impacts to benthic, fish, marine mammal and estuarine bird communities.

11.4.2 All potential impacts reported in the impact assessment are negative unless otherwise stated. These impacts include noise and vibration, habitat loss, disturbance, pollution, and changes in sediment loading. Indirect impacts are also examined such as the bioaccumulation of released contaminants within the food chain.

11.4.3 All potential impacts are assessed in accordance with IEEM guidance. The significant impacts are addressed in detail within this section. Any insignificant impacts are summarised. Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation) discusses in full the insignificant impacts. Where an impact is assessed as significant, mitigation is proposed to avoid, reduce or offset the potential impact in Section 11.5 (Mitigation).

Construction Phase Impacts

11.4.4 The construction activities discussed are those which pose any potential threat to the estuarine environment, the nature and timetabling of these activities are given in Chapter 4 (The Proposed Scheme), Section 4.7.

11.4.5 Though the precise construction methods are as yet unconfirmed, the impact assessments are based on reasonable, informed assumptions on the methods of construction. Potential impacts from construction activities to the estuarine environment are associated with:

- construction of piers and towers in the inter- and subtidal environment which will involve piling and dredging;
- the construction of a temporary causeway for construction traffic on the south bank;
- construction of earth bunds on the high water mark of the north and south shore;
- the construction of a tower on Beamer Rock and the associated works; and
- on-site construction with potential emissions to surface waters.

11.4.6 For the purpose of this assessment the resulting impacts from each of the activities outlined above are summarised in Table 11.12. Detailed discussion of potential impacts is provided in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation).

11.4.7 The associated impacts on the conservation status of the River Teith SAC, Firth of Forth SPA and Forth Island SPA are given in the relevant Appropriate Assessments for these designated sites.

Table 11.12: Summary of potential impacts associated with construction phase of the Main Crossing

Activity	Marine area impacted and duration	Assumed method	Brief description	Potential impact
Excavation of Beamer Rock	Excavation of Beamer Rock (6 Months). Disturbance on Beamer Rock will remain for the duration of the construction period (5 years).	Drill and blast, possibly combined with non-explosive techniques	Drill small holes in rock, plant explosive to fracture and then dig out. Approx. ½m per excavation per cycle. Total of five metres of excavation. Mooring area covering 3,950m^2, foundation base area 5,784m^2 and foundation work area 1,591m^2. Rock extracted will be re-used as back fill to tower foundations.	• Noise/vibration; • habitat loss; • increased vessel movements; • pollution (shipping pollutants, possible spills); • sediment loading and changes in sedimentation; and • physical disturbance.
Piling	Intertidal (1 year).	Impact piling and sheet piling	Alternating force applied to pile to drive into sediment over a duration of time. Piling undertaken from jack-up platform and consists of three metre diameter piles. Material within the piles will be removed. Sheet piling will consist of driving sheets into the ground within the middle of earth bunds (see below). Auger piling consist of the use of a corkscrew like device (auger) to bore in the piles. Vibro piling consists of rapid vibration of the pile to drive it into the ground.	• Noise/vibration; • severance to migration; • habitat loss; • sediment loading and changes in sedimentation; • increased vessel movements; and • pollution (release of sediment bound contaminants, shipping pollutants, possible spills).
	Subtidal (1 year).	Auger piling and vibro piling		
Dredging	Intertidal (only). (Unknown duration).	Pier dredging on north and south shore.	Barge-mounted long arm back actor and around 55 000m^3 of material dredging. Material will not be suitable for re-use. Floating barge which dries out at low water from which a JCB operates. Material dug out and put in another barge moored along side.	• Noise/vibration; • habitat loss; • sediment loading and changes in sedimentation; • increased vessel movements; • pollution (release of sediment bound contaminants, shipping pollutants, possible spills); and • physical disturbance.
Temporary causeway	Intertidal (only). (2 months piling)	Intertidal piling to form trestle to jetty structure.	0.9m diameter (approx.) piles will be installed from barge	• Noise/vibration; • severance to migration;

Activity	Marine area impacted and duration	Assumed method	Brief description	Potential impact
	Structure in place for duration of development (5 years).		and cut off at 0.5m below the existing bed level.	• habitat loss; • sediment loading and changes in sedimentation; • increased vessel movements; • pollution (shipping pollutants, possible spills); and • physical disturbance.
Earth bund south shore	Intertidal Construction eight months, operation. Removal, four months at end of development.	Excavation of weak material; gravel layer followed by sand and rock to build up the bund; sheet piling through bund to prevent water ingress; and a further gravel layer on surface. All material deposited into the marine environment would be subject to FEPA licensing requirements.	120m earth bund will be constructed using tracked excavation. Dump truck delivery (50 deliveries). Crawler crane driven.	• Noise/vibration; • severance to migration; • habitat loss; • sediment loading; and • changes in sedimentation.
Earth bund north shore	Intertidal area only. Four month construction.	Rock fill from material excavated from foundation works. All material deposited into the marine environment would be subject to FEPA licensing requirements.	Dump trucks and tracked excavator.	• Noise/vibration; • severance to migration; • habitat loss; • sediment loading; and • changes in sedimentation.

Noise and vibration

11.4.8 The most likely impact resulting from the construction of the Main Crossing upon fish, marine mammals and estuarine birds is that associated with anthropogenic noise. Anthropogenic noise is a generic term that refers to any man-made sound or vibration which intrudes into the natural environment and which can mask a biologically useful sound (a 'signal'), disturb the natural behaviour of the animals, impair hearing or cause injury. Such anthropogenic noise sources include piling, shipping, dredging, drilling, earth works and underwater and airborne explosives.

11.4.9 An animal's sensitivity to sound varies according to the sound frequency. The response to sound depends on the presence and levels of noise within the range of frequencies to which an animal is sensitive. For most fish, sound above 1kHz is ultrasonic i.e. above their detection range. Marine mammals such as seals, dolphins and porpoises typically hear between 1 and 100kHz, although baleen whales communicate at frequencies below 100Hz (Nedwell & Howell, 2004).

11.4.10 To be audible, a sound 'signal' must be detectable against the background noise, the level of which will determine whether a sound is detectable or not. To mask a sound, the background noise will need to be in an overlapping frequency range (Hammond et al., 2006).

11.4.11 Richardson et al. (1995) define four zones of noise influences, depending on the distance between source and receiver:

- Zone of audibility: the area within which the sound can be detected by the animal.
- Zone of responsiveness: the region in which the animal reacts behaviourally or physiologically. This zone is usually smaller than the zone of audibility.

- Zone of masking: the region within which noise is strong enough to interfere with detection of other sounds, such as communication signals or echo location clicks used to detect prey. This is highly variable, usually somewhere between audibility and responsiveness.
- Zone of hearing loss: the area near the noise source where the received sound level is high enough to cause tissue damage, resulting in either temporary threshold shift (TTS), permanent threshold shift (PTS) or even more severe damage (Thomsen et al., 2006).

11.4.12 Sound levels generated during piling operations are variable and depend on the method, frequency and duration of piling. A report by Nedwell & Edwards (2004) summarised sound levels produced during impact- and vibro-piling operations. Underwater sound levels recorded during piling operations in Southampton Water (Nedwell et al., 2003) ranged between 130 and 150dBre1µPa at a distance of 400m (see Appendix A11.4: Detailed Estuarine Ecology Impacts and Mitigation, paragraph A11.4.1.4 for unit description). It was evident from these measurements that the noise generated through piling operations was not discernible over the background noise. Southampton Water is a busy shipping channel with constant ferry operations and therefore is subject to large background noise levels, similar to those expected in the Firth of Forth.

11.4.13 The following paragraphs describe a review of the piling activities associated with the installation of piles for temporary jetties, bridge towers and approach structure towers and are based on the assumed methods detailed in Table 11.12. This was undertaken by the Jacobs Arup noise team. The review acknowledges that some waterborne noise will be generated but considers that at relatively short distances from the activities the noise will fall below the general ambient noise levels.

11.4.14 The sound exposure level (SEL) is a means of measuring the energy in a sound normalized to a duration of one second. In the smallest fish species, the risk of permanent physical injury starts at just over 190dB SEL. This threshold increases slightly with increasing fish mass, although the risk of mortality reaches 100% at around 210dB SEL.

11.4.15 To make assessments of the impacts of piling noise, the noise tolerances of salmon were used as a guideline. Salmon are neither the most, nor the least sensitive fish species to noise but are a major species of conservation value. Salmon would be expected to demonstrate a mild behavioural response to sound at around 170dBre1µPa and a strong response at 185dBre1µPa and above (see Appendix A11.4: Detailed Estuarine Ecology Impacts and Mitigation, paragraph 1.1.4 for unit description).

11.4.16 Piling activity has been assessed as unlikely to give rise to any risk of morbidity or physical injury to marine life. Risk of physical injury is only likely within 8-10m of the noise source and fish are expected to be well outside this range owing to general construction disturbance.

11.4.17 Noise transmission is discussed further in detail in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation) and summarised below for key ecological receptors.

Benthic Habitats

11.4.18 All potential noise and vibration impacts on benthic habitats and communities have been assessed as insignificant and are summarised at the end of this section and detailed in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation).

Fish

11.4.19 Fish responses to noise are related to the anatomy of their hearing mechanisms. The presence of a swimbladder enhances hearing sensitivity as the bladder acts as a pressure transducer, converting sound pressure to particle velocity.

11.4.20 The impact of anthropogenic noise on fish is not well understood, although the sensitivity of the Atlantic salmon to sound is very much less than that of humans and is at lower frequencies (Vagle,

2003). Therefore, it is thought that fish are more at risk of pressure pulses rupturing the swimbladder than effects on their hearing (Vagle, 2003). Flatfish (e.g. plaice), sea and river lamprey have no functional swimbladder and are relatively insensitive to sound pressure, therefore relying on particle displacement for detection of noise (Turnpenny & Nedwell, 1994).

11.4.21 It has been well documented by Malme et al. (1989, cited in Richardson et al., 1995) that TNT explosions at a depth of 60m created source levels (in the broadband range of 45-7070Hz) ranging between 267-279dBre1µPa at one metre distance (amount of TNT ranging from 0.5kg to 20kg). Although, the proposed construction methods for the Main Crossing will not include the use of explosives at 60m depth, it gives an indication of the high source levels emitted for both small and large amounts of TNT.

11.4.22 Should explosive methods be used in the excavation of Beamer Rock, each event will consist of a discrete, single event with a period of time between blasts where the rock will be excavated.

11.4.23 The noise and vibration emitted during the excavation of Beamer Rock could have a significant, impact on migratory fish in the absence of mitigation. Despite the width of the Firth of Forth and the discrete nature of the blasts the impact would result in mortality of migratory fish close to Beamer Rock at the time of each blast for the duration of works. Following each blast, all migratory fish unaffected by the blast could continue to migrate past the construction area. This potential impact is assessed as being of high magnitude on species of international importance.

11.4.24 The noise and vibration emitted during the excavation of Beamer Rock could also have a significant impact on non-migratory fish in the absence of mitigation. The impact could result in mortality of non-migratory fish at the time of each blast. Following each blast, all non-migratory fish unaffected by the blast would recolonise the area. This potential impact is predicted to be of high magnitude on species of national importance.

11.4.25 Studies in Southampton Water on the effects of pile driving on caged salmonids suggested that no physical effects were experienced between 20-400m from the noise source (Nedwell et al., 2003). Further studies showed that fish showed active avoidance of sound sources within their hearing range (Nedwell et al., 2007). Further details of each study are presented in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation).

11.4.26 Predictions of waterborne noise propagation arising from the construction activities are presented in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation). The predictions indicate the likely impacts on salmonids arising from noise with increasing distance from the source. Together, with additional reference to the works in Southampton Water, the predictions indicate that piling noise will not cause undue concern for salmonids at distances exceeding 10-20m from the sound source.

11.4.27 Migratory species known to be present in the Firth of Forth include the Atlantic salmon and sea trout (both relevant to the aforementioned studies) and the river and sea lampreys, see Appendix A11.3 (Detailed Estuarine Baseline Information). In the absence of mitigation, the piling operations, occurring during the construction of the temporary causeway, earth bunds, piers and towers, could result in a temporary barrier slowing migration, leading to a significant impact on migratory species, typically salmon and sea trout, for the duration of construction. Sound is not predicted to propagate above the levels causing barriers to fish over the whole width of the estuary, and in addition the fish could swim around the areas with high sound levels. Following cessation of piling works, fish will be expected to re-enter the areas previously affected by the highest noise levels. Owing to the width of the estuary, the potential impact is therefore assessed as having a low magnitude on migratory fish species of international importance.

11.4.28 Piling operations could also lead to a significant impact on non-migratory fish species in the intertidal and subtidal communities within the local vicinity of the construction works, for the duration of operations. It is anticipated that during the operations, non-migratory fish species would move away from the noise source and re-enter the area following cessation of piling activity. The

distance of this movement will depend on the propagation of the sound within the channel, the amount of disturbance caused and species-specific tolerances to noise levels. The potential impact has therefore been assessed as having a low magnitude on non-migratory fish species of national importance.

Marine Mammals

11.4.29 The effect of anthropogenic noise on marine mammals is not fully understood at present. It is recognised that noise levels in the sea increased steadily with the onset of industrialisation in the mid-nineteenth century. Very little is known of the impact of noise on the long-term well-being of marine mammals and the ecosystems on which they depend (Ocean-Studies-Board, 2003).

11.4.30 With no reliable information available on the levels of sound likely to cause hearing damage for certain marine mammal species, it has been common practice to transfer human Damage Risk Criteria (DRC) to other mammals. Humans exposed in air, to continuous sound levels 80dB above their absolute hearing thresholds are likely to suffer TTS (Temporary Threshold Shift) and eventual PTS (Permanent Threshold Shift). If DRC is applied to marine mammals we would predict that at low frequencies (<500Hz) TTS would occur at around 165 to 180dBre1µPa in pinnipeds and at around 180 to 210dBre1µPa in small odontocetes. From the limited research to date, this estimation is considered reasonable (Hammond et al., 2006).

11.4.31 Behavioural responses of marine mammals to noise are highly variable and dependent on a suite of internal and external factors (Ocean-Studies-Board, 2003). Behavioural responses can include changes in surfacing patterns, cessation of vocalisations or active avoidance of or exit from, the area with the highest sound levels (Ocean-Studies-Board, 2003). In pinniped species, behavioural responses include the displacement of seals from haul-out sites, seals becoming agitated and/or the display of alert posture (Vella et al., 2001).

11.4.32 Internal factors include individual hearing sensitivity and tolerance, activity pattern, motivational and behavioural state at the time of exposure, past exposure of the animal to the noise (which may have led to habituation or sensitisation) and demographic factors such as age, sex and presence of dependent offspring.

11.4.33 External factors that influence behavioural responses of marine mammals can include the size of the sound source and whether the sound source is stationary or moving (e.g. a vessel, see Appendix A11.4: Detailed Estuarine Ecology Impacts and Mitigation). Physical habitat characteristics can also influence sound transmission, such as being in a confined location or proximity to a shoreline.

11.4.34 The noise associated with the fracturing of Beamer Rock may result in TTS and/or PTS. Studies carried out on Race Rocks near Victoria, British Columbia, found that blasting caused common seals to become increasingly active and a number were displaced from the site; no spatial data regarding the distances over which the animals were affected was reported (DND, 2003). It is likely that similar behavioural responses will be evident at Beamer Rock.

11.4.35 A number of cetacean species have been sighted around Beamer Rock (Figures 11.5a and 11.5b), utilising the area for its food resources. Like pinnipeds, cetaceans are susceptible to noise and vibration and without any mitigation in place; cetaceans may suffer from TTS/PTS.

11.4.36 Since pinnipeds occupy both land and water, they will be susceptible to underwater and airborne noise and vibration occurring throughout the construction phase of the development. The excavation of Beamer Rock would therefore lead to a significant impact on pinniped species. However, pinniped species are known to be less sensitive to sound received in air, compared to sound received underwater (DoC, 2008). In addition, it is likely that pinnipeds will be displaced from the immediate vicinity of the construction site. Therefore, in the worse-case scenario, the noise and vibration from the excavation of Beamer Rock for a duration of six months has been assessed as unlikely to cause PTS. Should PTS occur in some individuals, the integrity of the Firth of Forth

pinniped population would not be affected. The impact associated with blasting, in the absence of mitigation, has therefore been assessed as being of medium magnitude on pinniped populations of international importance.

11.4.37 In the absence of mitigation, the noise and vibration emitted during the excavation of Beamer Rock would also lead to a significant impact on cetacean populations during the duration of operations. However, as displacement/exclusion from the construction area of cetaceans is likely to occur owing to the general construction noise disturbance (Appendix A11.4: Detailed Estuarine Ecology Impacts and Mitigation), the occurrence of TTS or PTS resulting from operations has been assessed as unlikely. The excavation of Beamer Rock has therefore been assessed as having an impact of medium magnitude on cetacean populations of international importance.

11.4.38 It is envisaged that the piling works on the three towers will utilise 3m diameter hollow steel pipes. The construction method is likely to use a jack-up platform where a steel tube will be vibrated down to rockhead and then a large drill will be used to auger out the soils and rock.

11.4.39 It is envisaged that a temporary causeway would be constructed using intertidal pile driving, forming a trestle which will extend from the jetty structure. The piles would be installed from barges and cut off at 0.5m below the existing seabed. The duration of piling is uncertain with activities likely to exceed one year. The temporary causeway will remain in place for the duration of construction (approximately five years).

11.4.40 It is also expected that sheet metal piling will also be utilised within the earth bunds on the north and south shore. A structural coffer dam will be constructed around pier S5 within the temporary earth bund and will consist of sheet piles driven in to the ground.

11.4.41 As pinnipeds spend a significant amount of time on land they are susceptible to airborne noise and vibration from construction activities. It is thought that in air, pinniped species have a similar hearing sensitivity to humans and DoC (2008) state that the hearing range for these species is from 1kHz to 22kHz with sensitivity at 12kHz compared to 1kHz to 180kHz in water with peak sensitivity at around 32kHz.

11.4.42 Cetaceans utilise the Firth of Forth on a regular basis as a hunting ground, and are often seen penetrating upstream within close proximity of the Forth Road Bridge (see Figures 11.5a and 11.5b). It is anticipated that without any mitigation in the form of best practice techniques that any noise emitted from the development may cause TTS or at worst, PTS. High source levels emitted at low frequencies are of particular concern for the minke whale that utilises the lower frequencies for communication and finding prey. The harbour porpoise may demonstrate avoidance behaviour and a temporary drop in acoustic activity. These changes in behaviour will displace populations of cetaceans temporarily towards the estuary mouth whilst the works are carried out and might result in them moving offshore to locate food resources.

11.4.43 Few studies have researched the effect of pile driving on marine mammals with varying conclusions. Pile driving is considered to be a potentially detrimental activity to marine mammals as it generates very high sound pressure levels which are relatively broad-band (20Hz to >20kHz) (Nedwell & Howell, 2004).

11.4.44 The zone of responsiveness to pile driving cannot be reliably assessed for minke whales. However, responsiveness to impulsive sounds occurs in other mysticetes, sometimes at considerable distances (Richardson et al., 1995; Madsen et al., 2006 cited in Thomsen et al., 2006), and the potential of pile-driving noise to alter the behaviour of minke whales cannot be ruled out.

11.4.45 Studies of pile driving activity on an offshore windfarm construction site recorded a temporary drop in acoustic activity of harbour porpoises during piling. However, the activity returned to baseline levels three to four hours later. Temporary avoidance of the area was also observed up to 15km from the piling noise although no observations were made at a greater distance (Tougaard et al., 2005).

11.4.46 Pinnipeds use the Forth islands as haul-out sites (see Plot 11.1) but will often become agitated and disperse in response to human presence and/or approaching vessels. Despite existing disturbances in the Firth of Forth, it is anticipated that any pinnipeds present in the vicinity of the Main Crossing during construction would alter their behavioural pattern and avoid or disperse from the area.

11.4.47 Pinnipeds and cetaceans foraging in the water column within a few kilometres of the Main Crossing would be susceptible to the certain noise and vibration from piling for a duration exceeding one year, potentially causing TTS and/or PTS. In the absence of mitigation, the noise and vibration from piling has been assessed as a significant impact unlikely to have a lasting effect on any populations. This potential impact is therefore assessed as having low magnitude on pinniped and cetacean populations of international importance.

Estuarine Birds

11.4.48 In the absence of mitigation, noise and vibration generated during construction activities have the potential to result in significant disturbance to estuarine birds which could displace bird species that use areas close to the Main Crossing including areas of open water, islands (notably Long Craig Island) and intertidal and shore areas.

11.4.49 Activities likely to result in the generation of airborne noise and vibration impacts are outlined in the previous paragraphs and include the re-location of the sewage outfall at Port Edgar.

11.4.50 The generation of noise and vibration caused by construction activities would lead to a significant impact on estuarine birds for the duration of construction; estuarine birds are expected to be able to recolonise areas following the cessation of construction activity and remain ecologically functional during the operation phase. This potential impact has been assessed as being of low magnitude due to the small extent of the estuary which will actually be affected by the construction of the Main Crossing.

Summary of insignificant impacts

11.4.51 The following noise related impacts were assessed as insignificant and the full justification for these assessments can be found in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation):

- anthropogenic noise on benthic fauna (mobile and sessile);
- noise from dredging activities on fish and marine mammals;
- noise from dump trucks and tracked excavators used to form earth bunds on the north and south shores on benthic fauna, fish and marine mammals;
- noise and disturbance from the relocation of sewage outfall at Port Edgar on benthic fauna, fish and marine mammals;
- noise from vessel movements on fish; and
- general workforce presence/noise and subsequent disturbance on pinnipeds and cetaceans.

<u>Increased Vessel Movements</u>

11.4.52 The construction of the Main Crossing would result in a temporary increase in vessel traffic in the Firth of Forth and surrounding area owing to construction activities and the import/export of materials. Marine vessels have the potential to introduce non-native marine species carried in ballast water or attached to hulls of vessels undertaking works. However, in the context of the already high number of vessel movements within this busy area, the increase in risk will be very small. In the absence of mitigation, the potential introduction of non-native marine species has been assessed as a significant impact although unlikely to occur. This potential impact is therefore assessed as having low magnitude on benthic habitats and fish.

Summary of insignificant impacts

11.4.53 The following vessel-related impacts were assessed as insignificant and the full justification for these assessments can be found in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation):

- vessel anchor drag/propeller wash on benthic fauna; and
- vessel strike on mammals.

Severance to Juvenile Fish Migration Routes

11.4.54 Certain activities associated with construction of the Main Crossing may affect migration of some juvenile fish species. The temporary intertidal causeway and the presence of could result in the fragmentation of juvenile migratory corridors. Species such as lamprey, plaice, eels and gobies utilise selective tidal stream transport (STST), riding favourable tides along high intertidal margins, and sitting out the reverse tide on the bottom or in the lea of structures. Any break in this system may impact on the recruitment success of these key species forcing individuals around the structures into deeper water, where there is an increased risk of predation and loss of orientation to the bed.

11.4.55 The activities associated with construction of the Main Crossing that may affect migration of some juvenile fish species have been assessed as insignificant and detailed in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation). All impacts on interest features of the River Teith SAC are described in detail in the relevant RIAA (Jacobs Arup, 2009c).

Habitat loss

11.4.56 Construction of piers, towers, earth bunds and temporary causeway and relocation of the sewage outfall would involve temporary and permanent loss of intertidal and subtidal benthic habitat with the loss of associated flora and fauna. The construction plans were used to calculate the approximate areas of habitat loss in both the intertidal and subtidal zones.

11.4.57 During construction, an area in excess of 1480m^2 of intertidal habitat would be lost temporarily under the footprints of the pile caps and the earthwork bund associated with pier S6. The total permanent loss will be 950m^2 following the re-establishment of mudflats around the base of the piers.

11.4.58 During construction, an approximate area of 1430m² of subtidal habitat would be lost under the footprints of the pile caps of the three subtidal piers (S1, S2 and N1) and their associated dredged pockets and the piles of the two flanking towers. The total permanent and temporary subtidal habitat loss will be 840m² and 590m² respectively.

11.4.59 Following pier and tower construction, tidal currents are likely to re-establish sedimentary habitat around the piers and towers. The time-scale of this process will be subject to the natural sediment transport regime in the estuary.

11.4.60 Based on hydrodynamic modelling results, the influence of additional tidal scour above that which would occur naturally in the subtidal habitats is likely to be minimal (see Hydrodynamic Impacts, Initial Assessment Report).

Benthic Habitats

11.4.61 Where temporary habitat loss occurs, as a result of the activity footprint, re-colonisation by flora and fauna from surrounding areas is expected to be rapid following completion of activities. However, an initial loss of benthic habitat is certain to occur.

11.4.62 The areas of habitats expected to be permanently lost in relation to the Main Crossing constitute very small proportions of these habitat types within the context of the entire estuary. However, both temporary and permanent habitat loss is predicted to have a significant potential impact in the local area.

11.4.63 The permanent loss of benthic habitat would involve soft substrate habitat being replaced by hard substrate. The temporary loss of habitats will see rapid re-colonisation by flora and fauna from surrounding areas following cessation of construction activity and returning ecological functionality to the habitat. Owing to the total area representing less than 0.01% of the total intertidal area (23.3km^2 (Bennett & McLeod, 1998)) of the Firth of Forth and the loss of subtidal habitat representing even less, both the permanent and temporary loss of intertidal habitats have been assessed as having a low magnitude potential impact.

Summary of insignificant impacts

11.4.64 The following habitat loss related impacts were assessed as insignificant and the full justification for these assessments can be found in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation):

- loss of habitat on migratory and non-migratory fish;
- temporary and permanent intertidal habitat loss on south and north shore and Beamer Rock for pinnipeds;
- habitat loss from the relocation of sewage outfall at Port Edgar on benthic fauna;
- permanent subtidal habitat loss on pinnipeds;
- permanent subtidal habitat loss on cetaceans; and
- loss of intertidal habitat for estuarine birds.

Habitat Gain

11.4.65 Habitat gain as a result of the construction of the Main Crossing has been assessed as insignificant on all estuarine ecological receptors and is detailed in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation).

Airborne Contamination

11.4.66 No impacts of airborne contamination on benthic habitats, fish and marine mammals or estuarine birds exists and therefore no assessments have been made.

Release of Sediment-bound Contamination

11.4.67 The impacts on benthic habitats, fish and marine mammals from the release of sediment-bound contamination for example from dredging or piling activities have been assessed as insignificant and are detailed in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation). Construction information indicates that around 120,000m^3 of material will require to be dredged prior to the construction of the Main Crossing. Using a multiplier of 1.6 this equates to 192,000 tonnes of dredged material. While the disposal site has yet to be defined it is likely that one of the existing licensed disposal sites on the Firth of Forth will be used e.g. Bo'ness. This compares with between 250,510 and 1,139,967 tonnes of maintenance dredging from Grangemouth, disposed of annually in the Firth of Forth off Bo'ness in the Upper Firth, during the period 2003-06 (Scottish Parliament, 2006). All material used for bunds, dredging spoil and piling arising are required to meet FEPA / CPA licence requirements before deposition into the marine environment, therefore the effect of this activity on estuarine ecology is not considered to be significant and has not been assessed within this ES.

Estuarine Birds

11.4.68 The release of pollutants from re-suspension of contaminated sediments during construction (including the re-location of the sewage outfall at Port Edgar), or as a result of accidental spillage, has the potential to bioaccumulate within the food chain. This could affect a range of estuarine bird species although the impact would depend on contaminants and concentration.

11.4.69 The impact from re-suspended contamination has been assessed as unlikely with any populations affected recovering soon after completion of the construction activity. The significant potential impact would be of a low magnitude for estuarine birds.

Chemical Spills from Construction Activities

11.4.70 The spillage of any polluting materials from shipping or construction plant associated with the Main Crossing construction process could result in entry of the material into the estuarine ecosystem. Although the level of impact could be severe and potentially irreversible (depending on the quantity and toxicity of the spilled material) the spatial extent over which contamination is likely to occur should be limited to the immediate vicinity of the construction site.

11.4.71 The ultimate sink for insoluble solids will be the benthos. The exact locations where any spilt material is incorporated into the seabed will depend on whether it first enters the water column or lands directly onto the intertidal habitats during a period of emersion. Again, the distance over which material entering the water column is distributed will be related to local currents, tidal state, water depth and settling velocity of material.

Benthic Habitats

11.4.72 The release of chemical pollutants from construction activities into the subtidal zone is unlikely, but, in the absence of mitigation, would present a significant impact to benthic habitats should it occur. Although any impact associated with the spillage of liquid contaminants could have a permanent impact on benthic habitats the extent of the impact will be influenced by the nature of the receiving environment. Any such materials entering the water column are likely to be rapidly diluted and carried away. Although bed sediments represent the ultimate sink for any contaminants, material originating from the construction of the Main Crossing will be distributed over a wide area. The release of chemicals into the subtidal zone has therefore been assessed as a potential impact of medium magnitude on benthic habitats.

11.4.73 The release of chemical pollutants from construction activities into the intertidal zone is also unlikely. However, as any liquid contaminants falling directly onto exposed intertidal habitats will impact directly on flora and fauna, any associated impacts would be significant and possibly permanent depending on the nature of the sediment. Concentrations may be diluted by the influence of subsequent inundation, with some contaminating material removed by tidal action. Studies have shown that sediment-dwelling, benthic communities can be impacted heavily by petroleum hydrocarbon contamination (e.g. Kingston, 1992). Rocky shore fauna such as herbivorous gastropods are similarly sensitive, although intertidal macroalgae, particularly fucoids are more tolerant to petroleum hydrocarbon contamination (Linden et al., 1979; Conan, 1982; Bokn et al., 1993). Therefore, in the absence of mitigation, the release of chemicals onto the intertidal zone has been assessed a potential impact of medium magnitude on benthic habitats.

Fish

11.4.74 Chemical spills could result in a large number of fish kills in the intertidal and subtidal areas. Such events were assessed as unlikely to occur but if they should, these would present a significant impact on both migratory and non-migratory fish species. Once any spill is cleaned-up and/or dispersed, fish would be expected to re-colonise the affected area. In the absence of mitigation, this potential impact is of medium magnitude on both migratory and non-migratory fish species.

Marine Mammals

11.4.75 Other than the indirect effects of pollution events on the prey species of marine mammals, the main pollution risk to marine mammals is likely to come from shipping pollutants and chemical spills. Many proposed works undertaken within the Firth of Forth involve the use of additional vessels and as such, risk accidental spillages or fuel leaks. In the absence of mitigation, such releases into the environment could adversely affect cetacean and pinniped populations.

11.4.76 The increase in shipping activity associated with the construction of the Main Crossing is described in Chapter 4 (The Proposed Scheme). On a local and regional scale there will be a considerable increase in vessel activity that will be greatest for a period of up to two years and will involve tug boats, safety boats, cranes and dredging/piling barges etc.

11.4.77 Although pollution caused by the release of shipping pollutants and chemical spills is unlikely, it would present a significant impact on pinniped populations; pinnipeds depend on their fur coat for their survival. Nevertheless, despite the significant problems pollution poses to pinnipeds, the population would be expected to recover following a chemical spill. The occurrence of pollution as a result of the increased shipping has therefore been assessed, in the absence of mitigation, as a potential impact of medium magnitude on pinniped populations of international importance.

Estuarine Birds

11.4.78 The release of chemicals into the estuary during construction (including the re-location of the sewage outfall at Port Edgar) has the potential to result in contamination of the food chain upon which estuarine birds feed. This impact could result in the direct mortality of both adults and juvenile birds.

11.4.79 Although the release of chemicals into the estuary during construction is unlikely, in the absence of mitigation, it may present a significant impact to estuarine birds through contamination of the food chain. The release of chemicals into the estuary is considered an impact of high magnitude for estuarine birds.

Summary of Insignificant Impacts

11.4.80 The following pollution related impacts were assessed as insignificant and the full justification for these assessments can be found in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation):

- Impact of chemical spills on cetacean populations.

<u>Changes to Estuarine Hydrodynamic Regime</u>

11.4.81 Activities such as bridge pier construction involving in-channel works, piling, blasting, the use of cofferdams and the re-location of the sewage outfall, have the potential to alter water velocity and sedimentation, which may cause temporary or permanent changes in the local current flow and sediment regime. However, there are no predicted potential impacts during construction on any estuarine ecological receptors.

<u>Sediment Loading and Changes in Sedimentation</u>

11.4.82 The impacts on all estuarine ecological receptors from sediment loading and changes in sedimentation have been assessed as insignificant and are detailed in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation).

<u>Light Pollution</u>

11.4.83 No impacts are predicted on benthic habitats, fish or marine mammals as a result of increased lighting during construction and therefore no assessments are made.

Estuarine Birds

11.4.84 Disturbance of foraging or to roosting sites may occur as a result of increased light pollution.

11.4.85 Light pollution can have adverse impacts and can affect both breeding and foraging behaviour in a number of species of bird. Hill (1992) observed that seabirds were disorientated by street lights on cloudy nights and observed that redshank and oystercatchers were observed feeding within 50m of artificial lighting at night, while flocks of dunlin were observed roosting near to a large roundabout lit by flood lighting.

11.4.86 There is the potential for temporary construction lighting to result in disturbance to estuarine birds within the vicinity of Long Craig Island and Port Edgar Marina. These impacts are assessed as being of low magnitude.

Operational Phase Impacts

11.4.87 Following construction very limited impacts associated with the operation of the Main Crossing are predicted on estuarine ecological receptors. Noise and vibration from road traffic are predicted to be minimal and have no significant impacts. Likewise, the impacts from carriageway lighting on the Main Crossing on migrating fish or estuarine birds will have no significant impact and the day-to-day operation of the Main Crossing, introducing pollutants to the Firth of Forth via run-off will have no significant impact. All insignificant impacts are discussed in full in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation). Impacts associated with nitrogen deposition are assessed as insignificant and are discussed in Appendix A10.7 (Terrestrial and Freshwater Ecology: Impacts and Mitigation, Section A10.7.2: Pollution – Operation). The following comprises a description of the type of significant impacts that could occur during the operational phase.

Road Traffic Accident on Main Crossing

All Ecological Receptors

11.4.88 The biggest risk is posed by an accident on the Main Crossing where large quantities of liquid are discharged, such as fuel, industrial chemicals, fire fighting foam and food substances (e.g. milk). The predicted accidental spillages risk for Main Crossing is 0.0387% Annual Exceedence Probability (AEP), return period 1 in 2,582 years (Appendix A9.4: Water Quality - Road Drainage Assessment) and therefore the likelihood is extremely unlikely (Jacobs Arup, 2008c). Consequently, no further measures are required to reduce the risk of such an incident any further. However, with the drainage system proposed, if such an event occurred it could have a significant impact on ecological receptors and depending on the nature of a spillage, the ecological receptors in the Firth of Forth could take decades to recover. This potential impact has been assessed as being of medium magnitude for all benthic habitats, fish and marine mammals and of high magnitude for estuarine birds in the vicinity of the Main Crossing in the very unlikely event should an incident occur. Depending on the type of pollution this could cause direct mortality and impact breeding success of internationally important bird species and would have implications for the integrity of internationally designated sites.

Severance to Migration

Estuarine Birds

11.4.89 A study on four bridges in Hong Kong and Macau (Ove Arup, 2002) recorded no bird collisions during a four month period and demonstrated that flying birds avoided collision by gaining altitude or flying under the bridge.

11.4.90 A 2006 study showed that there was little evidence that the M4 Severn Road Bridge affected the feeding, distribution or roosting behaviour of wading birds (Halton Borough Council, 2008). This is of particular interest since the Severn Estuary is a site of international importance for wading birds

and wildfowl and is classed as a SSSI, a SPA a Ramsar site and as an Important Bird Area by Birdlife International. The authors carried out a literature review regarding the site and the crossing and found no evidence that the crossing was a current or future threat to the wading bird interest.

11.4.91 There did appear to be a short-term impact of the M4 Severn Road Bridge on curlew, dunlin and lapwing, as their flight paths were altered and the birds appeared to prefer to fly over the bridge. However, this effect was short-lived and the birds returned to their normal flying height.

11.4.92 Assessments at smaller developments in the UK have also suggested that bridges are not likely to cause problems for bird behaviour in the longer term. A report on mute swans and a potential new road suspension bridge over the River Thames indicated that the bridge would have only a temporary effect (WWT Wetlands Advisory Service, 2004). The report pointed out that the less visible the bridge or cables were, the more likely it would be that swans would fly into them. The authors concluded that careful bridge design would minimise collision, including ensuring that the bridge and construction equipment are clearly visible both day and night and during poor daylight conditions.

Summary of Insignificant Impacts

11.4.93 Operation of the Main Crossing is unlikely to result in any increased fragmentation/severance effects owing to the presence of the proposed scheme, the Forth Road Bridge and the Forth Rail Bridge. Therefore any negative impact on estuarine birds has been assessed as insignificant and of low magnitude.

11.5 Mitigation

Introduction

11.5.1 This section of the chapter outlines measures to prevent, reduce or offset the significant potential impacts (identified in Section 11.4) of the Main Crossing on the receptors identified in Table 11.11. Each mitigation measure is detailed in full in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation). A summary of the Schedule of Environmental Commitments is provided in Chapter 23, Table 23.5.

11.5.2 The principles and objectives for mitigation associated with the Main Crossing have been developed through discussion with SNH, SEPA and other relevant stakeholders (Chapter 6: Consultation and Scoping).

11.5.3 Mitigation measures are applicable during construction and operation and include Best Practice methods and principles applied to the Main Crossing as a whole (generic measures) (see paragraphs 11.5.5 and 11.5.6) and site-specific mitigation measures applied to individual activities (specific measures) (see paragraphs 11.5.7 to 11.5.32).

11.5.4 IEEM guidelines for ecological impact assessment suggest that professional judgement should be used when determining if specific mitigation is required. Wherever possible, mitigation measures should be developed and incorporated into the project and priority should be given to the avoidance of impacts at source whether through re-design of the project or through regulation of timing or locations of activities (IEEM, 2006).

Generic Mitigation

11.5.5 Generic mitigation measures that apply to all significant impacts on ecological receptors across the Main Crossing are outlined in full in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation) and Chapter 23 (Schedule of Environmental Commitments) and summarised in the following points:

- pre-construction surveys will be undertaken as appropriate prior to commencement of project works in order to identify sensitive sites and vulnerable species. These include intertidal biotope surveys, water quality surveys and estuarine bird surveys (mitigation item EE1);
- plant and personnel will be constrained to a prescribed working corridor through the use of temporary barriers, thereby minimising damage to habitats and potential direct mortality and disturbance to species (mitigation item EE2);
- suitably constructed structures including access roads/bridges with fencing and visual screens will be created on intertidal commuting corridors (mitigation items EE3/EE14);
- an Ecological Clerk of Works (ECoW) to be present on site to monitor construction works (mitigation items EE4/EE14/EE15/TE1);
- development of a Code of Construction Practice (CoCP), incorporating industry Best Practice (mitigation item EE5); and
- adherence to SEPA pollution prevention guidelines e.g. PPG1, PPG2, PPG5, PPG7, PPG8, PPG13, PPG21 and PPG26 (mitigation item EE6).

11.5.6 The Code of Construction Practice is provided as Appendix A19.1 to Chapter 19 (Disruption Due to Construction).

Specific Mitigation

11.5.7 In addition to the provision of generic mitigation measures, a range of specific mitigation measures are proposed to avoid or reduce potential impacts on ecological receptors due to the Main Crossing.

Construction Mitigation - Noise and Vibration

Fish

11.5.8 Blasting and piling activities will create noise disturbance, hearing impairment, mortality or avoidance in the water that will impact upon migratory and non-migratory fish populations.

11.5.9 Mitigation measures (mitigation item EE7) proposed to reduce blasting impacts are:

- Consider undertaking explosive excavation within Beamer Rock so that edges of the Rock act as noise buffers reducing emissions to water.
- Use a string of explosions milliseconds apart to reduce the peak emission rather than one explosion that will reach a higher peak emission (JNCC, 2008).
- Use acoustic deterrents at appropriate frequency during key construction periods and bubble curtains if appropriate, to attenuate sound waves. An equipment maintenance programme will be required.
- Aim to undertake explosive excavation in intertidal zones during low water periods to restrict underwater noise (i.e. when area is exposed).
- Incorporation of non-explosive techniques for fracturing rock, where constructionally effective.
- The dBht $_{(salmon)}$ should not exceed the maximum tolerance exposure for this species across e.g. 50% of the river, thus enabling migrating salmon to pass the construction area. The remaining 50% would be permitted to experience levels above this, provided all other mitigation listed here is implemented.

11.5.10 Mitigation measures proposed to reduce piling impacts (mitigation item EE8) are:

- Consider using a low noise alternative to impact piling resulting in less noise than impact piling and will reduce the physical injury to resident fish species and produce less of an acoustic barrier to migratory species.
- Use of a 'soft-start' approach where-by the noise level is increased gradually, fish can escape the area prior to full-scale operation.
- Use acoustic deterrents at appropriate frequency during key construction periods to deter fish and bubble curtains where practicable to attenuate sound waves. An equipment maintenance programme would be required to service and maintain the efficiency of this equipment.
- Best Practice piling procedures to be followed with guidance taken from JNCC procedures (JNCC, 2008).

Marine Mammals

11.5.11 Blasting and piling activities will create noise disturbance, hearing impairment, mortality (PTS/TTS) or avoidance in the water that will impact upon marine mammals.

11.5.12 Mitigation measures proposed to reduce blasting impacts are as summarised in paragraph 11.5.9 (mitigation item EE7) with the addition of (mitigation item EE9):

- A trained Marine Mammal Observer (MMO) to be present during blasting to enforce a mammal mitigation zone. The mitigation zone will be set dependant on the predicted/measured noise levels. The mitigation zone should be surveyed by a MMO for at least one hour prior to detonation (JNCC, 2008).
- Passive Acoustic Monitoring (PAM) to be used by a trained operative to identify mammals within the mitigation zone for one hour prior to detonating charges. When marine mammals are known to be present within mitigation zone no charges are to be detonated (JNCC, 2008).
- If a marine mammal is observed or acoustically detected within the mitigation zone, it is to be monitored and tracked until it moves out of the zone. If, once detected, the marine mammal is not spotted again for 30 minutes, it is to be assumed that it has left the area. The use of explosives should not commence until at least 30 minutes after the last detection of a marine mammal (JNCC, 2008).

11.5.13 Mitigation measures proposed to reduce piling impacts are as summarised in paragraph 11.5.10 (mitigation item EE8) with the addition of:

- A trained Marine Mammal Observer (MMO) to be present during piling to enforce a mammal mitigation zone. The mitigation zone will be set dependant on the predicted/measured noise levels but be no smaller than 500m radius from the pile head and the MMO should follow JNCC guidance on minimising the risk of disturbance and injury to marine mammals (JNCC, 2009) (mitigation item EE9).
- Passive Acoustic Monitoring (PAM) to be used by a trained operative to identify mammals within the mitigation zone prior to piling. Piling should not commence if marine mammals are detected within the mitigation zone or until 20 minutes after the last visual or acoustic detection. The PAM operative should follow JNCC guidance (JNCC, 2009) (mitigation item EE9).
- Should marine mammals be detected within the mitigation zone during the soft-start, then piling should cease or reduce power until the mammal exits the mitigation zone and there is no further detection for 20 minutes (JNCC, 2009) (mitigation item EE9).

Estuarine Birds

11.5.14 Construction activities (including the re-location of the sewage outfall) would create visual and noise disturbance, hearing impairment, mortality or avoidance of estuarine birds.

11.5.15 Mitigation measures required to prevent disturbance impacts to estuarine birds include:

- Visual screens to be installed along the perimeter of the temporary trestle bridges on both shores to reduce the impact of construction activities on birds using adjacent areas of the Firth of Forth (mitigation item EE14).
- A clear working site boundary will be marked out and an Ecological Clerk of Works (ECoW) will provide tool box talks to ensure compliance with working within the construction site boundary to minimise the risk of disturbance outside it. The ECoW will also monitor the adherence to working within the site by contractors (mitigation items EE2/EE5).
- For boats/barges transporting personnel and supplying materials for construction, Jacobs Arup (in consultation with SNH and the Harbour Master) will identify where construction boat traffic is not permitted so that the constructor can stipulate routes in consultation with the Harbour Master. The compliance of boats/barges to defined routes will be determined by ECoW (mitigation item EE15).
- No construction boat traffic including small water vessels to go within 100m of Long Craig Island (except in the case of an emergency). The compliance of boats/barges to defined routes will be determined by ECoW (mitigation item EE15).
- If in exceptional circumstances, encroachment within 100m of Long Craig Island is unavoidable, prior approval by an ECoW will be required and the ECoW will over see the specified activity (mitigation item EE15).
- Between 15th August and 31st October, works for the relocation of the sewage outfall will not take place at night-time (between 1 hour before dusk and 1 hour after dawn) and within 200m and in direct view of the Port Edgar floating tyre raft at night-time (mitigation item EE18).

11.5.16 Mitigation measures required to reduce piling impacts on estuarine birds include:

- Use of a 'soft-start' approach where-by the noise level is increased gradually prior to full-scale operation (mitigation item EE11).
- Monitoring of noise levels from construction activities to be undertaken at Long Craig Island during the breeding season for terns (May to mid-August) and at Long Craig Island and Port Edgar tyre raft from 60 minutes before sunset until sunrise between mid-August and October (mitigation item EE13).
- ECoW present to identify and assess noise levels during works (mitigation item EE4).

Increased Vessel Movements

11.5.17 The construction of the Main Crossing would result in a temporary increase in vessel traffic in the Firth of Forth and surrounding area due to construction activities and the import/export of materials.

11.5.18 The following mitigation measures are proposed to reduce the risk of the introduction on non-native marine species:

- Vessels involved in the construction activities for the FRC should adhere to the industry recommended guidelines for preventing the introduction of non-native marine species. UKMarineSAC (2009) recommends that vessels comply with International Maritime Organisation guidance wherever possible, seek guidance from the local port authority regarding areas where ballast water uptake should be avoided (e.g. near sewage outfalls), encourage the exchange of ballast water in the open ocean, and discourage/prohibit the unnecessary discharge of ballast water in port and harbour areas (mitigation item EE19).

Construction Mitigation - Habitat Loss

Benthic Habitats

11.5.19 Piling and dredging activities would cause direct mortality of benthic fauna in the location of the proposed activity.

11.5.20 Mitigation measures proposed to reduce habitat loss include:

- Follow best practice piling and dredging procedures (mitigation item EE8).
- Minimise activity footprint outside of identified works corridor (mitigation item EE16).

Release of Sediment-bound Contamination

Estuarine Birds

11.5.21 Re-suspension of sediment-bound contamination has the potential to bioaccumulate up the food chain to cause mortality on estuarine birds. Mitigation measures proposed to reduce the impacts are:

- Follow best practice procedures (mitigation item EE6).
- Minimise dredging footprint and activity outside of identified works corridor (mitigation item EE16).

Construction Mitigation – Chemical Spills

Benthic Habitats

11.5.22 Chemical spills (i.e. fuel and oil) could cause mortality to benthic habitats, the scale of which will be dependant on the toxicity and quantity of the spillage.

11.5.23 Mitigation measures proposed to minimise risk of pollution impacts:

- Follow best practice pollution prevention procedures (e.g. SEPA's Pollution Prevention Guidance) (mitigation item EE6).
- Develop and follow a CoCP to consider and address all pollution risks and implement an emergency pollution response plan (mitigation item EE5).
- ECoW to be present on site (mitigation item EE4).

Fish

11.5.24 Chemical spills could cause mortality or skin lesions to fish populations depending on the toxicity and quantity of the spillage.

11.5.25 Mitigation measures proposed to minimise pollution impacts on fish are summarised in paragraph 11.5.23.

Marine Mammals (pinnipeds)

11.5.26 Chemical spills would cause mortality to pinniped populations depending on the toxicity and quantity of the spillage.

11.5.27 Mitigation measures proposed to minimise risk of pollution impacts on pinnipeds are summarised in paragraph 11.5.23.

Estuarine Birds

11.5.28 Chemical spills would cause mortality to estuarine bird population depending on toxicity and quantity of the spillage.

11.5.29 Mitigation measures proposed to minimise risk of pollution impacts on estuarine birds are summarised in paragraph 11.5.23.

Construction Mitigation – Light Pollution

Estuarine Birds

11.5.30 Light pollution will significantly impact estuarine bird populations. Mitigation measures proposed to minimise this impact include:

- Design of lighting arrangements to ensure minimal light spillage out with the boundary of the construction the sites and associated site compounds: compliance to be determined by ECoW (mitigation item EE17).
- Monitoring of construction site lighting to be undertaken at night by ECoW to identify any potential adverse impacts on birds (mitigation item EE17).
- Monitoring of construction site lighting to be undertaken at night by ECoW to identify potential adverse impacts on birds and implement appropriate procedures to reduce/confirm levels (mitigation item EE17).

Operation Mitigation – Road Traffic Accident on Main Crossing

All Ecological Receptors

11.5.31 The impact of a major spill into the Firth of Forth would impact on all ecological receptors. Mitigation measures proposed to minimise operational pollution impacts include:

- Follow best practice pollution prevention guidelines (mitigation item EE6).

11.5.32 As noted in paragraph 9.4.148 of Chapter 9 (Water Environment), due to the ecological sensitivity of the intertidal habitat the proposed scheme design ensures that routine runoff from the Main Crossing over the intertidal areas on the north and south shores would be taken back to land. This would then be subject to treatment (refer to description of SUDS mitigation in Chapter 9: Water Emvironment) prior to outfall to the Firth of Forth.

11.6 Residual Impacts

11.6.1 With the mitigation detailed in Section 11.5 and in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation) in place, the impacts determined to be significant were re-assessed. This section provides a re-assessment of significant construction and operation phase impacts with the mitigation outlined in Section 11.5 applied. Despite the mitigation measures in place, some impacts remain significant although the likelihood of the impact occurring is much reduced.

11.6.2 As noted in Section 11.2 (Approach and Methods), reports to inform the Appropriate Assessment (RIAA) of potential impacts on the integrity of the Forth Islands SPA (incorporating Imperial Dock Lock, Leith SPA), Firth of Forth SPA and River Teith SAC have been prepared in parallel with the EIA. These demonstrate no significant effect on the integrity of these designated areas or their conservation objectives. A short summary of the RIAAs is included in Section 11.7.

Construction Phase Residual Impacts

Noise and vibration

11.6.3 Using the mitigation measures described in paragraphs 11.5.10, and 11.5.13, the potential impacts of noise and vibration from piling activity on migratory and non-migratory fish and marine mammals have been assessed as extremely unlikely to occur. Should this occur, it would result in a residual impact of low magnitude, fish populations are expected to return to previous numbers once piling activities cease.

11.6.4 Mitigation as outlined in paragraph 11.5.16 will reduce the potential impact of piling noise and vibration on estuarine birds with impacts unlikely to occur. Should this occur it would result in a

residual impact of low magnitude. Bird populations are expected to return to the area once piling activities cease.

11.6.5 With mitigation in place for the noise and vibration impacts resulting from the excavation of Beamer Rock (as described in paragraph 11.5.9) on migratory and non-migratory fish are unlikely to occur. A significant residual impact would be of low magnitude, with fish populations expected to return to previous numbers once excavation activities cease.

11.6.6 Mitigation as outlined in paragraphs 11.5.9 and 11.5.12 for marine mammals, would reduce the potential impacts of the noise and vibration resulting from the excavation of Beamer Rock. Impacts are extremely unlikely to occur and would result in an insignificant residual impact of low magnitude. Mammal populations are expected to return to the area once excavation activities cease.

11.6.7 Paragraph 11.5.13 outlines mitigation measures for impacts associated with piling activities on marine mammals. These measures would reduce the potential impacts of the noise and vibration resulting from piling operations. Impacts are extremely unlikely to occur and would result in an insignificant residual impact of low magnitude. Mammal populations are expected to return to the area once piling activities cease.

11.6.8 The impacts on estuarine birds from the noise and vibration resulting from the excavation of Beamer rock with the mitigation described in paragraph 11.5.15 are unlikely to occur, but would result in a residual impact of low magnitude, with bird populations expected to recover post excavation. Further information regarding this residual impact is provided with the following reports:

- Report to Inform an Appropriate Assessment for the Forth Islands and Imperial Dock Lock, Leith SPAs (Jacobs Arup, 2009a); and
- Report to Inform an Appropriate Assessment for the Firth of Forth SPA (Jacobs Arup, 2009b).

Increased Vessel Movements

11.6.9 The mitigation for the impact of the introduction of non-native marine species on benthic habitats and fish is described in paragraph 11.5.18. With this mitigation in place, the potential impact is extremely unlikely to occur and the residual impact of low magnitude.

Habitat Loss

11.6.10 The mitigation for the impacts of temporary and permanent habitat loss on benthic habitats is described in paragraph 11.5.20. With this mitigation in place, the potential impacts of temporary benthic habitat loss are certain to occur resulting in a residual impact of low magnitude. Benthic fauna and flora will rapidly recolonise and establish in these areas once the construction is complete. The potential impacts from the permanent habitat loss associated with the Main Crossing construction are also certain to occur resulting in a residual impact of low magnitude. The area that would be impacted is small compared to the total area of intertidal habitat within the Firth of Forth and some degree of habitat creation would occur in the form of the hard structures of the Main Crossing.

Release of Sediment-bound Contamination

11.6.11 Mitigation as outlined in paragraph 11.5.21 for estuarine birds would reduce the impact of the release of sediment-bound contaminants resulting from dredging and piling activity and impacts are extremely unlikely to occur, but would be a residual impact of low magnitude. Bird populations are expected to recover from such an impact.

Chemical Spills

11.6.12 Mitigation as outlined in paragraphs 11.5.22 to 11.5.29 for all receptors (benthic habitats, migratory and non-migratory fish, pinniped populations and estuarine birds) would reduce likelihood of a chemical spill during the construction phase and an impact is extremely unlikely to occur. Should a spill occur it may result in a significant residual impact of low magnitude. In this case the risk of an impact remains. The nature of a spillage and its full effects could result in any one of a number of possibilities and therefore the assessment must take the worse case into account.

Light Pollution

11.6.13 Mitigation as outlined in paragraph 11.5.30 for estuarine birds would reduce the potential impact of light pollution. An impact is extremely unlikely to occur, should this occur it may result in a residual impact of low magnitude, however bird populations are expected to recover from such an impact.

Operational Phase Residual Impacts

Road Traffic Accident on the Main Crossing

11.6.14 The mitigation for a chemical spill resulting from a road traffic accident on the Main Crossing is described in paragraph 11.5.31. With this mitigation in place, the impact of a spillage from a road traffic accident on the Main Crossing on all receptors (benthic habitats, migratory and non-migratory fish, marine mammals and estuarine birds) is extremely unlikely to occur, but would result in a significant residual impact of low magnitude.

11.7 Appropriate Assessment

Legislative Background

11.7.1 An Appropriate Assessment (AA) considers the potential impacts of a proposed development (plan or project) on a European site. Under Regulation 48(1) of the Habitats Regulations, the 'competent authority', in this case the Scottish Government, must undertake an appropriate assessment of the implications for the site in view of the site 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".*

11.7.2 The term European site refers to Special Areas of Conservation (SACs) designated under the Habitats Directive (92/43/EEC) and Special Protection Areas (SPAs) classified under the Birds Directive (79/409/EEC), collectively known as Natura 2000 sites.

11.7.3 A report to inform a strategic Appropriate Assessment for the proposed scheme (Jacobs/Faber Maunsell/AECOM, 2007) 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 British law in Regulation 49 of the Habitats Regulations).

11.7.4 Discussions with SNH provided advice on the need and scope for the scheme's RIAAs (Jacobs Arup 2008d). Four Natura 2000 sites were identified as potentially significantly affected by the scheme and therefore requiring AA. The four Natura 2000 sites identified were: Forth Islands SPA, Imperial Dock Lock, Leith SPA, Firth of Forth SPA and the River Teith SAC. The Forth Islands SPA and Imperial Dock Lock, Leith SPA are reported together in one report.

The Forth Islands SPA and the Imperial Dock Lock, Leith SPA

11.7.5 The Forth Islands SPA consists of seven islands, together with outlying rocky islets, in the Firth of Forth. The islands of Bass Rock, Craigleith, Fidra, Inchmickery, Isle of May and The Lamb were originally classified on 25 April 1990. The Forth Islands SPA was extended to include the island of Long Craig on 13 February 2004. Lying underneath and to the east of the existing Forth Road Bridge, Long Craig Island is the closest component area of the Forth Islands SPA to the proposed alignment of the new bridge.

11.7.6 A copy of the conservation objectives for both SPAs, together with a list of the qualifying species, are presented in the on the SNH's SiteLink website (2008) and Forth Islands SPA and the Imperial Dock Lock, Leith SPA RIAAs (Jacobs Arup, 2009a). The published conservation objectives for the Forth Islands SPA do not include reference to fulmar as a qualifying species, although SNH has advised that fulmar should be considered as such for the purposes of the Appropriate Assessment for the proposed scheme. Other qualifying species include gannet, shag (*Phalacrocorax aristotelis*), lesser black-backed gull (*Larus fuscus*), puffin (*Fratercula arctica*), cormorant, kittiwake (Rissa tridactyla), guillemot (*Uria aalge*) and razorbill (*Alca torda*).

11.7.7 The Imperial Dock Lock, Leith SPA, classified in September 2004, is a man-made structure at the mouth of the Imperial Dock Lock in the Port of Leith. The single qualifying species for this SPA is the Annex 1 species common tern. The SPA citation for the Imperial Docks notes that in recent years the common tern colony at the docks has been the largest in the Firth of Forth and one of the largest in Britain. The Imperial Docks Locks, Leith SPA lies 15 km from the alignment of the proposed scheme.

Firth of Forth SPA

11.7.8 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 Firth of Forth is one of the most important shipping areas in Scotland.

11.7.9 The Firth of Forth SPA is designated for: five Annex I species qualifying under Article 4.1 of the EU Birds Directive; five migratory bird species under Article 4.2 (Table 11.14) and its large overwintering waterfowl assemblage (10 individually cited species plus an additional 16 wildfowl and Sandwich terns). The Firth of Forth qualifying species and conservation objectives are provided in the RIAA for the Firth of Forth SPA and are also available on the SNH's SiteLink website (2008).

River Teith SAC

11.7.10 The River Teith SAC (EU Code: UK0030263) is the most significant tributary of the River Forth, flowing eastward through Central Scotland and discharging into the Firth of Forth west of Stirling, approximately 35km in a direct line upstream of the Main Crossing. The SAC includes both the main stem of the river and some important tributaries extending to 143.76km and covers an area of 1312.4ha.

11.7.11 The primary reasons for the designation of the River Teith as a SAC are the presence of significant populations of the three British lamprey species; brook lamprey, river lamprey and sea lamprey, with Atlantic salmon also present as a qualifying feature. Freshwater pearl mussels have been recently found within the catchment, but are not a designated feature of the SAC.

11.7.12 Atlantic salmon, river lamprey and sea lamprey are features of the SAC that are at risk of adverse impacts from the proposed scheme by virtue of their annual migration between freshwater and seawater. Brook lamprey, however, are restricted to the freshwater channels of the River Teith and

are therefore at no risk from the proposed scheme. No further assessment of brook lamprey was therefore made.

11.7.13 The conservation objectives for the River Teith SAC are provided in the RIAA for the River Teith SAC and are also available on the SNH's SiteLink website (2008).

Conclusions

11.7.14 The information used to compile the reports to inform the Appropriate Assessments was based upon a review of scientific literature, information gathered through consultation and data gathered through surveys. Bird surveys for the reports to inform the Appropriate Assessments of the SPAs covered two seasons worth of data collected over a two year period unlike the EcIA which relied on one year's data (see paragraph 11.2.11). The potential impacts were considered individually but also in the context of the project and their in-combination potential implication upon the Natura 2000 sites, potentially affected, and their conservation objectives.

11.7.15 No other plans and projects were assessed as having a potential effect, in combination with the proposed scheme, on the conservation objectives or site integrity of the Firth of Forth SPA, the Forth Islands SPA, Imperial Dock Lock, Leith SPA or the River Teith SAC.

11.7.16 Section 11.5 of the Chapter outlines measures to prevent, reduce or offset the significant potential impacts (identified in Section 11.4) of the Main Crossing. Each mitigation measure is detailed in full in Appendix A11.4 (Detailed Estuarine Ecology Impacts and Mitigation). A summary of the Schedule of Environmental Commitments is provided in Chapter 23, Table 23.5.

11.7.17 With the designed mitigation incorporated into the construction and operation of the FRC, the Reports to Inform the Appropriate Assessments conclude that there will be no implication upon site integrity or conservation objectives for the qualifying features of the Firth of Forth SPA, Forth Islands SPA, Imperial Dock Lock, Leith SPA or River Teith SAC. Full details of the assessment are provided in the RIAAs (Jacobs Arup 2009a-c) produced for the proposed scheme.

11.8 Ongoing Design Development

Alternative Construction Compound

11.8.1 An addition to the scheme proposals is the inclusion of an alternative location for the construction compound to the west of South Queensferry. This alternative was identified in response to concerns raised by local residents during the ongoing consultation process, and it locates the compound further to the west.

11.8.2 This alternative site was identified subsequent to the completion of the assessment of potential impacts of the proposed scheme as reported in this chapter. An assessment of its impacts on ecology and nature conservation is provided separately in Chapter 19 (Disruption Due to Construction).

Ferry Hills Rock Cuts

11.8.3 The proposed scheme design as assessed in this chapter includes significant rock cuts to the north and south of Ferrytoll Junction. Detailed design may allow these rock cuts to be avoided or reduced. Design development indicates that there could be potential for a westward shift of the proposed scheme alignment of up to approximately 15m between approximate ch7500-7800 (southwest of Jamestown) and ch8150-8500 (west of Hope Street Cemetery) to allow the rock cuts to be avoided.

11.8.4 Environmental review of this refinement indicates that this could reduce adverse impacts associated with the rock cuts without materially increasing other environmental effects. There would be no significant additional ecological impacts to the west of the amended alignment.

11.9 References

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