MERSEY TIDAL POWER

FEASIBILITY STUDY: STAGE 3

Sustainability Report

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Project Sponsors:

PEEL ENERGY

Northwest REGIONAL DEVELOPMENT AGENCY

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www.merseytidalpower.co.uk

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Project Background

In the face of current and anticipated issues of security of supply and climate change, the need to find local sources of renewable energy has never been more urgent.

The Mersey Estuary has one of the largest tidal ranges in the UK, making it one of the best locations for a tidal power generation scheme. It has the potential to make a significant contribution to the Government's target to secure 15% of UK energy from renewable sources by 2020.

A large scheme could deliver enough renewable electricity to meet the needs of a significant proportion of the homes within the Liverpool City Region, as well as beyond. Any scheme put forward will need to take into account the ecological diversity of the Estuary, which supports internationally important bird habitats.

Phase 1 Pre-Feasibility Study - 'Power from the Mersey'

Peel, in partnership with the NWDA set out to explore the potential, the impacts and the implications of utilising the Mersey Estuary's renewable energy potential for the benefit of the Northwest region.

The Mersey Basin Campaign gave its full backing to the work and a consortium of consultants led by Buro Happold was commissioned in July 2006 to undertake a 'pre-feasibility' Phase 1 Study.

The primary objective of the Phase 1 Study was to undertake a full and open assessment of the options available for the generation of renewable energy and to undertake a preliminary assessment of viability.

A number of potentially viable schemes were identified. The continued development of marine power technology means that others may also need to be considered as the project moves into the next phase.

Meeting 2020 Renewable Energy Targets

An overall timetable was defined to ensure the project supports the policy objective of contributing to 2020 renewable energy targets. The key milestones of the project include submission of applications for planning or other statutory consents by 2012 and commissioning of the scheme by 2020.

Phase 2 Feasibility Study

Peel Energy and the Northwest Development Agency are progressing the project in line with the principles for sustainable development. A feasibility study has been commissioned to assess the options and identify a preferred scheme to take forward for submission of a planning application.

The feasibility study has been led by URS Scott Wilson, EDF and Drivers Jonas Deloitte, and supported by RSK, APEM, HR Wallingford, Regeneris, Turner and Townsend, University of Liverpool, Proudman and Global Maritime.

The feasibility study has been undertaken in three stages as follows:

- Stage 1: Definition of project strategies, data gathering and gap analysis, and selection of long list of suitable technologies
- Stage 2: Appraisal of the long list of technologies and formulation and appraisal of scheme options to identify a shortlist
- Stage 3: Further refinement and appraisal of the short list of scheme options and selection of the preferred scheme.

The project has been pursued in an open and transparent manner, building on the consultation and stakeholder engagement started in the Phase 1 study. An extensive programme of stakeholder engagement has taken place through project advisory groups, consultation with statutory and non-statutory consultees and public consultation targeted during appropriate stages of the project.

Mersey Tidal Power Scheme Objectives

The objectives of the Mersey Tidal Power scheme are:

(a) To deliver the maximum amount of affordable energy (and maximum contribution to Carbon reduction targets) from the tidal resource in the Mersey Estuary with acceptable impacts on environment, shipping, business and the community either by limiting direct impact in the Mersey Estuary or providing acceptable mitigation and/or compensation;

and in doing so,

(b) To maximise social, economic and environmental benefits from the development and operation of a renewable energy scheme, including where appropriate:

(i) the development of internationally significant facilities and skills to support the advancement of renewable energy technologies and their supply chains,
(ii) improvements to local utility and transport infrastructure,
(iii) improvements to green infrastructure and environmental assets,
(iv) the development of a leisure opportunity and tourist attraction.

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1 Introduction

1.1.1 This report provides a summary of the findings of the sustainability appraisal of three scheme variants at Stage 3.

1.1.2 The consideration of sustainability issues forms an intrinsic part of the option appraisal process of the Mersey Tidal Power project, and ensures that sustainability is embedded in the development of scheme design. This process allows for the consideration of economic, social and environmental factors to be undertaken for each of the scheme variants under consideration in an integrated way.

1.1.3 21 sustainability indicators were identified for the Mersey Tidal Power project through a scoping process completed at Stage 2. These indicators are focussed on strategic topics that will influence the option appraisal process. The indicators were chosen to represent the range of environment, social and economic issues that may be affected by the Mersey Tidal Power project.

1.1.4 At Stage 2, a number of indicators were found not to be key differentiators between schemes because all schemes performed similarly. These indicators could have been scoped out for Stage 3, but the decision was taken to assess schemes against all 21 indicators for completeness.

1.1.5 The sustainability indicators are detailed in Table 1.1.

Table 1.1: Sustainability indicators

No.	Sustainability indicator
1	Internationally and nationally designated nature conservation sites
2	Species and habitats of conservation importance
3	Habitat creation or ecological enhancement
4	Levels of flood risk
5	Character and accessibility of places, landscapes and heritage assets
6	Lifecycle carbon balance of the development
7	Utilities infrastructure and resources
8	Waste production, reuse and recycling
9	Ecological status or potential of the Mersey Estuary and other water bodies (in relation to the Water Framework Directive)
10	Emission of air pollutants
11	Land quality
12	Transport infrastructure
13	Amenity for recreation, tourism and leisure
14	Human health and wellbeing
15	Education and skills training

No.	Sustainability indicator
16	Local business and jobs
17	Inward investment and image
18	Technological innovation
19	Commercial navigation
20	Generation of renewable energy from the Mersey Estuary
21	Commercial fish stocks

2 Methodology

2.1 Policy and Legislation

2.1.1 A review of relevant policy at European, national, regional and local levels in relation to sustainability objectives has been undertaken, and will continue to be reviewed and updated throughout the life of the project. The aim has been to understand the sustainability priorities at different levels of government in order to identify where the Mersey Tidal Power project could contribute to government objectives and where there is the potential for conflict between the priorities of government, stakeholders and the Mersey Tidal Power project.

2.1.2 The key policies identified in relation to sustainability are listed below.

2.1.3 European Policy

- Ramsar Convention 1971;
- Birds Directive 1979 (as amended);
- Habitats Directive 1992;
- Water Framework Directive 2000; and
- European Union Climate and Energy Package.

2.1.4 United Kingdom (UK) Legislation

- Planning Act 2008;
- Climate Change Act 2008;
- Energy Act 2008;
- Marine and Coastal Access Act 2009;
- Habitats Regulations 2010; and
- Act for Better Preserving the Navigation of the River Mersey 1842.

2.1.5 National Planning Policy and Strategy:

- National Policy Statements (NPSs);
- UK Government Sustainable Development Strategy;
- The UK Renewable Energy Strategy;
- Planning Policy Statement 1 (PPS 1): Delivering Sustainable Development (ODPM, 2005);
- PPS 1: Planning and Climate Change - Supplement to PPS1 (DCLG, 2007);
- Planning Policy Statement 5 (PPS 5): Planning for the Historic Environment (DCLG, 2010);
- Planning Policy Statement 9 (PPS 9): Biodiversity and Geological Conservation (2005);
- Circular 06/05: Biodiversity and Geological Conservation;
- Planning Policy Statement 12 (PPS 12): Local Spatial Planning;
- Planning Policy Statement 22 (PPS 22): Renewable Energy (ODPM, 2004a);
- Meeting the Energy Challenge: A White Paper on Energy;
- Planning for a Low Carbon Future in a Changing Climate;

- Planning Policy Guidance 20 (PPG 20): Coastal Planning (DoE, 1992);
- Planning Policy Statement 23 (PPG 23): Planning and Pollution Control ((ODPM, 2004b);
- Planning Policy Statement 25 (PPS 25): Development and Flood Risk (DCLG, 2010);
- PPS 25: Supplement: Development and Coastal Change (DCLG, 2010);
- Draft Marine Policy Statement;
- The UK Low Carbon Transition Plan: National Strategy for Climate and Energy;
- Turning the Tide: Tidal Power in the UK;
- Environment Agency Corporate Plan 2009-2012; and
- Natural England Corporate Plan 2009-2012.

2.1.6 Regional Planning Policy:

- The Regional Spatial Strategy (RSS) for North West England;
- North West Sustainable Energy Strategy (2006);
- Northwest Climate Change Action Plan 2010-2012;
- Regional Health Inequalities Strategy;
- North West Mental Wellbeing Survey; and
- Joint Strategic Framework for Public Mental Health 2009-2012.

2.1.7 Sub-Regional Planning Policy:

- Liverpool Multi Area Agreement;
- River Basin Management Plans;
- Liverpool Sustainable Communities Strategy – Liverpool 2024: A Thriving City;
- Liverpool Climate Change Strategic Framework: A Prospectus for Action (2009);
- Liverpool Green Infrastructure; and
- Merseyside Transport Plan (2006-2011).

2.1.8 Local Planning Policy:

- Wirral;
- Liverpool;
- Cheshire West and Chester;
- Halton;
- Sefton;
- Knowsley; and
- Warrington.

2.2 Baseline Data

2.2.1 Baseline data collection was undertaken at Stage 2, for all sustainability indicators, to inform the scheme appraisal and has been updated as appropriate at Stage 3. Baseline data sources are listed in Table 2.1.

Table 2.1: Baseline data sources

No.	Indicator	Baseline review
1	Internationally and nationally designated nature conservation sites	Current status of Special Protection Area (SPA), Ramsar site and Sites of Special Scientific Interest (SSSIs) and conservation objectives
2	Protected species and habitats	Available information on protected and Biodiversity Action Plan (BAP) species
3	Habitat creation or ecological enhancement	Identification of opportunities dependant on location
4	Levels of flood risk	Review of the Catchment Flood Management Plans and Strategic Flood Risk Assessments that have been carried out by the relevant local authorities.
5	Character and accessibility of places, landscapes and heritage assets	Locations and nature of Scheduled Monuments, Conservation Areas, Listed Buildings, World Heritage Site (WHS) and Buffer Zone and protected wrecks, sites identified through the Historic Environment Record, regional/local landscape character assessment and historical landscape character
6	Lifecycle carbon balance of the development	Carbon costs associated with relevant types of materials, and carbon saving from renewable energy
7	Utilities infrastructure and resources	Capacity of existing of utilities infrastructure
8	Waste production, reuse and recycling	Locations and capacity of waste management sites
9	Ecological status or potential of the Mersey Estuary and other waterbodies in relation to the Water Framework Directive	River Basin Management Plans
10	Emission of air pollutants	Locations of any Local Air Quality Management Areas and Local Air Quality Action Plans that could be affected by the project
11	Land quality	Current land classification from National Land Use Database (NLUD)
12	Transport infrastructure	Review of any known local transport issues
13	Amenity for recreation, tourism and leisure	Identification of existing amenities and opportunities for synergies
14	Human health and wellbeing	Internet sources such as the Association of Public Health Observatories and Office for National Statistics
15	Education and skills training	Local information on education and skills
16	Local business and employment	Information on employment including current (un)employment levels as required

No.	Indicator	Baseline review
17	Technological innovation	Current tidal power technologies and possible contribution to innovation
18	Inward investment and image	Recent trends in Liverpool city region and North West competitiveness (UK Competitiveness Survey, Centre for International Competitiveness)
19	Commercial navigation	Information on existing navigation in the Mersey Estuary
20	Generation of renewable energy from the Mersey Estuary	Current percentage of energy and electricity from renewable energy and targets for the percentage of energy from tidal energy
21	Commercial fish stocks	Current commercial fishing activity in the Mersey Estuary, and species of fish

2.3 Indicators and Measures

2.3.1 At Stage 3, further study and appraisal of the short list of scheme options has been undertaken, with the aim of identifying a preferred scheme. At Stage 3, the three scheme variants chosen for detailed assessment fall within Band A.

2.3.2 The three scheme variants assessed at Stage 3 have been:

- IBv2b – an impounding barrage with 28 turbines, operated on the ebb tide only, using an unrestricted head;
- VLHBv2a – a barrage with 44 turbines designed to operate at a restricted (low) head, on the ebb tide only; and
- VLHBv3a – a barrage with 44 turbines designed to operate at a restricted (low) head, on ebb and flood tides.

2.3.3 Each of the three scheme variants was appraised against the 21 sustainability indicators using defined measures. These measures are summarised in Table 2.3. These were developed during a scoping process, including consultation with the Environment Technical Group and socio-economic stakeholders.

2.3.4 Using these measures, each scheme has been assessed to determine the potential level of impact on each of the sustainability indicators. The terminology in

Table 2.2 has been used to indicate the performance of each scheme against each indicator.

2.3.5 The ratings have each been designated a colour and symbol. This 'traffic light' system will be used in the comparison matrix for ease of comparison and visual clarity

Table 2.2: Indicator ratings

+ + (double plus sign)	Large benefit (potential for large improvements to sustainability indicator as a result of the scheme)
+ (single plus sign)	Some benefit (potential for some improvements to sustainability indicator as a result of the scheme)
O (zero)	Negligible (no appreciable likely effect, either beneficial or adverse)
─ (single negative sign)	Some adverse effect (potential for some adverse impact on sustainability indicator as a result of the scheme)
─ ─ (double negative sign)	Large adverse effect (potential for large adverse impact on sustainability indicator as a result of the scheme)

2.3.6 The indicators have not been weighted to show their relative importance. It is acknowledged that some indicators are likely to be more important than others to decision-making on schemes because they affect resources of national or international importance, or issues that are social or political priorities. Therefore, a sum of the ratings for each scheme into an 'overall sustainability' rating has not been provided as it is not appropriate without weighting the indicators (which is also not proposed due to inherent difficulties with agreeing weightings with all stakeholders).

2.3.7 Methodologies for appraisal against each indicator are summarised in Appendix A.

2.3.8 Where possible, recommendations for mitigation and enhancement will be made, but they have not been incorporated into scheme designs or this assessment.

2.4 Consultation

2.4.1 The scope and methodology for assessment and appraisal of sustainability has been the subject of consultation with a range of stakeholders representing economic, social and environmental interests.

2.4.2 Following this initial consultation, a Sustainability Scoping Report was published for wider consultation in summer 2010. The report was issued to a wide range of project stakeholders and published on the project website.

2.4.3 An additional measure has been added for sustainability indicator 13, following consultation with yachting and sailing clubs during Stage 3.

Table 2.3: Measures used for sustainability indicators

No.	Indicator	Measure(s)
1	Internationally and nationally designated nature conservation sites	Potential for effects on conservation objectives of SPA/ Ramsar and overall structure and function of SPA/ Ramsar Short and long term changes to areas of SSSI habitats Potential for effects on conservation status of SSSIs
2	Species and habitats of conservation importance	Short and long term changes to potential legally protected species' habitats Short and long term changes to potential local and national BAP species' habitats Short and long term changes to areas of locally designated habitats
3	Habitat creation or ecological enhancement	Opportunities for direct marine/intertidal/terrestrial habitat creation or enhancement
4	Levels of flood risk	Extent of any changes in water level at areas at risk of flooding Potential for change in risk of fluvial flooding Fit with existing flood risk strategies Potential for change in groundwater levels
5	Character and accessibility of places, landscapes and heritage assets	Direct and indirect effects on World Heritage Sites (including Buffer Zones), Scheduled Ancient Monuments (SAMs), Conservation Areas, Listed Buildings, Registered Battlefields, Protected Wrecks, Registered Parks and Gardens, Areas of Outstanding Natural Beauty, National Forest, National Parks, Public Rights of Way, Landscape Character Areas and Local Character Areas
6	Lifecycle carbon balance of the development	Approximate lifecycle carbon balance
7	Utilities infrastructure and resources	Potential for effects on existing (or potential for new) abstraction licences Potential for effects on quality of groundwater Potential for effects on existing (or potential for new) major utilities infrastructure
8	Waste production, reuse and recycling	Locations and capacity of waste disposal/ management locations (existing and future) Approximate quantity and type of waste associated with the decommissioning phase (based on construction materials) Life expectancy of development Potential for use of recycled materials during construction

No.	Indicator	Measure(s)
9	Ecological status or potential of the Mersey Estuary and other water bodies (in relation to the Water Framework Directive)	Potential for development to affect attainment of good ecological status/ potential Effect on areas of known contaminated sediments
10	Emission of air pollutants	Potential for change in local air quality at Air Quality Management Areas and Local Air Quality Action Plan areas Proximity to air quality sensitive receptors
11	Land quality	Area of brownfield re-used/ greenfield land lost Area of contaminated land remediated
12	Transport infrastructure	Potential for new transport infrastructure to be created Availability of existing road access Access by public transport and walking/ cycling Traffic impact on road network
13	Amenity for recreation, tourism and leisure	Potential leisure visitor numbers Potential to create leisure facilities Potential for change to recreational and leisure use of Estuary (yachting, sailing and angling)
14	Human health and wellbeing	Potential to improve local unemployment statistics Potential change in average income Potential change in rank for Liverpool City Region in Indices of Deprivation Potential to create leisure facilities Potential change in air quality emissions Change in noise levels at sensitive human receptors
15	Education and skills training	Potential education visitor numbers Specialist skills required for direct jobs Potential number of apprenticeships
16	Local business and jobs	Indicative operational staffing (direct jobs) Indicative indirect jobs created (supply chain) Gross Value Added (GVA)
17	Inward investment and image	Potential for new business infrastructure (e.g. business park) Potential change in rank of competitiveness for North West and Liverpool City Region

No.	Indicator	Measure(s)
18	Technological innovation	Opportunities to create tidal power technology test facility Extent of 'new' technology required
19	Commercial navigation	Potential change in vessel transit (time, destination, safety, towing/pilot requirements) Potential change in type of vessel that can access destinations within the Estuary Potential change in levels of traffic to destinations within the Estuary
20	Generation of renewable energy from the Mersey Estuary	Predicted output in GWh/yr
21	Commercial fish stocks	Potential change to commercial fish stocks (existing and future)

3 Lessons Learnt from Stage 2

3.1.1 The range of indicators that allowed a differentiation to be made between schemes at Stage 2 were:

- lifecycle carbon balance;
- ecological status or potential of the Mersey Estuary and other water bodies (in relation to the Water Framework Directive);
- transport infrastructure;
- technological innovation;
- commercial navigation; and
- generation of renewable energy from the Mersey Estuary.

3.1.2 The tidal fence schemes considered at Stage 2 were found to be net carbon emissions generators. The energy production of these schemes was relatively small, while the carbon emissions associated with construction was similar to those for the other schemes. The lack of any carbon benefit meant that these schemes were discounted.

3.1.3 At Stage 2 it was determined that IBv1 (impounding barrage) and VLHBv1 would have the greatest carbon cost during construction but also have the most favourable overall carbon balance due to the large renewable energy yield. The selected Stage 3 schemes are variations of these schemes.

3.1.4 The Stage 2 sustainability appraisal scoring system was based on the North West Regional Development Agency (NWDA) Integrated Appraisal Toolkit. Following the spending review in October 2010 the Government decided to abolish regional development agencies, of which the NWDA is one. The Integrated Appraisal Toolkit has therefore been withdrawn and will not be used in any further appraisal of schemes.

3.1.5 The sustainability appraisal methodology for Stage 3 has been refined to consider more clearly the likely relative magnitude of impacts. The aim has been to allow clearer differentiation between schemes on the basis of sustainability (see Section 2 for details on the refined scoring system).

4 Stage 3 Scheme Assessment

4.1.1 The three scheme variants being assessed at Stage 3 have each been considered against the 21 sustainability indicators identified in Table 2.3. Details of the assessments are provided in Annex A.

4.2 Sustainability Indicator 1 – Internationally and Nationally Designated Nature Conservation Sites

4.2.1 Detailed consideration of potential impacts on internationally and nationally designated nature conservation sites is provided in the Stage 3 Marine Ecology report.

4.2.2 The unrestricted head, ebb only operation of IBv2b was predicted to have greater impacts on the overall structure and function of the Mersey Estuary SSSIs/ SPA/ Ramsar site, due to resulting changes to the tidal regime which would reduce the overall area, quality and time of exposure of intertidal habitats for bird feeding.

4.2.3 The scheme variant predicted to have the least impact on the designated sites was VLHBv3a, operated using restricted head, ebb and flood generation. This scheme variant was predicted to follow the natural tidal cycle most closely, resulting in the smallest effects on the SPA features and sub-features.

4.2.4 VLHBv2a, operated using restricted head, ebb only generation, was predicted to have less of an impact than IBv2b but greater impact than VLHBv3a.

4.2.5 A range of measures to prevent harm and mitigate impacts have been developed at Stage 3, and taken into account in the marine ecology assessment.

4.2.6 IBv2b has been scored ‘large adverse effect’ and VLHBv2a and VLHBv3a have been scored ‘some adverse effect’.

4.3 Sustainability Indicator 2 – Species and Habitats of Conservation Importance

4.3.1 Detailed consideration of potential impacts on species and habitats of conservation importance is provided in the Stage 3 Marine Ecology report.

4.3.2 The assessment concludes the same as for sustainability indicator 1 above – IBv2b has been scored ‘large adverse effect’ and VLHBv2a and VLHBv3a have been scored ‘some adverse effect’.

4.4 Sustainabilty Indicator 3 – Habitat Creation or Ecological Enhancement

4.4.1 A range of measures to prevent harm and mitigate impacts on ecological receptors have been identified for each scheme variant (see Stage 3 Marine Ecology report), including habitat creation. Opportunities for habitat creation or ecological enhancement over and above mitigation (and any compensation that may be required) would be limited but similar for all schemes, and all have been scored 'no change' (neutral).

4.5 Sustainability Indicator 4 – Levels of Flood Risk

4.5.1 An assessment of the potential change in flood risk (including tidal, fluvial, groundwater and surface water) has been undertaken by considering the predicted effects of the schemes on mean and high water levels. The assessment has also taken into account how the scheme fits with existing strategies and surface water management plans (SWMPs).

4.5.2 The predicted change in flood risk for each of the schemes takes account of the duration of the high water stand period as well as the high water level, and the probability that a high flow fluvial event occurs at the same time.

4.5.3 All of the schemes considered in Stage 3 would result in an increase in the mean water level and a potential decrease in the high water level, but the ebb only generation scheme variants (IBv2b and VLHBv2a) would have longer high water stand periods than the ebb and flood scheme variant (VLHBv3a). Based on the available information, these have therefore been scored 'some adverse effect', and VLHBv3a has been scored 'no change'.

4.6 Sustainability Indicator 5 – Character and Accessibility of Places, Landscapes and Heritage Assets

4.6.1 A desktop study of available information on landscape character and landscape planning policy in the area has been completed and the proximity of the Band A alignment to potentially sensitive landscape receptors has been considered.

4.6.2 A desktop appraisal of available information on cultural heritage assets in the area has also been completed using internet sources, and the proximity of the Band A alignment to potentially sensitive cultural heritage assets has been appraised.

4.6.3 All three scheme variants have the same alignment and similar massing and height of structures on the both banks and across the Mersey. Ancillary structures for any scheme would be secondary compared to the scale of the main structures.

4.6.4 Generally, each of the three schemes would have a similar impact on cultural heritage in terms of construction impacts (piling or sea bed-cut), dredging, massing, scale and height of structures on both banks and across the Mersey.

4.6.5 It is therefore concluded that there is unlikely to be any difference between the physical impacts of the construction of the three schemes on the character and accessibility of places, landscape and heritage assets. Any scheme would result in potential adverse impacts on unrecorded archaeological remains and changes to the landscape character and setting of cultural heritage features, so all have been scored 'some adverse effect'.

4.7 Sustainability Indicator 6 – Lifecycle Carbon Balance of the Development

4.7.1 The lifecycle carbon balance study has provided an initial calculation of the carbon dioxide (CO_2) balance associated with the construction of the Mersey Tidal Power project. A quantitative approach was used to estimate the CO_2 emissions associated with the construction of each scheme variant and the CO_2 saved by the generation of renewable energy during operation.

4.7.2 The structure would be very large and require significant amounts of materials for structural stability and durability, like concrete and steel. Such materials have significant amounts of embodied energy increasing significantly the CO_2 emissions associated with the scheme. Furthermore, during the construction phase, significant amounts of energy would be needed, which also produces CO_2 emissions.

4.7.3 In order to maximise any reduction in CO_2 emissions, it has been necessary to consider the type of materials which will be used and select those which will have the lowest embodied energy. Using recycled instead of primary materials could significantly reduce the embodied carbon. It would also be essential to opt for locally sourced material whenever possible and use sustainable modes of transport.

4.7.4 Using energy efficient equipment during construction would also aid emission savings, as well as selecting low carbon fuel and renewable sources of energy to feed the power requirements for the construction phase of the project.

4.7.5 Operational and maintenance carbon costs from fuel use and replacement parts would be negligible in the context of the operational energy production.

4.7.6 The different schemes offer different amounts of operational emission savings, which depend on the amount of electricity they can generate over the lifetime of the project. All schemes would have a positive carbon balance within the first 25 years of operation (the period over which carbon savings can be estimated with any certainty) – in fact the 'payback' timescale for any of the schemes assessed was predicted to be less than five years. All scheme variants have been scored 'large benefit'.

4.8 Sustainability Indicator 7 – Utilities Infrastructure and Resources

4.8.1 All three schemes would require overhead power lines, potentially to Bromborough substation. The location of the schemes would not influence the grid connection point, but the electricity output would make a major difference in requirements for system upgrades.

4.8.2 All schemes have potentially negative impacts in terms of requirements for new or upgraded overhead lines, but there are anticipated to be significant benefits associated with these upgrades in terms of supply and network stability, both locally and regionally.

4.8.3 The geology of the study area is dominated by the Permo-Triassic Sandstone aquifer. The aquifer has a long history of heavy groundwater abstraction, although in recent years groundwater levels have been recovering. Under the Water Framework Directive the sandstone aquifer has been assessed as being at risk from over abstraction and saline intrusion. Other water quality issues include pollutants from the glass industry, landfill sites, and heavily industrialised areas of the catchment. The Environment Agency's objective is to not worsen the problems of saline intrusion (or other water quality issues).

4.8.4 One of the potential effects of a tidal power scheme is the adjustment of natural tidal fluctuations and average water levels. Tidal fluctuations of the Mersey Estuary are known to propagate into the sandstone aquifer in central Liverpool and similar groundwater level fluctuations are expected elsewhere around the Mersey Estuary.

4.8.5 There is greater potential for adverse impacts on groundwater quality from the ebb only generation scheme variants (IBv2b and VLHBv2a) as they would introduce longer high water stand periods, compared to the ebb and flood variant (VLHBv3a). As such, these have been scored 'some adverse effect' and VLHBv3a has been scored 'no change'.

4.9 Sustainability Indicator 8 – Waste Production, Reuse and Recycling

4.9.1 The construction and development of any tidal power scheme within the Mersey Estuary will inherently generate waste during and after construction through the requirement to refurbish and decommission structures.

4.9.2 The scheme variants have been assessed based on the location and capacity of waste disposal facilities within the area, the life expectancy of the development and the approximate volume and type of waste generated during any decommissioning/ renewal works and the potential for recycling of waste materials during and post construction.

4.9.3 Based on the available information and estimations, all three scheme variants have the potential to generate a substantial volume of waste during decommissioning due to the

requirement for landside, bankside and waterside structures. The expected lifespan of civil structures for all schemes is the same.

4.9.4 All the proposed major material constituents of the schemes have the potential to be reused and recycled in local, regional and national schemes. It is fair to assume that not all construction waste will be reused/ recycled and, therefore, based on proposed reuse/ recycling figures for 2012, approximately 50% may need disposing using alternative methods.

4.9.5 All scheme variants are scored 'some adverse effect'.

4.10 Sustainability Indicator 9 – Ecological Status or Potential of the Mersey Estuary and Other Water Bodies (in Relation to the Water Framework Directive)

4.10.1 The assessment of potential impact of scheme variants on ecological status or potential has been limited to the potential effect of each scheme on the ability of the Estuary itself to 'flush' (that is, allow pollutants contained in the Estuary to discharge to sea), and consideration of likely impacts on migratory fish.

4.10.2 Numerical modelling of the 'flushing' of the Estuary has been completed for the three schemes under consideration. A flushing study provides an indication of the rate of exchange of water within the estuary with water outside of the estuary and is used as a first indication of the potential changes to water quality parameters. The modelling outputs focus on potential effects of developments on the Mersey Estuary.

4.10.3 The flushing rate was predicted to be reduced most by IBv2b (4.5 days to reduce the initial pollutant concentration by 25% compared to 2.4 days in the baseline case) and VLHBv2a (4.4 days to reduce the initial pollutant concentration by 25% compared to 2.4 days in the baseline case), whereas VLHBv3a was predicted to cause less reduction in the flushing rate (3.4 days to reduce the initial pollutant concentration by 25% compared to 2.4 days in the baseline case).

4.10.4 With regards migratory fish, all schemes have potential to affect the movement of fish due to the presence of a structure across the Estuary and potential for injury and mortality (e.g. due to turbine passage). Fish passage routes were included in all Stage 3 scheme designs, but further measures would need to be developed for the preferred scheme to enable safe fish passage.

4.10.5 Although IBv2b and VLHBv2a were found to have greater effects on the flushing rate of the Estuary based on the calculations undertaken compared to VLHBv3a, the potential adverse impacts on fish resulting from all scheme has lead to all schemes being scored 'some adverse effect'.

4.11 Sustainability Indicator 10 – Emission of Air Pollutants

4.11.1 A desktop study of available information on baseline local air quality in the area has been completed, and the proximity of the schemes to potentially sensitive receptors has been investigated. Any likely differences between the scheme variants in terms of construction dust, construction traffic and operational traffic have been considered.

4.11.2 Some adverse impact due to construction dust and construction traffic is inevitable for all the schemes; however the magnitude of the impact is unlikely to be high. An adverse impact due to operational/ visitor traffic is also predicted for all the schemes; however the magnitude of the impact is unlikely to be high.

4.11.3 There is no apparent difference between the three scheme variants, so all variants have been scored equally 'some adverse effect'.

4.12 Sustainability Indicator 11 – Land Quality

4.12.1 The quality of the land at either ends of Band A has been reviewed based on available information on historic land uses. It is likely that both the Liverpool Bank and Wirral Bank would require some remediation prior to development.

4.12.2 When considering sustainability, land quality can be considered in two ways:

- remediation of contaminated land is inherently sustainable as it brings derelict land back into beneficial use and creates economic, environmental and social benefits; and
- it can require a significant amount of resources (in terms of energy and natural resource usage) to realise.

4.12.3 However, remediation is seen as an overall sustainability benefit. Energy and natural resources are considered by other indicators.

4.12.4 The extent of the areas that may require remediation would be similar for all three scheme variants, and all have been scored 'no change'.

4.13 Sustainability Indicator 12 – Transport and Infrastructure

4.13.1 Road access routes to the proposed development area have been considered as part of the feasibility study. Access by water would also be available.

4.13.2 On the Liverpool bank access to the waterside would be from the A561. Access routes to Band A would pass through some residential areas.

4.13.3 On the Wirral bank, access would be from the A41. Band A would most likely be accessed via Birkenhead to the north (via the Kingsway tunnel) or Eastham to the south (from the M53 Junction 5), and traffic would pass through a mixture of residential, retail and industrial areas. The Wirral Unitary Development Plan identifies highway capacity issues along the A41 between Birkenhead and the M53. An alternative route would be from the M53 Junction 4 and along the B5137/B5136 and A41, but this route passes through primarily residential areas.

4.13.4 No significant differences have been identified between the scheme variants under consideration and all are scored 'no change' (neutral).

4.14 Sustainability Indicator 13 – Amenity for Recreation, Tourism and Leisure

4.14.1 Band A provides a high profile location relatively close to the tourist attractions at the historic waterfront. The appearance of each scheme would be broadly similar and purely functional, but there is the potential for features to be placed on the structure to create either iconic structures within the facility, or related public artworks. The success of enhanced branding will improve the chances of successfully attracting of visitors and related jobs.

4.14.2 The potential to generate greater interest in the river and its habitats creates potential for increased visitor numbers and leisure facilities related to provision of greater access to river habitats. A visitor centre focused on wildlife and habitats need not be located next to the facility, and could be a means of ensuring greater access and awareness of the environmental value of the river.

4.14.3 The impact of visitor numbers both to the visitor centre and the wider Liverpool City Region would be significantly greater if attention is paid to design, access to and appearance of the preferred scheme.

4.14.4 There are potential synergies between the Mersey Tidal Power project and the Mersey Coastal Park Strategy, in particular there may be opportunities to enhance the plans for Bromborough Landfill Site by linking it to a pedestrian/ cycle access across the barrage structure. This would provide a range of additional benefits arising from such connectivity including improved access to employment, health benefits and tourism benefits.

4.14.5 There is potential for negative impacts on river users such as yachting, sailing and recreational angling due to the presence of the structure (as a potential barrier to movement) and changes to the tidal regime and water levels. A small boat lock will be provided to mitigate impacts, and further consultation with relevant stakeholders will be required to identify additional mitigation measures.

4.14.6 All schemes would have a significant positive impact, irrespective of technologies employed, but there is also potential for negative impacts on yachting, sailing and angling within the Estuary. All scheme variants have therefore been scored 'some benefit'.

4.15 Sustainability Indicator 14 – Human Health and Wellbeing

4.15.1 The three scheme variants have been assessed against human health and wellbeing issues, including unemployment, income, deprivation, leisure facilities and noise.

4.15.2 A desktop study of available baseline noise data in the area from the Defra Liverpool and Birkenhead Noise Maps has been completed, and the proximity of Band A to potential noise and vibration sensitive receptors has been investigated. Any differences between the technology options in terms of construction noise and vibration, construction traffic and operational traffic have been considered.

4.15.3 An adverse impact due to construction noise and construction traffic is inevitable for all the schemes; however the magnitude of the impact is unlikely to be high. Construction vibration impacts will only be an issue for works that are a potentially significant source of vibration, such as piling.

4.15.4 Adverse impact due to operational/visitor traffic are also possible for all the schemes; however the magnitude of the impact is very unlikely to be high.

4.15.5 Similar conclusions have been drawn with regards air quality impacts (see sustainability indicator 10 above).

4.15.6 With regards economic factors of human health and wellbeing, all schemes would make a significant positive impact on local unemployment, average income and deprivation, depending on investment level. The extent of this impact can be maximised by procurement methods which, within competition laws, favour local suppliers and residents and align with existing initiatives to maximise the link between new jobs and related training opportunities and local residents.

4.15.7 Both the construction and operation of the development would be likely to create and support employment across the North West. Many of the opportunities would be within the the Liverpool City Region. These are all areas which experience some of the highest levels of deprivation in the UK and are home to pockets of very high unemployment. Average incomes would rise as a function of the additional jobs which would be created by the project.

4.15.8 The project would also generate demand for low and intermediate skilled labour in construction related activity, which could provide opportunities for local people, sustain employment in those sectors and support the economic vibrancy of the surrounding area.

4.15.9 The North West and the City Region would be well placed to benefit based on their natural resource, maritime heritage and good port infrastructure. The North West is also home to a number of world class institutes including the University of Liverpool, Lancaster University's Renewable Energy Group, the Centre for Hydrology and the Proudman Oceanographic Laboratory. The region still lacks a major testing and research facility which could act as a major catalyst for sector activity. However the presence of a full scale tidal power facility is likely to stimulate the development of a stronger research base in the region and in turn will stimulate the development of a supply chain in the North West. All of this could have a significant impact on reducing Indicators of Deprivation.

4.15.10 All schemes could provide a significant impact on jobs created, lift to GVA and therefore change in rank to the City Region.

4.15.11 Potential improvements to local leisure facilities are discussed above in relation to sustainability indicator 13.

4.15.12 Overall there is potential for some negative and positive impacts on human health and wellbeing but the significant economic benefits predicted for all scheme variants have led to all schemes being scored 'some benefit'. A 'large benefit' has not been assigned in recognition of the potential negative impacts, albeit that they are anticipated to be less significant than the positive impacts.

4.16 Sustainability Indicator 15 – Education and Skills Training

4.16.1 All scheme variants could provide similar opportunities to attract education visitor numbers. The visitor centre could address a wider range of subject matter than just the technology of the turbines. The education visitor segment would be a major element of the overall market.

4.16.2 All scheme variants would generate a similar number of jobs and opportunities for skills training. Skills for visitor centre jobs currently well catered for in the city region.

4.16.3 Much of the expertise required for the construction process is available within the region or elsewhere in the UK. Some of the more specialised, higher level skills may need to be sourced from outside the region and in some cases overseas, however there should be a sufficient pool of lower and intermediate skills in the Liverpool City Region and the North West upon which Mersey Tidal Power project can draw.

4.16.4 The sourcing strategy and the composition and structure of the successful tenderer would influence the scale of benefits to local people. However construction work for any scheme would be onsite and give great opportunity for a wide range of skills to be provided locally.

4.16.5 All schemes have been scored 'large benefit'.

4.17 Sustainability Indicator 16 – Local Business and Jobs

4.17.1 Low and high estimates of the potential to source from within the region for different construction stages have been determined and the regional employment that would be supported by the design, manufacture and construction activity for each of the schemes was also estimated. The total employment supported by the project under each of the schemes has also been determined.

4.17.2 Estimates for total GVA (using GVA per Full Time Employee (FTE) estimates across the different construction stages in the closest matching sectors) have been calculated. The direct GVA generated by the construction of the project calculated in this way represents between 30 and 33% of the capital cost.

4.17.3 The extent of the beneficial impact could be maximised by procurement methods which, within competition laws, favour local suppliers and residents and align with existing initiatives.

4.17.4 All scheme variants would have a 'large benefit'.

4.18 Sustainability Indicator 17 – Inward Investment and Image

4.18.1 A tidal power scheme in the Mersey Estuary would raise the profile and image of the area and attract inward investment.

4.18.2 Opportunities for use of the scheme by the City Region for branding purposes would be similar for any scheme, as would wider benefits of inward investment and image.

4.18.3 There is the potential for design features to be placed on the structure for effect and branding purposes. Enhanced branding would improve the chances of successful attraction of visitors and related jobs and make a contribution to the competitiveness of the City Region. Opportunities also exists to create an additional brand image to sit alongside existing Liverpool City Region ones.

4.18.4 The impact of visitor numbers both to the visitor centre and the wider City Region would be significantly greater if attention is paid to design and appearance of the facility.

4.18.5 The UK already has a comparative advantage in the wave and tidal power market and the North West is well placed to benefit based on its natural resource, maritime heritage and good port infrastructure. It is also home to a number of world class institutes including the University of Liverpool, Lancaster University's Renewable Energy Group, the Centre for Hydrology and the Proudman Oceanographic Laboratory.

4.18.6 All scheme variants have been scored 'large benefit'.

4.19 Sustainability Indicator 18 – Technological Innovation

4.19.1 The three schemes have been assessed to determine whether technological innovation could be incorporated into the design. Several different test facilities for tidal range devices could be accommodated by converting the blank caissons, but water depth may be limited unless the test facility could be located among the deeper turbine caissons.

4.19.2 Technological innovation is possible for material selection/ development in an aggressive marine environment and in electrical control systems and mechanical governing of turbines.

4.19.3 Any of the three scheme variants assessed would have the space to incorporate a testing facility, so all schemes have been scored 'some benefit'.

4.20 Sustainability Indicator 19 – Commercial Navigation

4.20.1 All three scheme variants would impact on navigation by presenting a barrier in the navigation path, but solutions have been identified and consulted upon with relevant stakeholders. All three scheme variants include a double ship lock on the Wirral bank to enable navigation access to be maintained but as there is potential for delay all schemes have been scored 'some adverse effect'.

4.21 Sustainability Indicator 20 – Renewable Energy

4.21.1 The three schemes have been assessed to determine which generated the highest energy yield from the Mersey Estuary. IBv2b would generate greatest energy yield of the three scheme variants, and the restricted head operation used for VLHBv2a and VLHBv3a would generate around half the energy yield of IBv2b. IBv2b has therefore been scored 'large benefit' and VLHBv2a and VLHBv3a have been scored 'some benefit' because they would not make full use of the available resource.

4.22 Sustainability Indicator 21 - Commercial Fish Stocks

4.22.1 Visiting vessels (e.g. UK and Belgium beam trawlers and Scottish scallop dredgers) land their catches into Liverpool and Birkenhead Docks from where the fish are consigned to either UK or continental outlets.

4.22.2 Commercial fishing in the Estuary is limited. Shrimps are taken in the River Mersey and Penfold Channel whilst grounds off Rock Channel and Leasowe are fished for plaice, sole, rays and whiting. The main white fish grounds are found north of Taylors Bank offshore from Ainsdale. Sea bass is also caught in the Estuary and coastal waters.

4.22.3 All schemes have been scored 'no change' as impacts on commercial fishing would be limited.

5 Comparison of Schemes

Table 5.1: Sustainability appraisal matrix

No.	Indicator	IBv2b	VLHBv2a	VLHBv3a
1	Internationally and nationally designated nature conservation sites	--	-	-
2	Species and habitats of conservation importance	--	-	-
3	Habitat creation or ecological enhancement	0	0	0
4	Levels of flood risk	-	-	0
5	Character and accessibility of places, landscapes and heritage assets	-	-	-
6	Lifecycle carbon balance of the development	++	++	++
7	Utilities infrastructure and resources	-	-	0
8	Waste production, reuse and recycling	-	-	-
9	Ecological status or potential of the Mersey Estuary and other water bodies (in relation to the Water Framework Directive)	-	-	-
10	Emission of air pollutants	-	-	-
11	Land quality	0	0	0
12	Transport infrastructure	0	0	0
13	Amenity for recreation, tourism and leisure	+	+	+
14	Human health and wellbeing	+	+	+
15	Education and skills training	++	++	++
16	Local business and jobs	++	++	++
17	Inward investment and image	++	++	++
18	Technological innovation	+	+	+
19	Commercial navigation	-	-	-
20	Generation of renewable energy from the Mersey Estuary	++	+	+
21	Commercial fish stocks	0	0	0

6 Recommendations for Final Scheme

6.1 Preferred Scheme

6.1.1 The range of indicators that allow a differentiation to be made between schemes at this stage is limited to:

- internationally and nationally designated nature conservation sites
- species and habitats of conservation importance
- levels of flood risk;
- utilities infrastructure and resources; and
- generation of renewable energy from the Mersey Estuary.

6.1.2 For the above indicators, VLHBv3a scores slightly better for all but the last, generation of renewable energy. This indicator is an important consideration, as the project seeks to make the most of the available tidal energy resource.

6.1.3 All three scheme variants would provide significant net carbon savings, but IBv2b would provide the greatest positive net emission savings. It is predicted that this scheme variant would produce nearly double the energy of VLHBv2and VLHBv3, while the estimated embodied carbon within this design was estimated to be around 22% lower.

6.1.4 Schemes that have a greater effect on tidal regime would have a greater potential effect on the use of estuarine habitats by SPA bird populations.

6.1.5 Any tidal power scheme would have significant socio-economic benefits for the local area. The preferred scheme would be one that has a high energy yield (and consequently short carbon payback period) and limited adverse environmental impacts.

6.2 Further Work

6.2.1 In future stages, a sustainability assessment would support the consent applications for the project. The scope and methodology for this assessment, which would be more detailed than the appraisal undertaken to inform the options appraisal, would be the subject of further consultation with relevant stakeholders.

7 Assumptions and Limitations

7.1.1 The evaluation of the change in flood risk has been undertaken based on the predicted changes to the water levels within the Estuary and not through detailed analysis of the flood risk using numerical models. The operation of the schemes could be modified to provide some flood protection but this has not been considered in this assessment.

7.1.2 Assumptions have been made on the detail of the design, construction materials and working practices. These assumptions will be refined in a further iteration of the lifecycle carbon analysis as design detail emerges, but the assumptions are considered appropriate to inform comparison of scheme variants.

7.1.3 The Environment Agency's groundwater model covers the northern half of the Mersey Estuary study area, but not the entire southern half. Therefore, there exists greater uncertainty in the southern half of the study area with respect to groundwater conditions and the impact of a tidal power development.

7.1.4 The conclusions and assessment for the Water Framework Directive indicator are currently based purely on the outputs of flushing study to demonstrate potential effects of developments on flushing capability of the Estuary. This only considers one factor of water quality, with its potential to impact on the ecological status or potential of the Mersey Estuary under the Water Framework Directive. This has been used as an indication of the potential scale of impact from the development options to help differentiate between schemes, but there are a wider range of factors that would need to be considered for the preferred scheme, along with potential impact on other waterbodies. In the absence of guidance for consideration of new developments in relation to the Water Framework Directive, a scoping study has been undertaken for the project, in consultation with the Environment Agency, to determine the scope of assessment required for the preferred scheme and to inform future work.

7.1.5 Effects on water quality may be mitigated through appropriate design. This might include changes to the operating regime to reduce pooling behind the structure or using the potential for sediment contamination as a factor in the selection of the precise location of the development, but this cannot be assessed in any detail until further modelling of sediment transport and water quality has been undertaken in future stages.

8 Summary

8.1.1 This report provides a summary of the findings of the sustainability appraisal for the three scheme variants assessed at Stage 3, which has informed the options appraisal.

8.1.2 21 sustainability indicators were identified for the Mersey Tidal Power project in consultation with stakeholders. This was informed by a review of key policy at European, national, regional and local levels in relation to sustainability objectives.

8.1.3 At the level of differentiation enabled through the scoring system, many scheme variants are rated the same. The range of indicators that appear to allow a differentiation to be made between schemes at this stage is limited to:

- internationally and nationally designated nature conservation sites
- species and habitats of conservation importance
- levels of flood risk;
- utilities infrastructure and resources; and
- generation of renewable energy from the Mersey Estuary.

8.1.4 More detailed evaluation of the assessment findings however reveals further differentiation, for example, the carbon savings afforded by each scheme are all scored 'large benefit' but IBv2b would provide the greatest benefit and VLHBv2a and VLHBv3a would provide a slightly lesser benefit as they would generate around half the amount of renewable energy.

8.1.5 Any tidal power scheme would have significant socio-economic benefits for the local area. The preferred scheme would be one that has a high energy yield (and consequently short carbon payback period) and limited adverse environmental impacts.

9 References

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North West Regional Assembly (2006) *Sustainable Energy Strategy*

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Office of the Deputy Prime Minister (2005) *Sustainability Appraisal of Regional Spatial Strategies and Local Development Documents*

Sustainable Development Commission (2007) *Turning the Tide – Tidal Power*

World Commission on Environment and Development (1987) *Report of the World Commission on Environment and Development: Our Common Future [the Bruntland Report].*

Annex A: Evidence Base

The detailed evidence base for many of the indicators is described in other technical reports, and summarised below.

1. Internationally and Nationally Designated Nature Conservation Sites

Summary of Appraisal

Detailed consideration of potential impacts on internationally and nationally designated nature conservation sites is provided in the Stage 3 Marine Ecology report.

The unrestricted head, ebb only operation of IBv2b was predicted to have greater impacts on the overall structure and function of the Mersey Estuary SSSIs/ SPA/ Ramsar site, due to resulting changes to the tidal regime which would reduce the overall area, quality and time of exposure of intertidal habitats for bird feeding.

The scheme variant predicted to have the least impact on the designated sites was VLHBv3a, operated using restricted head, ebb and flood generation. This scheme variant was predicted to follow the natural tidal cycle most closely, resulting in the smallest effects on the SPA features and sub-features.

VLHBv2a, operated using restricted head, ebb only generation, was predicted to have less of an impact than IBv2b but greater impact than VLHBv3a.

A range of measures to prevent harm and mitigate impacts have been developed at Stage 3, and taken into account in the marine ecology assessment.

IBv2b has been scored ‘large adverse effect’ and VLHBv2a and VLHBv3a have been scored ‘some adverse effect’.

2. Species and Habitats of Conservation Importance

Summary of Appraisal

Detailed consideration of potential impacts on species and habitats of conservation importance is provided in the Stage 3 Marine Ecology report.

The assessment concludes the same as for sustainability indicator 1 above – IBv2b has been scored ‘large adverse effect’ and VLHBv2a and VLHBv3a have been scored ‘some adverse effect’.

3. Habitat Creation or Ecological Enhancement

Summary of Appraisal

A range of measures to prevent harm and mitigate impacts on ecological receptors have been identified for each scheme variant (see Stage 3 Marine Ecology report), including habitat creation. Opportunities for habitat creation or ecological enhancement over and above mitigation (and any compensation that may be required) would be limited but similar for all schemes, and all have been scored ‘no change’ (neutral).

4. Levels of Flood Risk

Summary of Appraisal

The assessment of potential change in flood risk regime (including tidal, fluvial, groundwater and surface water) has been undertaken by considering the effect of the scheme variants on mean and high water levels. The assessment also takes into account how the scheme fits with existing strategies and surface water management plans (SWMPs). All of the schemes considered in Stage 3 would result in an increase in the mean water level and a potential decrease in the high water level.

All of the schemes would have a similar high water level, with the schemes ranked in order of high water level (lowest to highest water level) VLHBv3, VLHBv2 and IBv2. The predicted change in flood risk for each of the scheme variants is not only based on the high water level but also on the duration of the high water stand period and the probability that a high flow fluvial event occurs at the same time.

There is the possibility that the barrage operation could be modified to provide some flood protection; however this has not been considered in the assessment.

The evaluation of the change in flood risk has been undertaken based on the changes to the water levels within the Estuary and not through detailed analysis of the flood risk using numerical models. The change to flood risk as a result of the preferred scheme will, however, be evaluated using the statutory process in consultation with the Environment Agency.

5. Character and Accessibility of Places, Landscapes and Heritage Assets

Methodology

Landscape

A desktop study of available information on landscape character and landscape planning policy in the area has been completed and the proximity of Band A to potentially sensitive landscape receptors has been investigated.

Any difference between the technology options is terms of massing and height and therefore potential impact on landscape and visual receptors has also been considered.

Heritage

A rapid desktop appraisal of available information on cultural heritage assets in the area has been completed using available internet sources and the proximity of Band A to potentially sensitive cultural heritage assets has been appraised.

Any difference between the technology options in terms of construction techniques, massing, scale and height and, therefore, potential impact on cultural heritage assets has also been appraised.

Key Findings and Mitigation Recommendations

Landscape

Landscape Character

Band A lies within the Natural England National Character Area (NCA) 58, Merseyside Conurbation, which includes the City of Liverpool and the urban/ industrial areas of Birkenhead. Urban growth and

the built-up landscape of the Liverpool Conurbation is dominant on the Liverpool Bank of the Mersey Estuary, extending to Birkenhead on the Wirral Bank.

Band A is covered by the Wirral Landscape Character Assessment and Visual Appraisal (WLCA) although no Landscape Character Areas are identified within proximity to Band A. Liverpool City Council does not currently have a Landscape Character Assessment.

Accessibility of Places

The site and surrounding area is generally flat at around 10 m AOD rising to a maximum of 89 m AOD at Woolton, approximately 5 km to the east from Band A. Expansive views across Liverpool, Birkenhead and Bebington would be limited by intervening development and vegetation.

Potential sensitive visual receptors may include local residents, visitors to the Liverpool WHS and Buffer Area (see Heritage section below), visitors to public areas adjacent to the River Mersey including footpaths, users of pleasure cruises, and visitors and employees working within the numerous tall buildings within Liverpool.

Three listed parks, as identified on the English Heritage Register of Parks and Gardens of special historic interest in England, are located within 1 km of Band A (Sefton Park, Prince's Park and Toxteth Park Cemetery). It is unlikely that visitors to these parks would gain views of the development at Band A due to intervening vegetation and built development.

With regard to Band A, potential sensitive visual receptors within close proximity to the development on the Liverpool Bank may include residential properties and users of the proposed refurbished festival grounds site, residential properties at Armstrong Quay, Columbus Quay, Promenade Gardens, users of the Britannia Inn public house and riverside footpath (not identified as Public Right of Way on Ordnance Survey Explorer Map).

Residential receptors at New Ferry on the Wirral Bank lie within close proximity to the potential development area.

An adverse impact due to available views of the construction of the development is inevitable for all the schemes, with potential significant impacts for a number of sensitive receptors that is anticipated to be major. During operation, there will also be a significant change to views from sensitive receptors, although the nature of the impact will be dependent on the design and appearance of the development. Although, due to the relatively flat topography and heavily built up nature of the surrounding areas these impacts will be limited.

An adverse impact on landscape character due to construction would occur for any of the schemes; however these impacts are anticipated to be limited due to the existing influence that industry has on these areas. As for visual impacts, impacts during operation would be dependent on the design and appearance of the development.

Heritage

The Liverpool WHS Maritime Mercantile City and its Buffer Zone lies to the north-west of Band A at a distance of c. 2.5km. A number of Conservation Areas, listed buildings, SAMs and Registered Parks and Gardens are located within the surrounding areas close to Band A. These include, on the Wirral Bank, listed buildings and a conservation area at Bromborough Pool and Port Sunlight, a Grade II Registered Park and Garden at Port Sunlight, the Scheduled Monument of Bromborough Court House Moated Site and Fishponds (SAM No. 13428). Close to Band A on the Liverpool Bank are two conservation areas and listed buildings at St Michael's and Fulwood Park. Further Registered Parks

and Gardens at Prince's Park and Sefton Park (both Grade II*) and at Allerton Cemetery (Grade II) as well as other listed buildings and SAMs are noted in the wider area.

A rapid review of wreck sites (mainly dating to the 18th, 19th and 20th centuries) suggests that there are numerous wrecks in the vicinity of Band A; none of these are protected wreck sites. The potential for estuarine deposits to contain buried archaeological remains or palaeo-environmental sequences is currently unknown.

The routes of the power lines that would be required to connect each scheme to the national grid (via bulk supply points at Rock Ferry or Bromborough) have not yet been determined, but a number of heritage assets are located in the vicinity of the potential routes including a number of Conservation Areas (Rock Ferry, Bebington, Port Sunlight, Bromborough and Eastham).

The development would not physically impact upon any known designated historic asset (World Heritage Site, SAM, Historic Battlefield, Registered Park and Garden, Listed Building or Protected Wreck), and it is assumed that grid connections would avoid physical impacts on any of these assets.

Band A lies c. 2.5 km from the WHS and, therefore, construction work would have an impact on the Site's setting and views from it along the Mersey Estuary. It should be noted that the structure would not cut off or block the WHS's key views out to sea or across the Mersey. It should also be noted that the proposed structures in all cases would be a maximum of 15 m high and, therefore, their visual impact on the WHS and the impact on its Outstanding Universal Value (lying at approximately c. 2.5 km to the north-west of Band A), would be limited.

Due to the close proximity of designated cultural heritage assets to both ends of Band A (and the required power lines), including SAMs, listed buildings and Conservation Areas, all three schemes at Band A would have some adverse impact on the setting of these cultural heritage assets. It is likely that wreck sites would also be impacted by the extensive construction works and dredging works alongside estuarine sequences of unknown archaeological potential. Some adverse impacts would be expected from any of the three scheme variants at Band A, on SAMs, listed buildings and Conservation Areas.

Key Assumptions/ Limitations

Landscape

The key assumptions/ limitations for landscape are:

- a number of sensitive visual receptors have been identified through the initial selection of representation viewpoints, but these have not been agreed with the planning authorities;
- details on the nature of the construction works are not currently available; and
- details of the likely heights or locations of ancillary buildings are not currently available.

Heritage

The key assumptions/ limitations for heritage are:

- no site visits or detailed assessments of the cultural heritage assets have been undertaken at this stage;
- more detailed assessments would be required on the location of historic wreck sites, aircraft crash sites, locally and regionally important archaeological sites and the sequences of estuarine deposits for their archaeological potential, as these have not been included within this appraisal;

- historic landscape or seascape has not been considered in this appraisal and should be included in any future more detailed assessment;
- details on the nature of the construction works are not currently available; and
- details of the likely heights or locations of ancillary buildings are not currently available.

Differences Between Scheme Variants

Landscape

Generally all of the three schemes would have a similar massing and height of structures on both banks and across the Mersey. The height and massing of ancillary structures would be secondary compared to the scale of the main structures. Therefore, there is unlikely to be any difference in impact between the three schemes.

Heritage

Generally all of the three schemes would have a similar impact in terms of extensive construction impacts (piling or sea bed-cut), necessary dredging, massing, scale and height of structures on both banks and across the Mersey. The scale, height and massing of ancillary structures would be secondary compared to the scale of the main structures. There is unlikely to be any difference between the physical impacts of the construction of the three schemes at Band A.

6. Lifecycle Carbon Balance of the Development

Methodology

The carbon balance study provides an initial calculation of the carbon dioxide (CO_2) balance associated with the construction of the Mersey Tidal Power project. Emissions would mainly include the embodied carbon in the materials used and the energy requirements for the construction of the project. The term embodied carbon in this report refers to the CO_2 emitted from the proposed tidal power plant's structure and construction from the extraction of raw materials, through to the fabrication and distribution of the building supplies and finally on to the energy used in the erection of the plant itself. Energy consumption during construction includes energy requirements for machinery operation, earthworks and transport of the personnel from and to the site.

A more detailed analysis would require very detailed data on the exact type, origin and quantity of each material used as well as energy type and fuel usage for each process during the construction phase of the project.

This study intends to provide an initial assessment with a reasonable level of accuracy based on the limited information available at this point together with a high level of transparency. To measure the CO_2 emissions associated with the construction of the scheme, a quantitative approach has been used. The methodology that has been followed (calculations and inputs selection) is direct and clear and the sources of data (emissions factors) that have been used for the analysis come from well recognised industry sources and thus, this study can provide an indicative estimate of CO_2 emissions associated with the construction of the project.

The model is a spreadsheet based tool which includes separate emission calculation sheets for each construction option. In total three schemes have been considered: IBv2b, VLHBv2a and VLHBv3a. A separate sheet has been compiled with the emission factors of the relevant material and energy sources, which feeds information to the emission calculation sheets. To allow for consistency and

direct comparison amongst schemes, the same set of emissions factors has been used in all cases. Most emission factors have been obtained directly from recognised sources such as the Inventory of Carbon and Energy (ICE), University of Bath[1] and Sustainable Concrete UK[2]. Where adjustments or additional estimates were necessary, assumptions and sources of data/information have also been provided. Material quantities for each of the three schemes have been based on costing schedules supplied by Turner and Townsend (see Stage 3 Cost Management report).

The emissions associated with the construction phase of the Mersey Tidal Power project have been compared with the expected emission savings that the project will achieve over the first 20 years of operation by generating green energy.

Key Findings and Mitigation Recommendations

The structure would be very large structure and require significant amounts of materials that offer structural stability and durability, like concrete and steel. Such materials have significant amounts of embodied energy increasing significantly the CO_2 emissions associated with the project. Furthermore, during the construction phase, significant amounts of energy would be needed, which would also produce CO_2 emissions. Consequently, even though the project aims to reduce CO_2 emissions by providing clean renewable energy, it is possible that the net change in terms of CO_2 emissions could be positive or negative, depending on the total amount of emissions associated with the construction, lifetime operation and decommissioning of the facility.

In order to maximise any reduction in CO_2 emissions, it is necessary to consider the type of materials which will be used and select those which will have the lowest embodied energy. Using recycled instead of primary materials might significantly reduce the embodied carbon.

Furthermore, transport of materials and personnel are usually another important source of carbon emissions. Therefore, it would be essential to opt for locally sourced material whenever possible and use sustainable modes of transport.

The energy requirements during the construction phase are likely to be high. Using energy efficient equipment would be important in saving emissions as well as selecting low carbon fuel and renewable sources of energy to feed the power requirements for the construction phase of the project.

Key Assumptions/Limitations

The CO_2 emissions estimates associated with the construction of the Mersey Tidal Power project are indicative only as they are based on a series of assumptions and their purpose is merely to provide support for the assessment. For the purposes of this analysis the following assumptions have been made:

- Typically embodied carbon emission factors are confined within the boundaries cradle to gate (i.e. to the point where building fabric materials leave the place of fabrication) to separate from operational impacts. As the origin of the materials to be used for the construction of the development is not known, cradle to gate emission factors have been used. It should be noted though that for those materials with high embodied energy and high density (e.g. steel, reinforced concrete) the difference between cradle to gate and cradle to site (i.e. to include the deliver of materials to the point of use) could be considered negligible. However this would not be the case for material with little embodied energy per kg (e.g.

[1] Hammond G & Jones C (2008) Inventory of Carbon and Energy (ICE) Version 1.6a. Department of Mechanical Engineering, University of Bath [online] available at: http://www.bath.ac.uk/mech-eng/sert/embodied/ (accessed 28 May 2010)
[2] Available online at: http://www.sustainableconcrete.org.uk/main.asp?page=230 (accessed 28 May 2010)

aggregates, sand) [3]. For simplicity it has been assumed that these materials are all sourced locally, thus the emissions from their transport have been assumed to be negligible compared with the rest of their life cycle. When adequate information is available on the origin and transportation of the different materials is available the model could be adjusted to account for these additional emissions.

- The project construction would require a significant amount of excavation, dredging and other earthworks. For that purpose it was necessary to provide an estimate of the emissions associated with these activities. For consistency it has been assumed that the same type of machinery is used in all cases for all the different schemes (assumed 3.7 tonne bucket capacity and 346kW engine)[4,5].
- All reinforced foundations have been assumed to high strength concrete with 100 kg/m^3 steel reinforcement. For examples capping beams to support sheet pilings have been assumed to be reinforced structures to ensure stability. For other constructions, where lower structural strength is needed such as roads slabs, 25 kg/m^3 steel reinforcement has been considered.
- All roads were assumed to comprise 200 mm of asphalt 150 mm of stone gravel/chippings and 350mm of recycled aggregate.
- Landside facilities have been assumed to be reinforced concrete constructions, with 100 kg/m^3 steel reinforcement.
- All steel requirements have been assumed to be produced with typical UK standards.
- Granular fill to abutments have been assumed to be general aggregates and/or sand.

Due to the level of information available at the options appraisal state, some assumptions have been made regarding the dimensions of the components to enable the analysis. In a few cases it has not been possible to identify the quantity of material used, thus figures for a small number of components have not been assessed e.g. elements of landscaping.

Rough estimates of energy and transport emissions have been produced based on the size (in terms of cost and personnel involved) and duration of the project. Default emissions factors for energy and transport have been obtained from the Environment Agency Carbon Calculator for Construction Activities[6]. Separate figures have been provided for excavation and ground compaction activities.

Emissions during decommissioning have not been included in the analysis because of a lack of relevant information at this stage. Disposal of waste from decommissioning is considered under sustainability indicator 8.

[3] Hammond G & Jones C (2008) Inventory of Carbon and Energy (ICE) Version 1.6a. Department of Mechanical Engineering, University of Bath [online] available at: http://www.bath.ac.uk/mech-eng/sert/embodied/ (accessed 28 May 2010)

[4] Online source: http://books.google.co.uk/books?id=balni_6mXmwC&pg=PA80&lpg=PA80&dq=mechanical+excavation+soil+typical+energy+per+m3&source=bl&ots=yRiRMduqmh&sig=aklt_FqeAk940wxrs1Ln51Asv30&hl=en&ei=TAMETJzuLJ-l4gbol4zMDg&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAkQ6AEwAA#v=onepage&q=energy&f=false (accessed 28 May 2010)

[5] Online source: http://www.volvo.com/NR/rdonlyres/2114B4A9-E1C6-482D-95E0-BDBBF7A812B5/0/brochureEC700C_21A1004294_200801.pdf (accessed 28 May 2010)

[6] Online source: http://www.environment-agency.gov.uk/business/sectors/37543.aspx (accessed 28 May 2010)

During operation there would be emissions from maintenance, dredging, periodic component replacement and machinery use. However these have been considered to be negligible as major components of power generation plant under consideration have an expected lifetime of greater than 50 years. Operation emissions are assumed to be negligible in the context of operational power generation.

Regarding the energy savings associated with the operation of the development, these are equal to the amount of the energy that the power plant will produce over its lifetime multiplied by the CO_2 intensity of the power source that it will displace (i.e. emission factor of the national grid, if it is assumed that the energy generated by the power plant will be fed to the national electricity grid). The Government uses a factor of 0.43 $kgCO_2$ per kWh when appraising policies that reduce electricity consumption or encourage the use of renewable electricity[7]. Therefore for the purposes of the analysis the 0.43 $kgCO_2$ per kWh has been used. The project lifetime has been considered to be 20 years.

Differences Between Scheme Variants

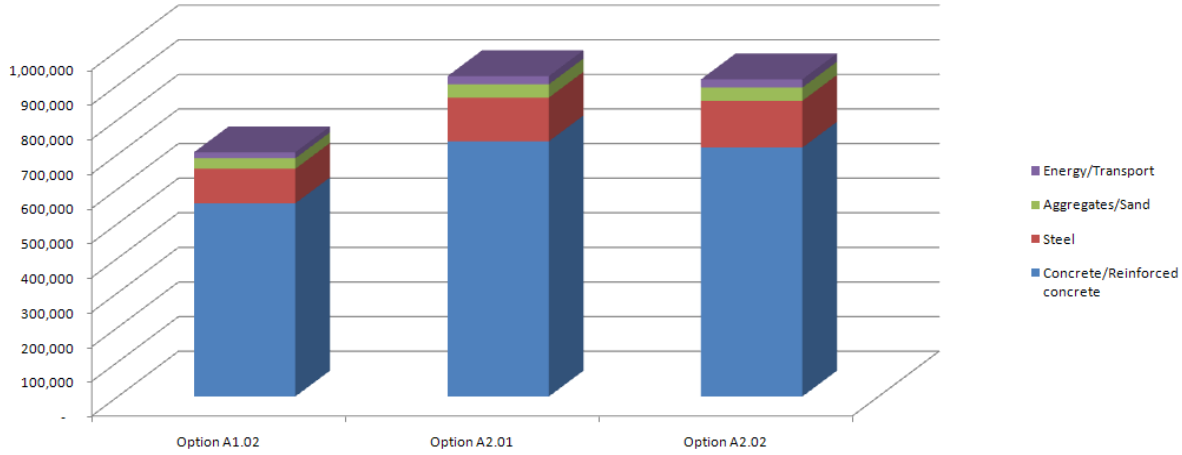
Amongst the three schemes that have been considered, IBv2b was predicted to have the least amount of CO_2 emissions associated with its construction phase, while VLHBv3a was predicted to have the largest. Table A1 and Figure A1 show the emissions associated with the construction of each of the proposed schemes and the main sources of these emissions.

Table A1: Carbon emissions associated with the construction phase

Scheme variant	Emissions associated with the project construction (tCO_2)	% of emissions from concrete/ reinforced structures	% of emissions from steel	% of emissions from aggregates/ sand	% of emissions from energy/ transport
IBv2b	731,495	76%	14%	4%	2%
VLHBv2a	943,847	78%	13%	4%	3%
VLHBv3a	935,860	77%	14%	4%	3%

[7]Defra (2008), Guidelines to Defra's Greenhouse Gas Conversion Factors for Company Reporting [online] available at: http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-cf-guidelines2008.pdf (accessed 11/11/2010)

Figure A1: Embodied Carbon emissions (tCO_2) associated with the construction phase



Concrete-based materials and reinforced structures are the main contributors to the total emissions during the construction phase for all schemes. This is mainly attributed to the large amounts of embodied energy associated with these materials as well as the large quantities required for the construction. Steel and sand/ gravel materials also contribute significantly to the total emissions of all three scheme variants. There would be significant amounts of gravel and sand used, while steel is important to ensure stability of the structure and would be required for power generation and transmission. Only a minor part of the total emissions were predicted to come from excavation and other earthworks.

The different schemes offer different amounts of emission savings, which depend on the amount of electricity they can generate over the lifetime of the project. Table A2 shows the annual and project lifetime energy generation potential of the considered schemes.

Table A2: Energy generation potential of the three different schemes

Scheme variant	Estimated annual energy generation (MWh/y)	Energy generation potential over the project lifetime (assumed 20 years) (MWh)
IBv2b	950,000	19,000,000
VLHBv2a	560,000	11,200,000
VLHBv3a	520,000	10,400,000

As already noted it has been assumed that the amount of energy generated by the project would be fed to the national grid. The difference between the avoided emissions from the project operation and the emissions associated with the construction phase (operation and decommissioning phases have not been considered in the analysis) provide an indicator of the carbon balance for each scheme variant. Table A3 shows the predicted emissions savings from operation, the emissions from the construction and the net savings associated with each scheme over the first 20 years of operation.

Table A3: Net emission savings associated with each scheme variant

Scheme variant	Predicted energy generated from tidal power operation over 20 years (MWh)	Predicted avoided emissions (tCO_2) over 20 years	Predicted emissions associated with project construction (tCO_2)	Predicted net emission savings associated with each Scheme (tCO_2)
IBv2b	19,000,000	8,170,000	731,495	7,438,505
VLHBv2a	11,200,000	4,816,000	943,847	3,872,153
VLHBv3a	10,400,000	4,472,000	935,860	3,536,140

IBv2b would provide the greatest positive net emission savings. It is predicted that this variant would produce nearly double the energy of VLHBv2a and VLHBv3a while the estimated embodied carbon within this design would be around 22% lower.

7. Utilities Infrastructure and Resources

Summary of Appraisal

Major Utilities

All three schemes would require overhead 132 kV lines to Bromborough substation. This would include an upgrade of Bromborough to Capenhurst with new towers and upgrade Capenhurst to Birkenhead, with an overhead route through existing industrial areas.

The location of the schemes does not influence the grid connection point, the output from the scheme makes a difference in requirements for system upgrades. At this stage there is little to differentiate between requirements for individual schemes above 200 MW.

All schemes have potentially significant negative impacts in terms of requirements for new or upgraded overhead lines, but there are anticipated to be significant benefits associated with these upgrades in terms of supply and network stability, both locally and regionally.

Further details of the assessment are provided in the Stage 3 Landside Facilities report.

Groundwater and Abstractions

The geology of the study area is dominated by the Permo-Triassic Sandstone aquifer. The aquifer has a long history of heavy groundwater abstraction, although in recent years groundwater levels have been recovering.

Under the Water Framework Directive, the Sandstone aquifer has been assessed as being at risk from over abstraction and saline intrusion. Other water quality issues include pollutants from the glass industry, landfill sites, and heavily industrialised areas of the catchment. The Environment Agency's objective is to not worsen the problems of saline intrusion (or other water quality issues).

One of the potential effects of a tidal power scheme is the adjustment of natural tidal fluctuations and water levels. Tidal fluctuations of the Mersey Estuary are known to propagate into the sandstone aquifer in central Liverpool and similar groundwater level fluctuations are expected elsewhere around the Mersey Estuary.

The Environment Agency's groundwater model covers the northern half of the Mersey Estuary study area, but not the entire southern half. Therefore, there is greater residual uncertainty in the southern

half of the study area with respect to groundwater conditions and the impact of a tidal power development.

8. Waste Production, Reuse and Recycling

Methodology

The construction of any tidal power scheme within the Mersey Estuary would inherently generate waste during and post construction waste would be generated through the requirement to refurbish and decommission structures. The key to assessing the impact of each of the proposed developments is by qualifying the potential sustainability of the projects in key areas such as material usage, material recycling and waste disposal.

For the purpose of this report each development has been assessed based on the following:

- location and capacity of waste disposal facilities within the Merseyside and Halton District;
- the life expectancy of the development and the approximate volume and type of waste generated during any decommissioning/ renewal works; and
- the potential for recycling of waste materials during and post construction.

Key Findings and Mitigation Recommendations

Landfills

Information from Merseyside's Waste Planning department indicates that there is currently only one active commercial landfill site within Merseyside and Halton, this is Lyme and Wood Pits. This site is expected to remain operational until June 2012 with permission to accept 425,000 tonnes of waste each year. It is confirmed that there will be no further extension to the waste licence for this site.

Information from the Environment Agency does not directly correspond with Merseyside's Waste Planning department. Environment Agency information indicates that within 5 km of Band A there is currently one operational hazardous waste landfill and one operational commercial waste landfill.

Within the wider region (within 30 km of Band A) there are a further two operational hazardous waste landfills and two operational commercial waste landfills (inclusive of Lyme and Wood Pits).

No data were available from the Environment Agency in regards to current and future capacity at the identified locations.

Project Lifespan

Different materials will have varying lifespans, dependent on their location and usage and will therefore require ongoing maintenance, refurbishment and replacement. Table A4 below identifies the projected potential lifespan of associated plant for each of the schemes.

Table A4: Potential Plant Lifespans

Scheme	Lifespan	Additional Information
IBv2b	25 years	Generally very robust with a phased programme of refurbishment starting after approximately 25 years.
VLHBv2a	20 years	The generating plant will probably be replaced progressively after approximately 20 years in service.
VLHBv3a	20 years	The generating plant will probably be replaced progressively after approximately 20 years in service.

The expected lifespan of the civil element of the works i.e. concrete/ steel structures would be approximately 120 years for major structures and 50 years for ancillary buildings and tidal fence steel structures.

Materials and Volumes

Using data provided by Turner and Townsend on estimated material volumes it is possible to identify the main waste streams that are likely to be generated during the decommissioning phase.

Due to the nature of the proposed structures and the requirement for them to be durable and stable the main construction materials would be concrete for prefabricated structures, buildings and foundations, steel for reinforcement and framework and granular fill for the provision of hardcore and ballast materials.

The estimated construction material volume for each scheme has been is shown in Table A5. Figures relating to dredging during construction and operation are not included in this table.

Table A5: Waste Material Generation Potential

Project	Total Estimated Volume - Construction Materials (Excluding Dredging Materials)
IBv2	5,100,000
VLHBv2	6,900,000
VLHBv3	6,900,000

Reuse and Recycling

Based on the assessed proposed construction materials it is likely that the majority of waste generated from decommissioned structures would be suitable for reuse or recycling in alternative projects/ developments following project specific processing, such as crushing of concrete which can be used for hardcore or as aggregate for new concrete, and re-melting of steel via a steelworks to be reprocessed as top quality steel.

However, due to the potential volumes of construction waste, the location of suitable recycling facilities and range of potential projects which can reuse material at the time of decommissioning, it is not possible to assess the full impact of each scheme at this time.

Key Assumptions/ Limitations

The key limitations in this assessment are:

- limited information regarding volumes and types of material used for some elements of the schemes;
- material volumes generated during decommissioning are not available for this assessment; and

- data obtained via the Environment Agency and the Merseyside Waste Planning Department do not correlate in regards to current available landfill capacity. In addition, no data were available in regards to future landfill capacity for the area as the Merseyside Waste DPD is not due to be adopted until 2012. Therefore, the likely impact on future landfill capacity on the developments has not been assessed.

Differences Between Scheme Variants

Based on the available information and estimations, all three potential scheme variants have the potential to generate a substantial volume of waste during decommissioning due to the requirement for landside, bankside and waterside structures.

The expected lifespan of civil structures for all schemes is similar. All major structures are estimated as having a life span of approximately 120 years with ancillary buildings having a life span of 50 years and plant life expectancy varies between 20 and 25 years.

All the proposed major material constituents of the schemes have the potential to be reused and recycled in local, regional and national schemes, although it is fair to assume that not all construction waste will be reused/ recycled and therefore based on proposed reuse/ recycling figures for 2012 approximately 50% may need disposing using alternative methods.

9. Ecological Status or Potential of the Mersey Estuary and Other Water Bodies (in Relation to the Water Framework Directive)

Methodology

Any tidal power development in the Mersey Estuary has the potential to lead to changes in the Mersey Estuary and other water bodies (such as watercourses discharging to the Estuary) that affect their ability to achieve Good Ecological Status/ Potential under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. Under the Regulations, any development that might to lead to a deterioration in status or to a water body not achieving its target status/ potential will need to meet a number of criteria set out under Article 4.7. In order to meet the duties under the Directive and achieve consent it is necessary to demonstrate overriding public need for the development and that the Best Environmental Option has been selected. The status of water bodies is judged by a number of measures, including chemical water quality, biological water quality and geomorphology of the water body (with a number of sub-measures under each of these).

At this stage, the assessment of potential impact of developments on ecological status or potential has been limited to the potential direct effect of developments on the ability of the Estuary itself to ‘flush’ (that is, allow pollutants contained in the Estuary to discharge to sea). This is expected to be the most significant potential effect of the various schemes on water quality, with the possibility of leading to changes in chemical and biological water quality, and is therefore used as a surrogate for other potential direct or indirect impacts (which will be investigated themselves in further detail at later stages).

Numerical modelling of the ‘flushing’ of the Estuary has been completed for the three scheme variants under consideration. A flushing study provides an indication of the rate of exchange of water within the estuary with water outside of the Estuary and is used as a first indication of the potential changes to water quality parameters. The schemes modelled are IBv2b, VLHBv2a and VLHBv3a. The modelling outputs focus on potential effects of developments on the Mersey Estuary. At this stage of

the assessment this is taken as a surrogate for potential impacts on other water bodies, as the Mersey Estuary will be subject to the greatest effect.

A second measure has been selected under this indicator to deal with the potential for re-mobilisation of contaminated sediments. At this stage of the study no data are available on the potential for specific areas of the Estuary to contain contaminated sediments. The assessment of this indicator has therefore focussed on the potential for developments to affect whether the Mersey Estuary can achieve Good Ecological Potential.

In addition to consideration of water quality, impacts on fish have also been considered as the classification of waterbodies under WFD also relates to biological indicators including fish. Impacts on fish are discussed in detail in the Stage 3 Marine Ecology Report.

Key Findings and Mitigation Recommendations

Effect of Developments on Ability of Estuary to Flush (Impact on Chemical or Biological Water Quality)

The initial outputs for the modelled estuary flushing scenarios have indicated the following:

Baseline (Neap and Spring)

The baseline scenario shows relatively rapid attenuation of initial concentrations (with a relatively significant reduction in concentration in less than a week). The spring tide condition, as would be expected, leads to a more rapid dilution with a flushing rate removing 25% and 50% of the initial concentration after 2.4 days and 5.3 days respectively.

IBv2b

The flushing rate for rate for this scheme variant was predicted to be the lowest of the Stage 3 schemes, achieving a 25% removal of the initial tracer concentration after 4.5 days in the modelled scenario. The hold at low water would reduce the tidal excursion within the basin just upstream of the barrage with an increase in ponding. Although the model suggests these effects at Eastham and Widnes would be much less pronounced the opportunities for increased sedimentation, sediment re-distribution and further interaction between the water column and benthos are greater compared to the other scheme variants. This scheme is likely to experience greater changes to water quality than the other schemes; whether these are beneficial or adverse needs to be determined.

VLHBv2a

The flushing modelling for this scheme variant suggests a slight improvement compared to the IBv2b scheme with a flushing rate to achieve a 25% removal of the initial concentration being 4.4 days. The combination of head control and low water sluicing would more closely mimic the natural elevations in the basin just upstream of the barrage, although there appears to be a small shift in the phase and the tidal amplitude. The effects to tidal elevation further upstream are predicted to be less pronounced and represent relatively small perturbations from natural conditions. Consequently, effects to water quality might be less for this scheme than IBv2b.

VLHBv3a

This scheme, using a combination of head control and low and high water sluicing, would result in a hydrodynamic regime that most closely mimics natural tidal elevations for most parts of the Estuary. The flushing rate predicted for this scheme is the highest of the Stage 3 schemes, with a 25% removal of the initial tracer concentration in 3.4 days. Whilst tidal elevations within the basin upstream of the barrage and at Eastham were predicted to achieve a closer fit to the natural variation in tidal

amplitude, the phasing and closeness of fit to the expected tidal elevation upstream at Widnes and downstream at Gladstone Dock was relatively poor.

This may have implications for water quality since these spatial differences may result in localised flushing rates that may be very different and lead to varying effects on water quality. For instance, lower flushing rates (exchange rates) may reduce the capacity of the water column to sustain dissolved oxygen concentrations since it is in these upstream reaches where fresh inputs of nutrients and organic matter are delivered to the estuary.

Potential Effects Due to Impacts on Flushing

The implications of a reduction in the ability of the Estuary to 'flush' contaminants through tidal processes on chemical water quality are as follows:

1) Potential for build up of dangerous substances – dangerous substances are rigorously controlled but there is the potential for remobilisation of historic substances locked up in sediments (in the event of a major storm or development upstream of a tidal energy device).
2) Potential for eutrophication – previous studies on the Mersey have concluded that whilst nutrients are not in short supply in the Estuary, very high turbidity has suppressed primary productivity and prevented eutrophication from being a problem in the Estuary.
3) It should be noted that flushing rates can vary spatially as well as temporarily and that changes to one part of the Estuary or scheme operating mode may have implications for other parts of the Estuary. Changes to the flushing (or exchange rates) in the upper part of the Estuary may result in a disproportionate effect since there is a constant supply of fresh nutrients and labile organic matter from the catchment in these upper reaches of the Estuary. Moreover, sediment contaminant concentrations tend to be higher further upstream which may result in complex and greater interactions between the sediments and the water column.

In combination these potential effects could lead to changes in biological quality through impact on diversity and abundance of invertebrates and other species as a function of space (position in the Estuary) or time (season, low freshwater inflow etc). Whether these are beneficial or adverse needs to be determined. The magnitude of these various effects could also be altered by a particular scheme configuration or its mode of operation.

Effects on Fish

Potential impacts on fish are discussed in the Stage 3 Marine Ecology Report. As well as presenting a physical barrier to movement (partially mitigated by the inclusion of fish passage routes within the structure), fish may be injured or killed during turbine passage, by increased predation and water quality changes.

Other Potential Effects

Whilst there has been no detailed consideration of geomorphological effects of a tidal power development on the Mersey, logic suggests that a development that would have a greater effect on the tidal range would have a greater geomorphological impact (though the direct effects due to construction would need to be assessed separately to the indirect and longer-term effects due to operation of a scheme). It is therefore likely that an IBv2b would have the greatest effect, and VLHBv2a and VLHBv3a (using restricted head operation) would have lesser but still negative effects (but some variation in sedimentation rates where deep channels are constrained and velocity changes are driven through the construction).

Recommendations for Mitigation

Further assessment is required regarding the potential for schemes to affect geomorphology of the Mersey Estuary and other water bodies, as well as more detail about potential for chemical or biological water quality impact to determine whether there is potential for the schemes to have a significant impact.

In terms of mitigating effects on water quality, the following mitigation measures are recommended for investigation in further stages:

1) For those schemes that have the potential to lead to ponding behind the structure (through amendment of tidal regime), changes to the operating regimes should be investigated through water quality modelling to determine the magnitude of the likely effects and how potential impact may be reduced; and
2) Once information regarding the potential for sediment contamination and accumulation is known, this information should be used as one of the factors to inform selection of the location and operating mode for the preferred scheme.

Measures to avoid and mitigate impacts on fish may include fish passage routes (included in the Stage 3 scheme designs) and measures to guide fish to fish passage routes. Further information is provided in the Stage 3 Marine Ecology Report.

Following more detailed assessment of all Water Framework Directive factors, it is likely that further mitigation will be recommended for consideration, however these will be brought into the assessment at a later stage (when appropriate). This will be informed by the conclusions of the Water Framework Directive scoping study.

Key Assumptions/ Limitations

The conclusions and assessment for this indicator are currently based on the outputs of flushing study to demonstrate potential effects of developments on flushing capability of the Estuary, and on consideration of impacts on migratory fish.

The flushing calculations only consider one factor of water quality, with its potential to impact on the ecological status or potential of the Mersey Estuary under the Water Framework Directive. This has been used as an indication of the potential scale of impact from the scheme variants to help differentiate between them, but there are a wider range of factors that need to be considered, along with potential impact on other water bodies, for a full assessment of the potential effects of developments on this indicator. Whether or not the effects of the development would, in practice, lead to the improvement or deterioration of the status of the water body (or aid/ prevent it achieving good ecological status or potential) would need to be assessed in more detail.

Whilst the Water Framework Directive was implemented into UK law in 2003, River Basin Management Plans (the first stage of the process) were only produced over the past year. The Environment Agency has not yet confirmed the process for consideration of new applications. Recent guidance provided by the Environment Agency has indicated a need to demonstrate consideration of alternatives for any Water Framework Directive assessment of a development option. For this reason a full scoping is being undertaken of likely effects of all development options on the various elements of water quality under the Water Framework Directive (chemical and biological quality and geomorphology). This will include detailed consultation with the Environment Agency.

No data are available on sediment quality at any of the locations under consideration; therefore an assessment of the potential for developments at different locations to lead to mobilisation of sediments is not possible at this stage.

Differences Between Scheme Variants

As would be expected, the modelling indicates that the schemes that have a greater effect on tidal range have a greater effect on the flushing capability of the Estuary, and therefore greater potential effect on chemical water quality (and hence potential for impact on biological water quality). This is particularly true where the tidal range is limited to part of the natural baseline range (e.g. IBv2b 'holds' the water level in the impounded basin at mean tide, rather than letting it drop to the low tide level). This logic applies for geomorphological effects also, though, to date, this has not been assessed in any detail.

Changing the operating regime through the use of head controls and variation in the timing and degree of sluicing would generally result in modifying and improving the tidal response upstream of the barrage.

The effects to water quality and geomorphology are likely to vary between the different operating regimes and vary spatially with some regimes having larger and/or more extensive effects than others. These differences can only be understood in detail through further modelling effort.

With regards migratory fish, all schemes have potential to affect the movement of fish due to the presence of a structure across the Estuary and potential for injury and mortality (e.g. due to turbine passage). Fish passage routes were included in all Stage 3 scheme designs, but further measures would need to be developed for the preferred scheme to enable safe fish passage.

10. Emission of Air Pollutants

Methodology

A desktop study of available information on baseline local air quality in the area has been completed and the proximity of Band A to potentially air quality sensitive receptors has been investigated.

Any likely differences between the scheme variants in terms of construction dust, construction traffic and operational traffic have been considered.

This section does not consider the potential regional/ national air quality benefits of the operation of the various schemes due to the offsetting of pollution emissions from a fossil fuel electricity generation source, as this issue is effectively covered as part of the lifecycle carbon balance appraisal (see indicator 6), by virtue of the fact that air pollutant emissions from fossil fuel power generation will be offset alongside carbon emissions.

Key Findings and Mitigation Recommendations

The Liverpool Bank of Band A is located within an Air Quality Management Area (AQMA) for nitrogen dioxide (NO_2). The Wirral Bank of Band A is within Wirral Metropolitan Borough Council, which has not declared any AQMAs within its area. Instead of declaring a number of discrete areas where the NO_2 annual mean air quality objective is exceeded, Liverpool City Council has declared the whole of its area as an AQMA. NO_2 levels on the Liverpool Bank are unlikely to exceed the air quality objective of 40 $\mu g/m^3$, however levels along main roads which may be used by both construction and operational/ visitor traffic may exceed the objective. No details are currently available on the likely route or volume of construction or operational/ visitor traffic in order to assess this impact further.

The Liverpool Bank of Band A is in an area of open vegetated land which forms part of the former Liverpool Garden Festival site. The closest identified existing sensitive receptors are residential properties to the north/ north-west beyond the A5036 Riverside Drive. However, the Garden Festival site has planning permission for approximately 1,300 residential properties, therefore it is likely that these new properties would be the closest sensitive receptors to Band A. Access for both construction and operational/ visitor traffic to the Liverpool Bank of Band A appears to be reasonably straightforward off the A5036 Riverside Drive, and significant lengths of new road would not be required.

The Wirral Bank of Band A is in an industrial area. The closest identified residential properties to Band A are located in York Street. Vehicle access appears to be available directly from the industrial areas.

The areas of the Estuary adjacent to both ends of Band A are designated ecological sites.

An adverse impact due to construction dust and construction traffic is inevitable for all the schemes; however the magnitude of the impact is unlikely to be high. All schemes are anticipated to take approximately 5 years in total to construct.

An adverse impact due to operational/ visitor traffic is inevitable for all the schemes; however the magnitude of the impact is unlikely to be high.

Key Assumptions/ Limitations

The key assumptions/ limitations for the emission of air pollutants are:

- none of the technology options would generate emissions to air directly;
- no details on the nature of the construction activities are currently available; and
- no details of the likely volume or route of construction or operational/visitor traffic are currently available.

Differences Between Scheme Variants

Details of the nature of the works required to construct any of the three schemes are not currently available, in particular any significant differences between the schemes in terms of dust generating activities or volume of construction traffic required is not currently known. Similarly, no details are currently available of any difference in traffic generated by staff and visitors for each scheme; therefore it is not possible to differentiate between the schemes in terms of operational local air quality impacts.

11. Land Quality

Methodology

In terms of sustainability, land remediation can be viewed in two ways:

1. remediation of contaminated land is inherently sustainable as it brings derelict land back into beneficial use and creates economic, environmental and social benefits; and
2. it can require a significant amount of resources (in terms of energy and natural resource usage) to realise.

In the case of this sustainability assessment, remediation is seen as an overall sustainability benefit.

The quality of the land at the ends of Bands A has been reviewed based on available information on historic land uses.

Key Findings and Mitigation Recommendations

Initial research has indicated that the Garden Festival site on the Liverpool bank of Band A is located on landfill material, is partially on a former oil storage depot and adjacent to a filled dockyard. This site is currently being redeveloped for mixed uses.

The New Ferry site on the Wirral bank of Band A is also on landfill material and is adjacent to former brick, soap, candle and sewage works. It is therefore likely that the site would require some remediation prior to any development. However, it is anticipated that the landside features at the Wirral bank will be constructed on a platform of ground that will be built as part of the contract.

Key Assumptions/ Limitations

A quantitative assessment is not possible as the exact locations have not been selected, the exact size of land areas involved is not known, information on soil and water contamination is not available to make an assessment of remediation requirement and information on landside structures is not available.

At present the indicator has been considered using only 'landside' land quality measures as land beneath the water column cannot be defined as brownfield/ greenfield nor can it be remediated as such.

It is assumed that no greenfield land will be lost.

Differences Between Scheme Variants

Overall, it is considered that the three Band A schemes cannot be differentiated at this stage given the information available on land contamination, re-use of brownfield land and use of greenfield land. All Band A schemes would be likely to require some land remediation.

12. Transport Infrastructure

Summary of Appraisal

Road access routes to the proposed development area have been considered as part of the feasibility study. Access by water would also be available.

On the Liverpool bank access to the waterside would be from the A561. Access routes to Band A would pass through some residential areas.

On the Wirral bank, access would be from the A41. Band A would most likely be accessed via Birkenhead to the north (via the Kingsway tunnel) or Eastham to the south (from the M53 Junction 5), and traffic would pass through a mixture of residential, retail and industrial areas. The Wirral Unitary Development Plan identifies highway capacity issues along the A41 between Birkenhead and the M53. An alternative route would be from the M53 Junction 4 and along the B5137/B5136 and A41, but this route passes through primarily residential areas.

No significant differences have been identified between the scheme variants under consideration.

13. Amenity for Recreation, Tourism and Leisure

Methodology

The focus of the investigations has been to determine the potential impacts of the preferred technologies and scheme alignment on tourism and leisure. This has been achieved through the following:

- detailing any direct/ obvious tourism and leisure implications of the preferred schemes and options, especially in relation to its visual appeal; and
- identifying and mapping existing tourism attractions and water based amentities across the Merseyside area to establish any direct correlation with exisiting provision that could be exploited.

Key Findings and Mitigation Recommendations

Potential Leisure Visitor Numbers

The appearance of each scheme would be broadly similar and purely functional. Additional features placed on the structure purely for design purposes (such as cowling) could be achieved, for effect and branding purposes. Success of enhanced branding will improve the chances of successful attraction of visitors and related jobs.

Landside visitor facilities are considered to be the same for all schemes at this Stage.

The visitor interest in various technology options is not likely to vary significantly. The visitor centre is likely to address a wider range of subject matter than just the technology of the turbines.

Visitor numbers and associated activity for all three schemes are considered to be broadly similar and in the range of 60,000 – 100,000 per annum.

The impact of visitor numbers both to the visitor centre (measurable) and the wider City Region (not measurable) will be significantly greater if attention is paid to design, access to and appearance of the facility, irrespective of which scheme is preferred.

Potential to Create Leisure Facilities

The main impact is likely to be in enhancing existing leisure facilities.

The potential to create new leisure facilities is limited with regard to water based tourism, although there is much greater potential to create either iconic structures within the facility, or related public artworks.

The potential to generate greater interest in the river and its habitats creates potential for increased visitor numbers and leisure facilities related to provision of greater access to river habitats. A visitor centre focused on wildlife and habitats would not need to be located next to the facility, and could be a means of ensuring greater access and awareness of the environmental value of the river.

Potential for Change to Recreational and Leisure Use of Estuary (Yachting, Sailing and Angling)

The presence of a structure spanning the Estuary could pose a barrier to movement of recreational and leisure vessels on the Estuary, but this will be mitigated by the inclusion of a small boat lock within the structure.

Changes to the tidal regime within the Estuary have the potential to impact on recreational vessel movements within the Estuary, particularly in the shallower parts of the Estuary where there are limited windows for movement. Further consultation with relevant stakeholders will be required to identify further mitigation (such as publication of information on changes to high and low water times).

Key Assumptions/ Limitations

Visitor numbers are assumed to be constant between all three schemes.

Differences Between Scheme Variants

Potential Leisure Visitor Numbers

All schemes can have a significant positive impact, irrespective of technologies employed. Band A provides a high profile location close to the tourist attractions at the historic waterfront.

Potential to Create Leisure Facilities

All schemes can have a significant positive impact, irrespective of technologies employed.

Potential for Change to Recreational and Leisure Use of Estuary (Yachting, Sailing and Angling)

All schemes could have a negative impact on recreational and leisure uses.

On balance, the overall impact of all schemes on amenity for recreation, tourism and leisure is considered to be positive, but a rating of only 'some benefit' has been assigned in recognition of the potential negative impacts on existing yachting, sailing and angling activities.

14. Human Health and Wellbeing

The measures for the human health and wellbeing indicator include unemployment, income, deprivation, leisure facilities, air quality and noise. Air quality is discussed for indicator 10, the remainder are discussed below.

Methodology

The assessment method is consistent with standard practice in the assessment of socio-economic impact assessment of major infrastructure projects, including key guides on economic appraisal such as HM Treasury's Green Book.

A desktop study of available information on baseline noise data in the area from the Defra Liverpool and Birkenhead Noise Maps has been completed.

The proximity of Band A to potentially noise and vibration sensitive receptors has been investigated.

Any differences between the technology options in terms of construction noise and vibration, construction traffic and operational traffic have been considered.

Key Findings and Mitigation Recommendations

Potential to Improve Local Unemployment Statistics

The main difference between the options would be in the number of construction jobs generated, as shown in Table A6.

Table A6: Indicative employment support in the North West by construction, operation and tourism (direct, indirect & induced)

Scheme	Construction (direct annual employment)		Operation (full time equiv jobs)	Visitor centre (full time equiv jobs)	
	Low	High		60k visitors per annum	100k visitors per annum
IBv2a	2,300	2,700	120	30	40
VLHBv2	3,000	3,600	120	30	40
VLHBv3	3,000	3,600	120	30	40

All schemes could make a significant impact, depending on investment level, ranging from a maximum of 2,700 people (directly employed) per year during construction of IBv2b to a maximum of 3,600 people (directly employed) per year during construction of schemes VLHBv2a and VLHBv3a.

This impact could be maximised by procurement methods which, within competition laws, favour local suppliers and residents and align with existing initiatives to maximise the link between new jobs and related training opportunities and local residents.

Potential Change in Average Income

Both the construction and operation of the development is likely to create and support employment across the North West. Many of the opportunities would be within the communities around Liverpool, Wirral and Knowsley. These are all areas which experience some of the highest levels of deprivation in the UK and are home to pockets of very high unemployment.

The project would also generate demand for low and intermediate skilled labour in construction related activity, which could provide opportunities for local people, sustain employment in those sectors and support the economic vibrancy of the surrounding area. Experience of other major construction has demonstrated the considerable scope for local labour to be utilised in construction and operations.

Average incomes would rise as a function of the additional jobs which would be created by the project. The range of investment levels between IBv2b (lowest) and VLHBv2a and VLHBv3a (highest) all can provide a significant impact on jobs created and therefore raising average income levels.

Potential Change in Rank for Liverpool City Region in Indicators of Deprivation

Many of the firms active in the supply chain for wind power in the North West would be well placed to compete in this market. There is a wide range of common infrastructure requirements as well as shared service industries that would dovetail with the timescales around marine energy commercialisation, and the Liverpool City Region could benefit from this.

The North West and the City Region would be well placed to benefit based on its natural resource, its maritime heritage and good port infrastructure. It is also home to a number of world class institutes including Lancaster University's Renewable Energy Group, the Centre for Hydrology and the Proudman Oceanographic Laboratory. The region still lacks a major testing and research facility which can act as a major catalyst for sector activity, however the presence of a full scale tidal power facility would be likely to stimulate the development of a stronger research base in the region and in turn stimulate the development of a supply chain in the North West. All of this could have a significant impact on reducing Indicators of Deprivation.

Each scheme could have a significant effect. The greater investment level in schemes VLHBv2a and VLHBv3a (highest) would have a greater impact compared to IBv2b (lowest), but all could provide a significant impact on jobs created, lift to GVA and therefore change in rank to the City Region.

Potential to Create Leisure Facilities

Landside visitor facilities would be the same for all schemes, as would the potential for job creation.

The visitor interest in various technologies is not likely to vary significantly. The visitor centre would be likely to address a wider range of subject matter than just the technology of the turbines.

Visitor numbers and associated activity for all schemes are predicted to be broadly similar and in the range of 60,000 – 100,000 per annum.

The potential to create new leisure facilities is limited with regard to water based tourism, although there is much greater potential to create either iconic structures within the facility, or related public artworks.

Potential to generate greater interest in the river and its habitats would create potential for increased visitor numbers. A visitor centre focused on wildlife and habitats need not be located next to the facility, and could be a means of ensuring greater access and awareness of the environmental value of the river.

Noise

The Defra noise map for road noise indicates, as expected, that road traffic noise levels on the banks of the Estuary at each end of Band A are reasonably low. However, traffic noise levels are higher along nearby local roads such as the A5036 to the north-west of the Liverpool Bank of Band A, and along major A roads such as the A561 and A41.

The noise map for railways indicates that rail noise affects a small band along the railway located to the north-east of the A5036 Riverside Drive. The industrial noise map indicates a number of significant industrial noise sources are located reasonably close to the Wirral bank of Band A. Finally, the aircraft noise map suggests that Band A is well outside the lowest aircraft noise contour for Liverpool Airport.

The Liverpool Bank of Band A is in an area of open vegetated land which forms part of the former Liverpool Garden Festival site. The closest identified existing sensitive receptors are residential properties to the north/ north-west beyond the A5036 Riverside Drive. However, the Garden Festival site has planning permission for mixed uses including approximately 1,300 residential properties (current under construction), therefore it is likely that these new properties would be the closest sensitive receptors to Band A. Any access for both construction and operational/ visitor traffic to the Liverpool Bank of Band A would be reasonably straightforward off the A5036 Riverside Drive, and significant lengths of new road would not be required.

The Wirral bank end of Band A is in an industrial area, the closest identified residential properties to Band A are located in York Street. Vehicle access appears to be available directly from the industrial areas.

The areas of the Estuary adjacent to both ends of Band A are designated ecological sites.

Some adverse impact due to construction noise and construction traffic would be predicted for all the schemes; however the magnitude of the impact is unlikely to be high. Construction vibration impacts would only be an issue if works which are a potentially significant source of vibration, such as piling, are required.

No details of any direct operational noise generated by any of the three schemes are currently available, though the magnitude of any impacts is not anticipated to be high. An adverse impact due to operational/visitor traffic is likely for all the schemes; however the magnitude of the impact is very unlikely to be high.

Key Assumptions/ Limitations

Visitor centre jobs relate to visitor numbers and apply equally to all schemes

Full time tourism related jobs at the visitor centre are assumed to be between 30 and 40, depending on the number of visitors.

Capital expenditure is assumed to have a greater effect at the City Region level with regard to elements of construction which can be sourced locally. This is less likely to relate to turbine manufacture, and more likely to refer to items such as construction of supporting structures, infrastructure, landside buildings etc.

The key assumptions/ limitations for the emission of noise measures are:

- no details are available on any noise generated directly by any of the schemes;
- no details on the nature or duration of the construction works are currently available; and
- no details of the likely volume or route of construction or operational/visitor traffic is currently available.

Differences Between Scheme Variants

Potential to Improve Local Unemployment Statistics

All schemes could make a significant impact, depending on investment level, ranging from a maximum of 5,400 (total jobs per annum for the North West for each year of construction) for schemes VLHBv2a and VLHBv3a, to a maximum of 4,100 for IBv2b.

Potential Change in Average Income

The greater investment level in schemes VLHBv2a and VLHBv3a (highest) would have a greater impact compared to IBv2b (lowest).

Potential Change in Rank for Liverpool City Region in Indicators of Deprivation

Application of any of the technologies will support development of the North West and City Regions potential and impact on Indicators of Deprivation. Greatest impact on GVA would be from schemes VLHBv2a and VLHBv3a, as a result of greater investment level.

Potential to Create Leisure Facilities

All schemes could have a significant positive impact, irrespective of technologies employed.

Noise

No details of the nature or duration of the works required to construct any of the three schemes is currently available. Similarly, no details are currently available of any difference in traffic generated by staff and visitors for each scheme. In addition, no details of any operational noise generated by the three schemes are currently available. Therefore, it is not possible to differentiate between the schemes in terms of operational noise impacts.

15. Education and Skills Training

Methodology

The assessment method is consistent with standard practice in the assessment of socio-economic impact assessment of major infrastructure projects, including key guides on economic appraisal such as HM Treasury's Green Book.

Key Findings and Mitigation Recommendations

Potential Education Visitor Numbers

With regard to tourism impact the lack of design detail constrains the ability to compare with similar developments elsewhere. The assumptions made with regard to the appearance of each scheme are that each would be broadly similar and purely functional. More importantly, additional features placed on the structure purely for design purposes (such as cowling) could be achieved, for effect and branding purposes. Success of enhanced branding would improve the chances of successful attraction of visitors and related jobs.

Landside visitor facilities would be the same for any of the schemes. Band A presents viewing opportunities of Liverpool's historic waterfront and potentially links with the Garden Festival site.

The visitor interest in various technologies is not likely to vary significantly. The visitor centre would be likely to address a wider range of subject matter than just the technology of the turbines. The education visitor segment would be a major element of the overall market.

Visitor numbers and associated activity for all schemes are considered to be broadly similar and in the range of 60,000 – 100,000 per annum.

Potential Skills Required for Direct Jobs

Visitor centre jobs are related to visitor numbers and apply equally to all schemes, and are of a range currently well catered for in the city region.

Much of the expertise required for construction process is available within the region or elsewhere in the UK.

Some of the more specialised, higher level skills may need to be sourced from outside the region and in some cases overseas. However, there should be a sufficient pool of lower and intermediate skills in Merseyside and the North West upon which the development could draw. Again, workforce development schemes or work with local building contractors could ensure that they are well placed to benefit from sub-contracting work for on-site manual tasks.

Typical participants in the design and development process would be land use consultants, engineering consultancies, materials engineers, electrical engineers and civil engineers, all of whom are abundant in the North West and would be in a position to form part of a bidding consultancy. However, the more specialised aspects of the development such as the design of the power generating elements of the facility would be likely to require the input of design expertise which may only be available from outside the region. The scope to source materials and labour from the North West therefore depends on the balance between expenditure on the design of the overall structure and its more specialised components. In addition, there are no large scale facilities in which to test prototypes or full scale devices in the region so it is assumed that all of this activity would be conducted outside the North West.

Another important factor would be the sourcing strategy, composition and structure of the successful tenderer. If the successful bid is led by an overseas company then a larger proportion of the design, research and development, testing and development may occur overseas. However, it is not possible to comment in detail on this at the current time.

Across all schemes, construction work would be on-site and give great opportunity for a wide range of skills to be provided locally.

Potential Number of Apprentices

All schemes can have a significant positive impact, irrespective of technologies employed, although there are variances as discussed above.

Key Assumptions and Limitations

Visitor numbers are assumed to be constant between schemes.

All schemes have been designed to use conventional bulb turbines and existing power generation technology. The civil engineering aspect of this development would be expected to make up a large proportion of the overall design costs given that the structure itself would represent a major engineering challenge, and there would therefore be greater scope for engineers from within the region to work on the project.

Across all schemes the physical construction of the project represents by far the largest component of expenditure. The major tasks in all of the schemes would include the construction of the cofferdam, land reclamation costs and construction of the caissons.

The vast majority of this work would be carried out on site as the major components (such as the caissons) would be too large to be manufactured elsewhere and transported to the site so would have to be constructed at a local site and towed to the site and sunk in to position. There is therefore a great deal of potential for this scheme to draw upon local labour. However, this would depend on the nature of the contract awarded and whether the contractor seeks to bring in labour from outside the region. The feasibility report for the Severn Tidal Barrage states that these types of construction project typically require mostly intermediate level skill sets and that up to 50% of the labour required could reasonably be assumed to be sourced locally (see Table A7).

Table A7: Skill content of employment for different construction tasks

Construction stage	Low Skill	Med Skill	High Skill	Key skill sets	Estimated local labour share
Prelims and site overheads	30%	60%	10%	General labourers/building trades/civil engineers	50%
Caissons	20%	60%	20%	General labourers/building trades/civil engineers	50%
Embankments	30%	60%	10%	General labourers/building trades/civil engineers	80%
Navigation Locks	20%	70%	10%	General labourers/building trades/civil engineers	50%
Surface Buildings	20%	70%	10%	General labourers/building trades/civil engineers	50%
Source: DTZ Feasibility Study for Severn Tidal Barrage Concept using research provided by Parsons Brinckerhoff					

Capital expenditure is assumed to have a greater effect at the City region level with regard to elements of construction which are more capable of being sourced locally. The impact on specialist skills would be less likely to relate to turbine manufacture, and more likely to refer to items such as construction of supporting structures, infrastructure, landside buildings etc. Skills required to construct and run the visitor centre are available locally and all schemes would have a similar impact.

Differences Between Scheme Variants

Potential Education Visitor Numbers

All schemes could have a significant positive impact, irrespective of technologies employed and have potential to exploit their location well. Band A would provide a high profile location relatively close to the historic waterfront.

Potential Skills Required for Direct Jobs

The gross direct employment operational impacts of the three schemes show no differences. The indirect impacts are predicted to be slightly higher for the two restricted head barrage schemes (VLHBv2a and VLHBv3a). In terms of design and construction, all schemes would require testing as part of the development process and specialist expertise input into the final design.

All schemes would be constructed onsite so giving equal opportunity for local trades, semi skilled and unskilled work. Differences relate to investment levels of the different schemes.

Potential Number of Apprentices

The greatest impact in terms of apprentices would come from the scheme with the largest capital expenditure, although all schemes could have a significant positive impact.

16. Local Business and Jobs

Methodology

The assessment method is consistent with standard practice in the assessment of socio-economic impact assessment of major infrastructure projects, including key guides on economic appraisal such as HM Treasury's Green Book.

Key Findings and Mitigation Recommendations

Sourcing of inputs for each of the components is described in Table A8. These include a low and high estimate of the potential to sourcing from within the region.

Table A8: Sourcing Assumptions for Different Construction Stages- Percentage of Cost

Component of expenditure	North West		UK	
	High	Low	Low	High
Preliminaries, site overheads	75%	85%	85%	95%
Cofferdam construction and land reclamation	80%	90%	90%	95%
Navigation locks	50%	60%	85%	95%
Landside facilities	80%	90%	90%	95%
Caissons	70%	80%	70%	80%
Power generation technology	0%	5%	5%	10%
Infrastructure and utilities	50%	60%	90%	100%
Design and supervision	50%	60%	70%	80%
Source: Regeneris Consulting Estimates				

On this basis, the estimate of the regional employment that would be supported by the design, manufacture and construction activity for each of the schemes is provided by Table A9, which includes low and high estimates based on the lower and upper estimates for local sourcing. Based on this, the IBv2b would generate the smallest level of new employment for the North West (between 2,300 and 2,700 jobs per year) whilst the VLHBv2a and VLHBv3a would generate the highest (between 3,000 and 3,600 jobs per year).

Table A9: Construction impacts - estimated direct employment supported in North West for each scheme variant (full time equivalent permanent jobs)

Scheme variant	Low	High
IBv2b	2,300	2,700
VLHBv2a	3,000	3,600
VLHBv3a	3,000	3,500

The construction activity would generate further beneficial impacts in a number of distinct ways, namely through supply and induced employment effects. An employment multiplier of 1.5 has been applied to the direct construction jobs, based on the English Partnership Additionality Guide and knowledge of the regional economy. On this basis, the total employment supported by the project under each of the schemes is given in the Table A10. This increases the total number of jobs supported during construction by IBv2b to between 3,500 to 4,100 and between 4,500 and 5,500 for VLHBv2a and VLHBv3a.

Table A10: Construction impacts – indicative total employment supported in North West by scheme variants (full time equivalent jobs each year of construction)

Scheme variant	Low	High
IBv2b	3,500	4,100
VLHBv2a	4,500	5,400
VLHBv3a	4,500	5,300

Estimates for total GVA have been calculated using GVA per FTE estimates across the different construction stages in the closest matching sectors. Based on this approach, the scheme with the greatest economic impact (VLHBv2a) would contribute up to £1.5bn in GVA to the North West over the course of the construction period and up to £2.2bn to the UK economy as a whole during construction (see Table A11).

The direct GVA generated by the construction of the project calculated in this way represents between 30 and 33% of the capital cost of the project.

The extent of this impact can be maximised by procurement methods which, within competition laws, favour local suppliers and residents and align with existing initiatives.

Table A11: Estimated GVA impact from construction period

Scheme variant	Estimated GVA (£bn)					
	Liverpool City Region		North West		UK	
	Direct	Total	Direct	Total	Direct	Total
IBv2b	0.69	0.89	0.96	1.14	1.54	1.72
VLHBv2a	0.93	1.19	1.28	1.52	2.02	2.24
VLHBv3a	0.91	1.17	1.26	1.49	1.99	2.21

A summary of the annual gross employment and associated GVA supported during the operation of each scheme is set out in Table A12 below. The jobs estimates are rounded to the nearest 10, whilst GVA estimates are rounded to the nearest £100,000. The estimates of GVA exclude the direct GVA associated with the production and sale of the electricity due to a lack of information available at the current time.

These differences in operation and maintenance costs are driven entirely by differences in the capital expenditure for each of the scheme variants. Given that each of the scheme variants require the same staffing levels, it seems plausible that the operation and maintenance costs would not differ significantly. If this is the case there may not be this difference in operational economic impact between the schemes in practice.

Table A12: Gross employment and GVA impact in the North West

Scheme variant	Employment (FTEs)				Estimated GVA (£m)			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
IBv2b	120	220	60	380	4.8*	8	2	14.8
VLHBv2	120	270	80	470	4.8*	12	3	19.8
VLHBv3	120	260	80	460	4.8*	12	3	19.8

* Includes direct GVA generated by people working at the facility but excludes direct GVA from production and sale of electricity due to lack of information at this stage

Leisure related jobs are assumed to be the same for all schemes, although these can be maximised by linkage with adjacent development and infrastructure projects. Likewise, additional iconic design features within the facility and public art can further maximise this potential.

Key Assumptions and Limitations

Leisure related jobs are assumed to be the same for all schemes.

A provisional estimate of the potential construction impact in the region has been made on the following basis:

- an average turnover per employee across the different construction components based on the closest 2 digit Standard Industrial Classification category;
- the translation of man years into temporary full time equivalent jobs using a construction period of 5 years for each of the schemes; and
- sourcing of inputs for each of the components as described in Table A8.

Differences Between Scheme Variants

All schemes could have a significant positive impact, irrespective of technologies employed. Greater capital expenditure in VLHBv3a and VLHBv3a would have a greater impact on indicative indirect jobs and GVA than IBv2b.

17. Inward Investment and Image

Methodology

The assessment method is consistent with standard practice in the assessment of socio-economic impact assessment of major infrastructure projects, including key guides on economic appraisal such as HM Treasury's Green Book.

Key Findings and Mitigation Recommendations

Potential for new business infrastructure (e.g. business park)

Linkage with adjacent existing and potential infrastructure development should be proactive so as to reduce costs of construction, ensure efficient construction and maximise indirect benefits.

Potential change in rank of competitiveness for North West and Liverpool City Region

Opportunities exist with regard to capital spend and related, especially tidal energy application, tourism investment and wider image and branding.

Opportunities for use by the City Region of the facility for branding purposes are not sensitive to location. Likewise, the branding potential of various technologies would not be likely to vary significantly.

Visitor numbers and associated activity for all schemes are considered to be broadly similar and in the range of 60,000 – 100,000 per annum. The wider impact of each scheme on the perception of the river for inward investment and image purposes is significant, though incalculable at this stage, and would be the same for each scheme.

With regard to tourism and branding impact, the lack of design detail constrains the ability to compare with similar developments elsewhere. The assumptions made with regard to the visual impact of each scheme is that each would be broadly similar, purely functional and as such whilst they will make an impact, it will be limited. More importantly, additional features placed on the structure purely for design purposes (such as cowling) could be achieved, for effect, image and branding purposes. Success of enhanced branding would improve the chances of successful attraction of visitors and related jobs and can make a contribution to the competitiveness of the City Region.

Opportunity exists to create an additional brand image to sit alongside existing Liverpool City Region ones.

The impact of visitor numbers both to the visitor centre (measurable) and the wider City Region (not measurable) would be significantly greater if attention is paid to design and appearance of the facility.

The UK already has a comparative advantage in the wave and tidal power market and is making significant progress in becoming the market leader. The private sector knowledge base has now reached a level which other countries will find hard to emulate and the amount of investment in the sector in the UK between 2004-08 represented half of global investment in marine technology development. The North West would be well placed to benefit based on its natural resource, its maritime heritage and good port infrastructure. It is also home to a number of world class institutes including Lancaster University's Renewable Energy Group, the Centre for Hydrology and the Proudman Oceanographic Laboratory. The region still lacks a major testing and research facility which could act as a major catalyst for sector activity, however the presence of a full scale tidal power facility would be likely to stimulate the development of a stronger research base in the region and in turn would stimulate the development of a supply chain in the North West.

Key Assumptions and Limitations

Landside visitor facilities would be the same for each scheme.

Differences Between Scheme Variants

Potential for new business infrastructure (e.g. Business Park)

All schemes would offer significant opportunities as discussed above.

Potential change in rank of competitiveness for North West and Liverpool City Region

Differences between scheme variants relate to the investment level.

Schemes VLHBv2a and VLHBv3a could have the greatest impact due to higher investment levels, and greater likelihood of capture of investment in the City Region in terms of employment and business benefit.

All schemes could have a significant impact on the City Region's competitiveness.

There is greater potential to capture a larger share of economic activity related to design and construction with schemes VLHBv2a and VLHBv3a because of the larger investment levels.

18. Technological Innovation

Summary of Appraisal

All schemes would comprise structures that span the Estuary and generate power using a head difference. Several different test facilities for tidal range devices could be accommodated by

converting the blank gate caissons, but water depth would be limited. Technological innovation is possible for material selection/ development in aggressive marine environment and in electrical control systems and mechanical governing of turbines. The blank passageways in the sluice caissons could be used as a test facility for tidal energy technologies.

19. Commercial Navigation

Summary of Appraisal

For the purposes of option appraisal, all three scheme variants included the same navigation solution comprising a double lock on the Wirral side. Further information on the navigation options considered in consultation with relevant stakeholders is provided in the Stage 3 Navigation Options report.

20. Generation of Renewable Energy from the Mersey Estuary

Summary of Appraisal

IBv2b has the highest predicted energy yield of the Stage 3 scheme variants at 950 GWh/year and a scheme without sluicing (IBv2a) would have a slightly higher energy yield (1,050 GWh/year). VLHBv2a and VLHBv3a would have lower energy yields (560 and 520 GWh/year respectively).

Further details are provided in the Stage 3 Civil Engineering (Power) report.

21. Commercial Fish Stocks

Summary of Appraisal

Commercial trawling is undertaken from Birkenhead and Merseyside by at least one vessel over 10 m in depth and several smaller boats are used in good weather for otter and beam trawling. In Liverpool, there are two full-time fishermen plus a number of part-time and casual boats trawling, shrimping and charter angling within the Mersey Estuary. Visiting vessels (e.g. UK and Belgium beam trawlers and Scottish scallop dredgers) land their catches into Liverpool Docks from where the fish are consigned to either UK or continental outlets.

Shrimps are taken in the River Mersey and Penfold Channel whilst grounds off Rock Channel and Leasowe are worked over high water for plaice, sole, rays and whiting. The main white fish grounds are found north of Taylors Bank offshore from Ainsdale. Visiting beam trawlers (mainly from Brixham and Belgium) often land soles at Birkenhead.

Sea bass is important to both commercial trawlers and sport fishermen. Over the past 10-15 years a breeding population of sea bass have developed around the Isle of Man and a sport fishery in the Mersey Estuary and coastal waters exists, with individuals up to 8 lbs in weight being recorded in catches. The area around Oglet foreshore and Hale lighthouse are considered to be prime areas to fish for sea bass. For other species such as cod and whiting the area around Middle Deep is considered ideal, with a number of individuals either chartering or taking their own boats to fish there.

Differences Between Scheme Variants

The Mersey Estuary is not a major commercial fishing location. The Stage 3 Marine Ecology report considers impacts on fish ecology and mitigation measures will be required to ensure fish passage is

maintained through the Estuary. Impacts on navigation are considered under sustainability indicator 19.

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