5. ENVIRONMENTAL IMPACTS AND EVALUATION CRITERIA

5.1 Introduction

5.1.1 This Section identifies the potential environmental impacts that may arise from the construction and operation of new landfill sites and extension options. Given the likely phased approach to construction of any new site/extension, it is envisaged that construction and operation would be carried out simultaneously. Following initial development of void space, landfilling can commence in tandem with the construction of the environmental control measures and preparation of the next phase of void space.

5.1.2 Environmental legislation and controls affecting the proposals are identified and the evaluation criteria for each environmental sub-criterion are introduced. This Section also identifies typical environmental protection measures (applicable to all sites) that may be recommended to reduce overall impacts.

5.2 Air Quality

Introduction

5.2.1 The geographical extent of air quality impacts has been considered up to 500m from the new site/landfill extension operations as well as up to 500m from a line source of vehicular traffic, where road delivery is employed. In addition, the total emission of air pollutants associated with the transportation of waste has been considered in terms of the mode of transport and the distance travelled to each site.

5.2.2 The reclamation / landfill development has the potential to cause the following air quality impacts:

- Dust (TSP / RSP) and exhaust emissions from on-site plant during construction and operation.
- Gaseous emissions during landfill operation and aftercare arising from non-point source emissions and gas flaring / utilisation (including emissions of methane, carbon dioxide, carbon monoxide, sulphur dioxide, nitrous oxides, etc.).
- Odours arising during the operation of the landfill from waste decomposition.
- Gaseous emissions from vehicles (road and marine) transporting waste during operation.

Government Legislation and Standards

5.2.3 In this Study, reference has been made to the Hong Kong Planning Standards & Guidelines (HKPSG), the Environmental Impact Assessment Ordinance (EIAO) and the associated Technical Memorandum (EIAO-TM).

5.2.4 The main legislative instrument to control air quality within Hong Kong is the Air Pollution Control Ordinance (APCO), Cap. 311, and its subsidiary regulations. Potentially relevant parts of the Ordinance include:

- Air Pollution Control (Dust and Grit Emission) Regulations.
- Air Pollution Control (Smoke) Regulations.
- Air Pollution Control (Specified Processes) Regulations.
- Air Pollution Control (Open Burning) Regulation.
- Air Pollution Control (Construction Dust) Regulation.

5.2.5 Whilst not directly applicable to landfills, Chapter 9 of the HKPSG recommends suitable buffer distances between small-scale community-based polluting uses and sensitive receivers. Examples of recommended buffers are given in *Table 5.1*:

Table 5.1 : HKPSG Recommended Buffer Distances for Land Uses

Polluting Uses	Sensitive Uses	Buffer Distance
Odour sources	Sensitive uses	200m
Dusty uses	Sensitive uses	100m

Air Sensitive Receivers

5.2.6 According to the EIAO-TM, Air Sensitive Receivers (ASRs) include (but are not limited to) any domestic premises, hotel, hostel, hospital, clinic, nursery, temporary housing accommodation, school, educational institution, office, factory, shop, shopping centre, place of public worship, library, court of law, sports stadium, or performing arts centre.

5.2.7 Any other premises or place with which, in terms of duration or number of people affected, has a similar sensitively to the air pollutants as the premises or place is also be considered to be a sensitive receiver.

Generic Air Quality Mitigation

5.2.8 Good site practice would include reduction of dust and odour by:

- Paving and subsequent regular sweeping of long-term haul roads within the site.
- Regular dampening of unpaved roads.
- Vehicle washing (both body wash and wheel wash) before leaving site.
- Immediate cover to odorous waste, eg. sludge, after disposal
- Daily covering of the current tipping face with inert material (e.g. selected construction and demolition material, tarpaulin covers, foam spray, etc.).
- Interim cover of any operational areas which are not currently in use.
- Design of enclosed-loop leachate collection / management system;
- Proper design, operation, management and maintenance of landfill gas combustion facilities to ensure destruction of odorous organic compounds.

Evaluation of Air Quality Impacts

5.2.9 The evaluation criteria for assessing air quality impacts are shown in *Table 5.2*. These criteria will be applied to each site on a qualitative basis taking into account known parameters and conditions that could result in relative improvement or exacerbation of impacts.

Further Assessment within SEA

5.2.10 Following the above process to identify the likelihood of impacts occurring, a qualitative and/or semi-quantitative assessment has been carried out where significant air quality impacts are considered possible.

5.2.11 Where the potential for cumulative air quality impacts has been identified, a qualitative assessment of the likely impacts has been carried out (taking into account ambient conditions), whilst recognising the potential for significant changes in baseline conditions (i.e. new developments) by the time the landfill site is developed.

5.2.12 In addition to local impacts upon identified ASRs, more widespread impacts upon air quality may arise from the transport of waste from the refuse transfer stations to a landfill site. The total emissions of air pollutants from this source contribute to the general air quality patterns of Hong Kong. These have been addressed qualitatively, in terms of both the mode of transport used to convey waste (i.e. marine vessel or road-based refuse collection trucks) and the overall round-trip distances that must be travelled to reach the various landfill sites. Whilst actual emissions associated with the two modes of transport would vary depending upon fuel, engine type etc. for the purposes of this SEA, it is assumed that overall, air quality impacts arising from marine transport are lower than those which would arise by truck as marine vessels can carry almost 100 times more waste thereby allowing significant economies of scale.

5.2.13 For the air quality assessment, developments that emit TSPs, NO_x, CO, SO_2, which could add to the emissions from the landfill, have been considered within 5km from the emission source (i.e. the landfill).

5.2.14 Following the cumulative assessment of likely air quality impacts, an assessment has been made as to whether impacts are likely to comply with the EIAO and the EIAO-TM, or whether air quality exceedances are likely. This has been carried out by reference to previously endorsed EIAs. By reviewing endorsed EIAs, potential impacts of emissions from the proposed landfills have been reviewed against quantitative data (from comparable studies) to further substantiate the potential for significant air quality impacts.

Table 5.2: Air Quality Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Distance to areas of air sensitive land use	**O**	>500m
		O	500-100m (if <10 properties affected)
		-	500-100m (if >=10 properties affected)
		-	<100m (if <10 properties affected
		- -	<100m (if >=10 properties affected)
2	Presence of topographic features which could decrease or exacerbate local impacts	**+**	High hills between LF and ASRs
		O	Low hills between LF and ASRs
		-	Flat land between LF and ASRs
		- -	Air shed may trap Air from LF
3	Occurrence of meteorological conditions which could exacerbate impacts	**+**	Prevailing wind blows from ASRs towards LF
		O	No prevailing wind
		-	Prevailing winds blow from LF towards ASRs
4	Cumulative impacts of relevant emissions (TSP (construction), NOx, CO, SO2 – LFG Flare) taking into account ambient conditions	**O**	No additional relevant emissions within 5km
		-	Relevant emissions present within 5km (AQOs unlikely to be exceeded)
		- -	Relevant emissions present within 5km (AQOs likely to be exceeded on occasions)
5	Total Emissions of Air Pollutants from the territory-wide waste transportation between the RTSs and the Site	**O**	Primarily by sea, accumulated distance to be travelled < 300km
		O/ -	Primarily by sea, accumulated distance to be travelled ≥ 300km but < 400km
		-	Primarily by sea, accumulated distance to be travelled ≥ 400km or by sea & road (combined)
		- -	Primarily by road
6	**Overall impact**	**O**	Neutral
		-	Negative – Low
		- -	Negative – High

Note: For criterion 1: The upper bound distance of 500m has been selected, as it is the Study area for air quality assessments commonly adopted for project level EIAs. The lower distance of 100m has been selected as it minimum buffer distance recommended in the HKPSG.

For criterion 5: The benchmark distances selected to differentiate between scores are derived from the Preliminary Marine Review for the Study. The range of distances for marine transport is between 200 – 500km. Distances travelled were divided around the "average" (i.e., ~350km), with the average taken as any distance between 300 and 400km (scored as "o/-"). From this basis, benchmarks of 300km and 400km were derived that were scored lower (i.e., "o") and higher (i.e., "-") respectively. The rationale for assigning "- -" for road transportation is on the basis that marine vessels can carry almost 100 times more waste than a truck, and so the total emissions per unit waste transported will be greatest for waste transported "primarily by road".

5.3 Noise

Introduction

5.3.1 The geographical extent of noise impacts would typically be local, extending a radius of around 300m from any land based landfill extension operations as well as a 300m radius from a line source of vehicular traffic, where road delivery is employed. For marine based sites, noise from transportation is not considered to be a key concern as all such sites have been located away from existing land based Noise Sensitive Receivers (NSRs).

5.3.2 Operations are likely to involve noise-generating plant and machinery with the potential to impact directly upon statutory noise limits for adjacent NSRs and indirectly upon habitats of conservation importance through disturbance.

5.3.3 There would be potentially noisy operations occurring at the landfill site during:

- Construction – from the delivery of filling material and other construction materials, placing fill material, piling works and general construction activities.
- Operation – from the use of heavy plant, marine vessels (for marine based sites), the waste reception area, pumping plant, etc.

5.3.4 Despite any description or assessment made in this Report on construction noise aspects, there is no guarantee that a Construction Noise Permit (CNP) will be issued for the project construction. The Noise Control Authority will consider a well-justified CNP application, once filed, for construction works within restricted hours as guided by the relevant Technical Memoranda issued under the NCO. The Noise Control Authority will take into account of contemporary conditions/situations of adjoining land uses and any previous complaints against construction activities at the site before making a decision in granting a CNP. Nothing in this Report binds the Noise Control Authority in making a decision. If a CNP is to be issued, the Noise Control Authority will include in it any conditions he thinks fit. Failure to comply with any such conditions will lead to cancellation of the CNP and prosecution action under the NCO.

5.3.5 It is possible that, during construction and operation, activities could continue into, or even through, the night-time period. This would need to be confirmed once the potential for noise impacts are agreed.

Government Legislation and Standards

5.3.6 The following noise related legislation has been considered:

Construction Phase

5.3.7 Technical Memoranda on:

- Noise from Percussive Piling (PP-TM).
- Noise from Construction Work Other Than Percussive Piling (GW-TM).
- Noise from Construction Work in Designated Areas (DA-TM).
- British Standard BS 5228.

Operational Phase

5.3.8 For noise emanating from the landfill during the operational phase, the noise level should be kept to within the criteria stated in the EIAO-TM.

5.3.9 With regards to road traffic noise, it is recommended that noise levels are kept below 70 dB(A), $L_{10,\ 1\ hour}$ for residential areas and 65 dB(A), $L_{10,\ 1\ hour}$ for education facilities as according to the EIAO-TM. The assessment of the traffic noise should follow the procedures given in the UK Department of Transport document “The Calculation of Road Traffic Noise”.

Noise Sensitive Receivers

5.3.10 The potential noise sensitive receivers include, but are not limited to, the following:

- Residential Uses (all domestic premises including temporary housing).
- Institutional Uses.
  - educational institutions (including kindergartens and nurseries).
  - hospitals / medical clinics.
  - homes for the aged / convalescent homes.
  - places of public worship.
  - libraries.
  - courts of law.
  - performing arts centre.
  - auditoria / amphitheatres.
- Others.
  - hostels.
  - country parks.

Generic Noise Mitigation

5.3.11 The degree to which noise impacts can be mitigated would vary depending on the location and nature of the noise source in relation to the sensitive receivers. In general, noise impacts from site areas, are likely to be more easily mitigated due to the fact that the areas are contained and there is greater flexibility in terms of constructing temporary bunds etc. As they are off-site, impacts arising from vehicles using haulage routes may be less easy to mitigate through simple techniques described for on-site activities. In the event that noise levels are found to exceed standards, possible noise mitigation measures as per Annex 13 S.6 of EIAO-TM, for example noise barriers, may be required for affected sensitive receivers.

5.3.12 During both construction and operation, any necessary overnight activities should be assessed on a case-by-case basis to evaluate their overall noise impact. During the operation and aftercare of the landfill, noise will be generated from the plant and machinery required to manage leachate and landfill gas, such as:

- Leachate treatment works.
- Landfill gas extraction system.
- Thermal Oxidiser (Flare).
- Electricity Generators (Landfill Gas GenSets).

5.3.13 Mitigation can be applied through acoustic shielding in the specification and through verification by modelling and monitoring. All of the strategic landfills and most of the restored landfills in Hong Kong use the plant and equipment listed in Section 5.3.12, and all have been shown to operate within the requirements of the NCO.

Evaluation of Noise Impacts

5.3.14 The evaluation criteria for assessing noise impacts are shown in *Table 5.3*. These criteria will be applied to each site on a qualitative basis taking into account known parameters and conditions that could result in relative improvement or exacerbation of impacts.

Table 5.3 : Noise Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Distance to areas of noise sensitive land use	**O**	>300m
		O	100-300m (if <10 properties affected)
		-	100-300m (if >=10 properties affected)
		-	<100m (if <10 properties affected)
		- -	<100m (if >=10 properties affected)
2	Topographic features (only applicable if there are NSRs within 300m)	**+**	High hills block line of sight between LF & NSRs
		O	Low hills block line of sight between LF & NSRs
		-	Line of sight between LF & NSRs
		- -	Line of sight + reflective source between LF & NSRs
3	Cumulative impacts of developments within 300m	**O**	No additional noise sources within 300m
		-	Minor noise sources within 300m
		- -	Major noise sources within 300m
4	**Overall impact**	**O**	Neutral
		-	Negative – Low
		- -	Negative – High

Note: The upper bound distance of 300m has been selected, as it is the Study area for noise impact assessments commonly adopted for project level EIAs

Further Assessment within SEA

5.3.15 Following the above process to identify the likelihood of impacts occurring, a qualitative and/or semi-quantitative assessment has been carried out where significant noise impacts are considered possible.

5.3.16 Where the potential for cumulative noise impacts has been identified, a qualitative assessment of the likely impacts has been carried out, whilst recognising the potential for significant changes in baseline conditions (i.e. new developments) by the time the landfill site is developed. For the noise assessment, the cumulative impacts of noise sources within 300m of the landfill have been considered.

5.3.17 Following the cumulative assessment of likely noise impacts, an assessment has been made as to whether impacts are likely to comply with the EIAO and the EIAO-TM, or whether noise exceedences are likely. This has been carried out by reference to previously endorsed EIAs. By reviewing endorsed EIAs, potential noise impacts emanating from the proposed landfills have been reviewed against quantitative data (from comparable studies) to further substantiate the potential for significant noise impacts.

5.4 Water Quality

Introduction

5.4.1 During construction, impacts would principally arise from extensions of coastal landfill sites or the development of artificial island sites. During landfilling operations and the aftercare the principal source of impact would be from uncontrolled releases of leachate.

5.4.2 The geographical extent of potential water quality impacts would vary depending upon the receiving waters and the proximity of the new landfill site / landfill extension to those water bodies. Potential impacts include breaches of Water Quality Objectives (WQO) and limits for discharges as well as potential impacts on beneficial uses. Impacts upon sites of ecological and fisheries importance are addressed separately.

5.4.3 The reclamation / landfill development has the potential to cause the following water quality impacts:

- Sediment transport during the site-formation phase.
- Sediment laden run-off entering the water during the landfill construction / operation phase.
- Leachate discharges from the leachate treatment plant.
- Accidental discharges from liquids / material stored on site.

5.4.4 A major reclamation would need to be carefully controlled and appropriate mitigation measures specified to ensure water quality impacts during construction were minimised. In particular the possible “disturbance” of seabed sediments and the suspension of sediments would need to be controlled.

5.4.5 The construction of an artificial island could affect hydrodynamics and cause changes to currents and flow velocities; and in certain instances potentially change the flushing characteristic of key channels around Hong Kong Waters. Generalised patterns of currents in Hong Kong waters are shown in *Figure 5.1*.

5.4.6 On the basis of experience gained from existing landfills, the assumption is made that for an operating landfill all site-based discharges would be controlled, so that the risk of associated water quality impacts during operation can be managed to acceptable levels. However, this assumption should be addressed in further detail, including a risk assessment (e.g. of a leachate breakout incident) during the detailed EIA stage of the project. The design of the landfill would have to incorporate environmental protection orientated designs to cater for such potential incidents.

Government Legislation and Standards

5.4.7 The SEA has taken into account the following relevant Hong Kong legislation:

- Water Pollution Control Ordinance (Cap. 358).
- Water Pollution Control (General) Regulations.
- Water Pollution Control (Sewerage) Regulations.
- Water Quality Objectives (WQO).
- EIAO and EIAO-TM.

Water Quality Sensitive Receivers

5.4.8 Ecological and fisheries issues, with respect to water quality, are considered in Sections 5.6 and 5.7 respectively. Existing or potential beneficial uses in Hong Kong (excluding ecological /fisheries receivers) include, but are not limited to :

- Areas for abstraction of water for potable water supply.
- Water abstraction for irrigation and aquaculture.
- Beaches and other recreational areas.
- Water abstraction for cooling, flushing and other industrial purposes.
- Areas for navigation/shipping including typhoon shelters, marinas and boat parks.

5.4.9 In addition, given the nature of impacts on water quality, potential impacts on identified sensitive receivers in Chinese Waters are also subject to consideration.

5.4.10 Detailed locations and nature of the water sensitive receivers are tabulated in *Table 3.1* and shown in *Figure 3.1* and *3.2* of the *Water Quality and Hydrodynamic Assessment Report*. Extracts are shown in *Appendix I*. Locations of EPD routine sediment and water quality monitoring stations are shown in *Figure 5.2*.

Generic Water Quality Mitigation

5.4.11 For artificial island sites, mitigation is likely to be required to avoid impacts associated with sediment releases and transport within the water column through dredging, and/or filling activities. The proposed method of construction described in Section 3.2 has been developed to minimise the potential for construction related sedimentation of the water column, by providing a sheltered area for construction behind the outer seawall which faces predominant wind and wave action. As is customary, mitigation measures should be specified in terms of construction procedures, which define the location, rates and method of dredging and filling taking in to account the hydrodynamics of the surrounding waters and tidal effects (ebb and flood).

5.4.12 If significant impacts are anticipated for those marine sites that require dredging and filling, a silt curtain may be installed around the immediate works area to prevent dispersion of sediments. In addition, a floating boom should be used to control the spread of any flotsam and also reduce the dispersal of any litter within public fill.

5.4.13 During construction, sediment-laden runoff from site can be controlled by installing settlement tanks, which allow sediments to settle prior to discharge. Run-off would be generated during periods of high rainfall and so the temporary surface water drainage works and settlement tanks would need to be sized according to the works.

5.4.14 During operation, the surface water drainage system should be designed to intercept stormwater, channel it away from active areas and discharge it as clean water from the site. Any stormwater that enters the active area and thereby becomes contaminated will be considered leachate and diverted to the leachate treatment plant.

5.4.15 To accommodate the unforeseen event of leachate breakout, from completed areas, provision should be made in the design to enable sections of the surface water drainage channels to be isolated in order to trap any leachate before it escapes from the site.

Evaluation of Water Quality Impacts

5.4.16 The evaluation criteria for assessing water quality impacts are shown in *Table 5.4*. Both qualitative and quantitative assessment approaches would be employed in the evaluation of water quality impacts.

Table 5.4 : Water Quality Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Watercourse diversion	**O**	No diversion necessary
		-	Minor diversion (e.g. to man-made channel / nullah)
		- -	Major diversion (e.g. to natural river)
2	Potential for sediment contaminant release	**O**	Area not contaminated / No dredging required
		-	Minor contamination present
		- -	Major contamination present
3	Potential impacts on WSRs (including increase or exceedance of WQOs)	**O**	Pollutant levels less than WQOs
		-	<10% exceedance of WQOs (minor mitigation measures required)
		- -	>10% exceedance of WQOs (major mitigation measures required)
4	Potential impacts on groundwater	**O**	No groundwater issues / aquifer
		-	Minor aquifer present
		- -	Major aquifer present
5	Potential cumulative impacts (potential for concurrent projects to exacerbate preceding impacts)	**O**	Low
		-	Medium
		- -	High
6	**Overall impact**	**O**	Neutral
		-	Negative – Low
		- -	Negative – High

Note: Criterion 3 is a quantitative output from hydrodynamic modelling exercise.

Further Assessment within SEA

5.4.17 Water quality impacts associated with land based sites are, in general, relatively simple and the magnitude of impact is relatively small provided that there is proper implementation of on-site pollutant control measures. Qualitative analysis would be sufficient to identify the nature and magnitude of potential impacts. Consequently, a qualitative approach has been employed for the water quality impact assessment of land based sites.

5.4.18 For marine based sites, the assessment of water quality impacts is more complex, since the magnitude of impact could be significant. For this reason, water quality impacts for marine based sites have been assessed quantitatively using the Delft 3D hydrodynamic computer model, as well as by qualitative means.

5.4.19 The Delft 3D model is capable of accurately simulating the stratified conditions and salinity transport within the modelled area. Cumulative impacts due to other concurrent projects, activities or pollution sources that might affect marine waters and sensitive receivers have been identified and incorporated into the model.

5.4.20 The modelling results have been assessed for compliance with Water Quality Objectives at selected sensitive receivers for respective sites. Daily sedimentation rate has been modelled and results have been incorporated into the ecological and fisheries assessments as appropriate. Further details of the modelling methodology are shown in Appendix I.

5.5 Waste Management / Materials Balance

Introduction

5.5.1 Impacts associated with the management of wastes and the balance of fill material may arise during the construction and landfilling operations. The principal source of waste arisings would be during the landfill construction phase.

5.5.2 Specific issues affecting the nature of impacts associated with public fill have been outlined in Section 3.5. For both land and marine sites, public fill is a valuable resource for landfill development as it is necessary for engineering fill and daily cover.

5.5.3 In general, land based sites result in the generation of material that can match the on-site demand for landfill development. For marine sites, reclamation for the construction of the platform on which the landfill would subsequently be developed would require additional fill material.

5.5.4 For the construction of an artificial island, inert C&D materials would be brought in from a network of barging points within the SAR, and the assumption is made that this would generally be public fill (except for some of the edge protection and other built infrastructure). Whilst this material would be sorted and selected prior to transfer to the site, some litter materials can be expected in the material. Various options for construction have been considered, the current strategy has minimised the need for dredging for all sites. In the event that a scheme is pursued which involves a limited amount of dredging, these excavated muds could be disposed of within the area to be reclaimed with public fill, thereby limiting the need for transport and disposal elsewhere. During operation daily cover requirements could be sourced from incoming C&D material.

5.5.5 For a land based site, the aim has been to ensure a balance of cut and fill requirements during construction, i.e., no net import or export of fill materials. Because of this, there is limited use of public fill during the construction phase, although during operation daily cover requirements could be sourced from incoming C&D material.

Greenhouse Gas Emissions as a Function of Mode of Waste Transport

5.5.6 As stated in paragraph 4.3.6, the GHG emissions associated with different waste transportation modes and routes will be qualitatively considered. The basis for this assessment would be the average mass of GHG released per kilogram of fuel used to transport the waste :

Table 5.5 : Road Transport – US Diesel Vehicles

US Heavy Duty Diesel Vehicles (Advanced Control; Assumed Fuel Economy: 2.4km/litre (41.7 l/100km)			
Parameter	**CO_2**	**CH_4**	**N_2O**
Average (g/km)	987	0.04	0.025
Average (g/kg fuel)	3,172	0.14	0.08

Source: Revised 1996 IPCC Guidelines Reference Manual; Table 1-32; page 1.75.

Table 5.6 : Road Transport – European Diesel Vehicles

European Diesel Heavy Duty Vehicles (Moderate Control; Assumed Fuel Economy: 3.3km/litre (29.9 l/100km)			
Parameter	**CO_2**	**CH_4**	**N_2O**
(g/km)	770	0.06	0.03
(g/kg fuel)	3,140	0.2	0.1

Source: Revised 1996 IPCC Guidelines Reference Manual; Table 1-39; page 1.82.

Table 5.7 : Freight Road Mileage Conversion Factors

Diesel Truck Type	**CO_2 (g/km)**
Articulated	938
Rigid	1,072

Source: UK DEFRA Environmental Reporting - Guidelines for Company Reporting on Greenhouse Gas Emissions July 2001, (Annex 6 – Transport Conversion Tables – Table 10)

Table 5.8 : Marine Transport – Non-Ocean Going Vessels

Boats			
Parameter	**CO_2**	**CH_4**	**N_2O**
(g/kg fuel)	3,188*	0.23	0.08

Source: Revised 1996 IPCC Guidelines Reference Manual; Table 1-47; page 1.89.

Note: * This CO_2 generation figure of 3,188 g/kg fuel utilised is supported by information in "Wright A.A., Effective Marine Exhaust Emission Controls, Lloyd's Register of Shipping (1996).

5.5.7 It should be noted that waste transferred from the transfer stations to the landfills is done so by special-built refuse transfer vessels. The above-mentioned CO_2 factor is a function of marine oil fuels which all have essentially the same carbon content (85.0 – 87.5%) and generate the 3,188g of CO_2 per every kg of fuel consumed.

5.5.8 From *Tables 5.5 to 5.8*, it can be seen that the average mass of GHG released per kilogram of fuel used is similar, whether the transportation is by road vehicle or marine vessel. However, the economies of scale between a road vehicle transporting one container and a marine vessel transporting, say, 100 containers is obvious. Therefore, the assessment would be based on the premise that is more beneficial, in terms of GHG emission, to transport waste by marine vessel than by road.

Government Legislation and Standards

5.5.9 The following legislation covers, or has some bearing upon, the handling, treatment and disposal of wastes:

- EIAO and EIAO-TM
- Waste Disposal Ordinance (Cap 354).
- Waste Disposal (Chemical Waste) (General) Regulation (Cap 354).
- Public Health and Municipal Services Ordinance (Cap 132) - Public Cleansing and Prevention of Nuisances Regulation.
- Dumping at Sea Ordinance (1995).

Generic Waste Management Mitigation

5.5.10 The principal approach to waste management is to achieve a materials balance or alternatively provide a valuable sink for excess C&D materials. This will require detailed consideration of generation rates and timing of materials arisings (particularly for marine sites), to avoid negative impacts.

5.5.11 For artificial island sites to be constructed using public fill, a silt curtain may be installed around the immediate works area to prevent dispersion of silt and other fines during filling activities. In addition, a floating boom should be used to control the spread of any flotsam.

5.5.12 Various potentially polluting materials may be stored, handled and transported to / from the island site. Examples may include leachate, chemicals for waste water/leachate treatment, waste oils, fuel for plant working on the site. All waste materials would need to be stored, handled and transported in an agreed and appropriate manner that complies with the Waste Disposal Ordinance (Cap 354) and subsidiary regulations such as the Waste Disposal (Chemical Waste) (General) Regulation. For this assessment it is assumed that potential impacts from dangerous goods would be controlled through appropriate designs and management systems.

Evaluation of Waste Impacts

5.5.13 The evaluation criteria for assessing waste impacts are shown in *Table 5.9*. These criteria will be applied to each site on a qualitative basis taking into account known parameters and conditions that could result in relative improvement or exacerbation of impacts.

Table 5.9 : Waste Management Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Balance of materials (surplus / deficit of public fill needed for landfill development)	**+**	Public fill required for landfill development, assuming overall surplus of public fill in Hong Kong
		O	Materials balance
		-	Virgin materials required / Surplus of material
2	GHG emissions by mode of transport for delivery of waste to the site from RTSs	**O**	Primarily by sea, accumulated distance to be travelled < 300km
		O/ -	Primarily by sea, accumulated distance to be travelled ≥ 300km but < 400km
		-	Primarily by sea, accumulated distance to be travelled ≥ 400km or by sea & road (combined)
		- -	Primarily by road
3	**Overall impact**	**+**	Positive
		O	Neutral
		-	Negative – Low
		- -	Negative – High

Note: For criterion 2: The benchmark distances selected to differentiate between scores are derived from the *Preliminary Marine Review* for the Study. The range of distances for marine transport is between 200 – 500km. Distances travelled were divided around the "average" (i.e., ~350km), with the average taken as any distance between 300 and 400km (scored as "o/-"). From this basis, benchmarks of 300km and 400km were derived that were scored lower (i.e., "o") and higher (i.e., "-") respectively. The rationale for assigning "- -" for road transportation is on the basis that marine vessels can carry almost 100 times more waste than a truck, and so the total emissions of greenhouse gases per unit waste transported will be greatest for waste transported "primarily by road".

Further Assessment within SEA

5.5.14 Following the above process to identify the likelihood of waste impacts occurring, a qualitative and/or semi-quantitative assessment has been carried out where significant waste management impacts are considered possible.

5.5.15 Where the potential for cumulative waste impacts has been identified, a qualitative assessment of the likely impacts has been carried out, whilst recognising the potential for significant changes in waste production (e.g. by the time the landfill site is developed). For the waste assessment, the cumulative impacts of public fill and marine mud generation across the SAR have been considered in consultation with CED's Fill Management Division (FMD).

5.5.16 Following the cumulative assessment of likely waste impacts, an assessment has been made as to whether impacts are likely to comply with the EIAO and the EIAO-TM. This has been carried out by reference to previously endorsed EIAs and FMD's register of projects and by use of professional judgement. By reviewing endorsed EIAs, potential waste impacts arising from proposed landfills have been reviewed against quantitative data (from comparable studies) to further substantiate the potential for significant waste impacts.

5.6 Ecology

Introduction - Terrestrial / Freshwater Ecology

5.6.1 The principal source of impact on terrestrial resources would be during the landfill construction phase arising from habitat loss and potential severance within and immediately adjacent to the footprint of the new landfill site / landfill extension area. There is also potential for direct, localised noise and visual disturbance impacts upon nearby species and communities. Disturbance of adjacent species and communities may also potentially occur during landfill operation, although such impacts should be avoidable / readily controllable through extension of existing landfill management measures that have been demonstrated to be effective in Hong Kong.

Introduction - Marine Ecology

5.6.2 The principal source of impact on marine resources would be during the landfill construction phase from the loss and disturbance of benthic habitat within and adjacent to the footprint of the landfill new site / extension area. The extent of benthic habitat smothering from sediment dispersal from dredging (as may be required) and reclamation activities is a function of water column depth and site-specific hydrodynamic patterns. As such, the spatial extent of aquatic ecology impacts has been quantified based on the outcome of the numerical modelling exercise that has been conducted for the water quality assessment for all marine sites.

5.6.3 Sediment plume formation / dispersal will induce a decline in dissolved oxygen levels in the water column that may lead to impacts upon less mobile species (fish larvae) and sessile benthic species in particular. The quality of disturbed sediment will also be significant in terms of mobilising and increasing the bio-availability of adsorbed contaminants as may be relevant.

5.6.4 The presence of marine mammals throughout the HKSAR's marine waters requires that attention be given to potential physical (vessel collision) and noise impacts during site construction and operation.

Government Legislation and Standards

5.6.5 The following Hong Kong SAR Government legislation and guidelines are relevant for the SEA :

- EIAO and EIAO-TM
- Forests and Countryside Ordinance (Cap. 96),
- Wild Animals Protection Ordinance (Cap. 170),
- Animals and Plants (Protection of Endangered Species) Ordinance (Cap. 187)
- Town Planning Ordinance (Cap. 131),
- Country Parks Ordinance (Cap. 208); and
- Marine Parks Ordinance (Cap. 476) and associated subsidiary legislation.

5.6.6 In addition, the Study makes reference to the following Technical Memoranda, Technical Circular and Guidelines for guidance on conservation, impact assessment and mitigation :

- "Guidelines for Implementing the Policy on Off-site Ecological Mitigation Measures" (PELB Technical Circular 1/97, Works Branch Technical Circular 4/97,
- Hong Kong Planning Standards and Guidelines: Chapter 10, "Conservation",

5.6.7 This Study also takes note of the following relevant international agreements :

- Convention on Wetlands of International Importance Especially as Waterfowl Habitat ("Ramsar Convention").
- Convention on the Conservation of Migratory Species of Wild Animals ("Bonn Convention").
- Convention on International Trade in Endangered Species of Wild Fauna and Flora ("CITES").
- Convention on Biological Diversity (“Rio Convention”).

Ecologically Sensitive Receivers

5.6.8 The following Protected Areas / Recognised Sites Of Conservation Importance are considered ecologically sensitive receivers :

- Existing or gazetted proposed Special Areas.
- Existing or gazetted proposed Country Parks.
- Existing or gazetted proposed Marine Reserves.
- Existing or gazetted proposed Marine Parks.
- Restricted Areas listed under the Wild Animals Protection Ordinance Chapter 170;
- Sites of Special Scientific Interest.
- The Mai Po & Inner Deep Bay Ramsar Site, and associated Wetland Conservation Area (WCA) and Wetland Buffer Area (WBA).
- Any other declared by the Government as having special conservation importance.

5.6.9 Using Annex 8 of the EIAO-TM as a guide, further ecological assessment would be recommended if the proposed development is likely to affect any one of the following important habitats:

- Terrestrial / Freshwater – Mature native woodland, freshwater/brackish marshes and natural stream courses/rivers.
- Marine / Coastal – Undisturbed natural coast, inter-tidal mudflats/established mangrove stands, established sea-grass beds and established coral communities.

It should be noted that the list of habitat types above for which more detailed ecological assessment may be required is not exhaustive.

5.6.10 Further ecological assessment has been recommended if the proposed development is likely to affect habitats supporting significant populations of wild fauna or flora that are *Species of Conservation Importance:*

- Listed in IUCN Red Data Books or those of the South China region.
- Listed in international conventions for conservation of wildlife.
- Endemic to Hong Kong or South China.
- Listed under local legislation, or
- Considered as rare in the SAR or having special conservation importance by scientific studies other than those listed above.

Generic Ecological Mitigation

5.6.11 The application of measures for noise and water quality can be applied to mitigate impacts on marine ecology, whilst air quality and visual impact control measures (particularly fugitive dust control) can also be applied for terrestrial resources.

5.6.12 Mitigation measures designed to minimise impacts to the seasonal population of marine mammals include restrictions on vessel speed and the use of bubble curtains during any underwater percussive piling work for marine structures such as jetties. Other mitigation measures designed to mitigate impacts to water quality to acceptable levels (compliance with WQOs) would also mitigate impacts on marine ecological resources.

5.6.13 Whilst not considered to be a mitigation measure, ecological enhancement measures can be applied to marine based sites. A number of reclamation design features, such as rubble mounds, armour rock or concrete armour edge protection would have consequent ecological benefits, facilitating colonisation by intertidal organisms and corals. As an additional habitat enhancement measure, artificial reefs could be deployed adjacent to an artificial island.

Evaluation of Ecological Impacts

5.6.14 The evaluation criteria for assessing ecological impacts are shown in *Table 5.10*.

5.6.15 The inherent differences in character between terrestrial and marine habitats, particularly with regard to sediment transport and dispersal processes, dictate that the type of ecological impacts on biological resources would differ. Whilst impacts on marine resources are largely felt through a change in water quality and are controlled by hydrodynamic processes, impacts on terrestrial resources may be more diverse but in most cases are also likely to be more localised. As such, it is appropriate that separate evaluation criteria be developed.

5.6.16 There are a number of “wetland habitats” within the HKSAR that, for the purpose of this SEA, may be considered either as terrestrial resources or as marine resources. Under the “Ramsar Convention”, to which the HKSAR Government is a signatory, wetlands includes all fresh, brackish and marine waters to a depth of no greater than 6 metres at low tide. Included with terrestrial resources are all freshwater and brackish wetlands, with all marine and estuarine wetlands (influenced tidal processes) included with the marine resources.

Further Assessment within SEA

5.6.17 Following the above process to identify the likelihood of ecology impacts occurring, a qualitative and/or semi-quantitative assessment has been carried out where significant ecology impacts are considered possible.

5.6.18 Where the potential for cumulative impacts has been identified, a qualitative assessment of the likely impacts has been carried out, whilst recognising the potential for significant changes in baseline conditions by the time the landfill site is developed. For the marine ecology assessment, no specific distance criteria have been applied to determine cumulative impacts as this is subject to specific hydrodynamic patterns that differ greatly between marine sites. As a rule of thumb a distance of 500m has been adopted for terrestrial sites as is commonly used to define the limit of the Study Area for designated EIA projects.

Table 5.10: Ecological Evaluation Criteria

	Criteria	Score	Construction / Operation	
1	Potential for secondary environmental impacts on "Areas of Absolute Exclusion"		Terrestrial	Marine
		O	>500m	No impact anticipated
		-	100-500m	Minor potential for impact
		- -	<100m	Major potential for impact
2	Affects an important habitat		Terrestrial	Marine
		O	100-500m	No impact anticipated
		-	<100m	Minor impact anticipated
		- -	landtake	Major impact anticipated
3	Affects a species of conservation importance	**O**	No disturbance	
		-	Minor disturbance	
		- -	Major disturbance	
4	Potential for cumulative ecological impacts on sites of recognised value	**O**	No / limited potential for cumulative impacts	
		-	Minor potential for cumulative impacts	
		- -	Major potential for cumulative impacts	
5	**Overall impact**	**O**	Neutral	
		-	Negative – Low	
		- -	Negative – High	

Notes : 1. Disturbance / disruption includes impacts arising from noise, dust, water pollution (e.g. hydrodynamic / sedimentation); habitat fragmentation and severance etc.

2. All freshwater wetlands are included under "Terrestrial"

3. All marine waters and marine / estuarine wetlands (Ramsar defined) are included under "Marine"

5.7 Fisheries

Introduction

5.7.1 The farming and harvesting of aquatic resources is termed either “aquaculture” (for “land based” confined wetland resources such as shrimp, fish and duck ponds) or “mariculture” (off-shore fish culture zones). Aquaculture activities only occur on a significant scale in the NWNT of Hong Kong and have been considered within the terrestrial ecology assessment (Section 5.6 refers). As such, the fisheries assessment section of the SEA refers only to mariculture and open-sea fisheries.

5.7.2 The principal source of impact on fisheries resources would be during the landfill construction phase through the direct displacement of important fisheries areas or mariculture areas, and from an associated increase in suspended sediment levels (decline in dissolved oxygen) from dredging / reclamation activities. During landfill operation there may also be a decline in water quality induced by hydrodynamic change (i.e. decreased flushing capacity and increased retention time of water quality parameters).

Government Legislation and Standards

5.7.3 Hong Kong SAR Government ordinances and regulations relevant to the consideration of fisheries and mariculture include :

- Fisheries Protection Ordinance (Cap. 171) and Regulations aims to promote the conservation of fish and other forms of aquatic life within the waters of Hong Kong and to regulate fishing practices and to prevent activities detrimental to the ‘fishing industry' (preamble). The Ordinance provides for Regulations to prohibit the use of explosives and fish poisons, such substances being listed in the Schedule. The Fisheries Protection Regulations enable enforcement of these prohibitions.
- Marine Fish Culture Ordinance (Cap. 353) and associated subsidiary legislation.
- Environmental Impact Assessment Ordinance (Cap. 499) and its associated Technical Memorandum (EIAO-TM) that presents criteria for evaluating fisheries impacts (Annex 9).

Fisheries Sensitive Receivers

5.7.4 The following are considered SRs with regard to fishery impacts within the SEA :

- Mariculture (gazetted marine fish culture zones).
- Spawning / fry nursery areas e.g. mangrove areas.
- Oyster beds.

Generic Fisheries Mitigation

5.7.5 The application of measures to maintain appropriate water quality can be applied to mitigate impacts on fisheries resources.

Evaluation of Fisheries Impacts

5.7.6 The evaluation criteria for assessing impacts upon fisheries are shown in *Table 5.11*. These criteria will be applied to each site on a qualitative basis taking into account the findings of the water modelling exercise for marine sites. For terrestrial sites, the criteria are applied on a qualitative basis taking into account the proximity of aquaculture areas.

5.7.7 The criteria for marine fisheries impact assessment are broadly the same as those for the marine resources as presented in Section 5.6.

Table 5.11: Fisheries Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Potential for secondary environmental impacts on "Areas of Absolute Exclusion"	**O**	No impact anticipated
		-	Minor potential for impact
		- -	Major potential for impact
2	Affects an important mariculture/ fisheries resources (including spawning / nursery ground)	**O**	No impact anticipated
		-	Minor potential for impact
		- -	Major potential for impact
3	Potential for cumulative fisheries Impacts on sites of recognised value	**O**	No / limited potential for cumulative impacts
		-	Minor potential for cumulative impacts
		- -	Major potential for cumulative impacts
4	**Overall impact**	**O**	Neutral
		-	Negative – Low
		- -	Negative – High

Note: Disturbance / disruption includes impacts arising from water pollution (e.g. hydrodynamic / sedimentation); habitat fragmentation and severance etc.

Further Assessment Within SEA

5.7.8 Where the potential for cumulative fisheries impacts has been identified, a qualitative assessment of the likely impacts has been carried out. For the fishery assessment, cumulative impacts have been considered where the impact of another scheme / development is predicted to affect the same resource(s) as the proposed landfill.

5.7.9 Following the cumulative assessment of likely fisheries impacts, an assessment has been made as to whether impacts are likely to comply with the EIAO and the EIAO-TM. This has been carried out by reference to previously endorsed EIAs and by use of professional judgement. By reviewing endorsed EIAs, potential fisheries impacts arising from proposed landfills have been reviewed against quantitative data (from comparable studies) to further substantiate the potential for significant fishery impacts.

5.8 Cultural Heritage Impacts

Introduction

5.8.1 Cultural heritage impacts would primarily occur during the landfill construction phase arising from the destruction of any previously known areas of importance (e.g. areas where significant archaeological finds may have occurred) and any unknown sites of archaeological interest within the footprint of the new landfill or landfill extension area. The potential geographical extent of potential impacts is likely to be localised. There should not be any additional operational impacts.

5.8.2 Whilst Declared Monuments, Graded Historical Buildings and Structures, Deemed Monuments and Archaeological Sites have been identified as "Areas of Absolute Exclusion", it is possible that during excavations, new sites of archaeological interest may be located. Thus the areas potential value may need to be considered.

5.8.3 There is no quantitative standard for determining the relative importance of sites of cultural heritage, but in general sites of unique, archaeological, historical or architectural should be considered as highly significant.

Government Legislation and Standards

5.8.4 The EIA Ordinance stipulates that consideration must be given to issues associated with cultural heritage and archaeology as part of the EIA process. Annexes 10 and 19 of the EIAO-TM outline criteria for evaluating the impacts on sites of cultural heritage and guidelines for impact assessment, respectively.

5.8.5 The principal legislation relevant to cultural heritage and archaeological issues is the Antiquities and Monuments Ordinance (Cap 53). Human artefacts, relics and built structures may be gazetted and protected as monuments under this Ordinance.

5.8.6 The Antiquities and Monuments Office (AMO) is responsible for advising the Government on sites that merit protection. The AMO has further responsibility for the protection of buildings, items of historical interest and areas of archaeological significance. The excavation and search for such relics requires a licence under the Ordinance. For archaeological sites, all relics dated prior to 1800AD belong to the Hong Kong Government under the Antiquities and Monuments Ordinance.

Sensitive Receivers

5.8.7 Archaeological sites are administratively classified into three categories, as follows :

- Designated – those that have been declared as monuments and are to be protected and conserved at all costs.
- Administrative Protection – those which are considered to be of significant value but which are not declared as monuments and should be either protected, or if found not possible to protect these sites then salvaged.
- Monitored – those which are of lesser significance or whose potential is not fully assessed which should not be disturbed with the exception of minor works if they are permitted and monitored by AMO.

Generic Cultural Heritage Mitigation Measures

5.8.8 The EIAO-TM identifies a general presumption in favour of the protection and conservation of all sites of cultural heritage, and requires impacts on sites of cultural heritage to be “kept to a minimum”.

Evaluation of Cultural Heritage Impacts

5.8.9 The evaluation criteria for assessing cultural heritage impacts are shown in *Table 5.12*. These criteria will be applied to each site on a qualitative basis taking in to account known parameters and conditions that could result in relative improvement or exacerbation of impacts.

5.8.10 A fundamental difference between evaluating cultural heritage impacts arising from marine based sites and land based sites, is the greater understanding of the cultural heritage of land areas in Hong Kong. There is still a relatively poor understanding of the marine archaeological potential for most areas of Hong Kong waters. This could potentially lead to a disparity in the subjective evaluation of land based sites and marine based sites. Therefore, for marine based sites, impacts will also be assessed in terms of whether a site has a reasonable potential to yield deposits of archaeological interest, by virtue of known land based activities in their vicinity.

5.8.11 It is also considered that for marine based sites, the absence of existing information does not at this stage preclude it from further investigation. However, it has been requested that any marine based sites investigated further under this project should include a marine archaeological investigation as part of the future studies.

Table 5.12: Cultural Heritage Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Important cultural (Declared, Deemed or Graded Sites) / archaeological sites	**O**	No direct or indirect impacts caused to an important site.
		-	Minor impacts (e.g. potential for vibration impacts to a building or affects the setting surroundings)
		- -	Major direct impact to an important site
2	Potential for archaeological value	**O**	No / limited potential for archaeological finds
		-	Minor potential for archaeological finds
		- -	Major potential for archaeological finds
3	Potential for cumulative cultural heritage Impacts on sites of recognised value	**O**	No / limited potential for cumulative impacts
		-	Minor potential for cumulative impacts
		- -	Major potential for cumulative impacts
4	**Overall impact**	**O**	Neutral
		-	Negative – Low
		- -	Negative – High

Further Assessment within SEA

5.8.12 Following the above process to identify the likelihood of cultural heritage impacts occurring, a qualitative and/or semi-quantitative assessment has been carried out where significant cultural heritage impacts are considered possible.

5.8.13 Where the potential for cumulative cultural heritage impacts has been identified, a qualitative assessment of the likely impacts has been carried out. For the cultural heritage assessment, cumulative impacts have been considered where the impact of another scheme / development is predicted to affect the same resource(s) as the proposed landfill.

5.8.14 Following the cumulative assessment of likely cultural heritage impacts, an assessment has been made as to whether impacts are likely to comply with the EIAO and the EIAO-TM. This has been carried out by reference to previously endorsed EIAs and by use of professional judgement. By reviewing endorsed EIAs, potential cultural heritage impacts arising from proposed landfills have been reviewed to further substantiate the potential for significant cultural heritage impacts.

5.9 Landscape and Visual Impacts

Introduction

5.9.1 The objective of the Strategic Landscape and Visual Assessment is to assess at a broad level, the significance of impacts of each of the proposed landfill new sites / landfill extensions on the existing landscape and visual baseline conditions.

5.9.2 As it is part of a strategic impact assessment, the landscape and visual impact assessment does not include the level of detail specified by the Environmental Impact Assessment Ordinance (EIAO) or its Technical Memorandum. This detailed level of information would be provided at subsequent detailed assessment stage of this project, carried out under other investigations, separate from this Study. The SEA, although at outline level, is sufficiently detailed to ensure that the collection of further detailed information at EIA stage would be unlikely to affect its conclusions.

Government Legislation and Standards

5.9.3 There is no primary legislation specifically related to landscape and visual impacts in Hong Kong. The assessment of landscape and visual impacts within this SEA *broadly* follows the guidelines in Annex 18 and Annex 10 of the Technical Memorandum of the EIA Ordinance.

5.9.4 For the purposes of assessing compatibility with landscape planning intention, the following designations are assumed to be relevant to landscape :

Territory Development Strategy Review (TDSR)

- **Conservation Area** - Countryside character with extensive area of high quality natural landscape. No development is envisaged.
- **Marine Park/Reserve** - Countryside character with extensive area of high quality natural landscape. No development is envisaged.
- **Landscape Protection Area** - Countryside character with areas of high quality natural landscape. Presumption against development, but certain compatible uses (e.g. agriculture and some types of recreation) may be considered.
- **Inshore Water Protection Area** - Countryside character with areas of high quality natural landscape. Presumption against development, but certain compatible uses (e.g. some types of recreation) may be considered.
- **Development Area Countryside** - Rural character with areas of scenic quality. Low density development and uses which are compatible with rural character.
- **Development Area High Landscape Value** - Suburban character with areas of scenic quality. Selected but constrained urban/suburban land use".

(extracted from "Final Technical Report on TDSR" , 1995, p.40)

Outline Zoning Plan (OZP)

- **SSSI** - to conserve and to protect fauna and flora and other natural features with special scientific value.
- **Country Park** - to encourage recreation and tourism, protect vegetation and wildlife, preserve and maintain buildings and sites of historical or cultural significance.
- **Coastal Protection Area** - to retain natural coastline.
- **Conservation Area** - to retain existing natural features and rural use.
- **Green Belt** - to define limits of urban development areas by conserving landscape features.

(extracted from "Hong Kong Planning Standards and Guidelines, Chapter 10 – Conservation" para 3.3.2.).

Visually Sensitive Receivers

5.9.5 For the purposes of landscape and visual assessment, the following are assumed to be sensitive receivers:

Landscape Resources

5.9.6 This includes features such as ; topography; hydrology (water features including areas of sea); vegetation; human features (including settlements, notable buildings or other features).

Landscape Character

5.9.7 Landscape character is the aggregate impression or feeling created by the specific combination of landscape resources in a given landscape.

Visual Sensitive Receivers (VSRs)

5.9.8 Visual sensitive receivers are those people who will view a proposed development. They are classified into four general types: residential, recreational, travelling and working. The sensitivity of receivers to visual impacts is influenced by the immediate context of the viewer, the activity in which they are engaged and the value that they attach to this location in particular.

5.9.9 As data on the precise numbers of VSRs affected at any given location at any given time is not available, the numbers of receivers is estimated on an indicative "order of magnitude" basis, using the terms "very few", "few", "many" and "very many". For example, locations such as small rural settlements might be said to have "very few" VSRs, when compared to an urban area of Hong Kong Island, which might be said to have "very many".

5.9.10 The Study has also considered VSRs in future developments which are committed, but has not considered those VSRs in developments that are the subject of tentative proposals or feasibility studies (such as the current resort proposals for South Lantau). It may be appropriate to consider VSRs in these latter types of development at full EIA stage, if they have become committed developments.

5.9.11 Residential Receivers - Those who view the scheme from their homes are considered to be highly sensitive to any visual intrusion. This is because the attractiveness, or otherwise, of the view will have a notable effect on a residents' general quality of life and acceptability of their home environment. VSRs are identified for the purpose of this Study at a broad, aggregate level only.

5.9.12 Recreational Receivers - For those who view the scheme whilst engaging in outdoor leisure pursuits, visual sensitivity varies depending on the type of recreational activity and the amount of time spent in a particular location. Those taking a stroll in a park, for example, would be classified as a high sensitivity group compared to football players who would have a low sensitivity rating.

5.9.13 Working Receivers - Those people who view the scheme from their workplace are considered relatively less sensitive to visual intrusion. This is because they are employed in activities where visual outlook plays a less important role in the perception of the quality of the working environment. They are classified as a low sensitivity group.

5.9.14 Travelling Receivers - For those people who view the scheme from public thoroughfares, the degree of visual intrusion experienced depends on the speed of travel and whether views are continuous or only occasional. Generally, the slower the speed of travel and the more continuous the viewing experience, then the greater the degree of sensitivity.

Evaluation

5.9.15 The evaluation of landscape and visual impacts comprises four basic parts as set out in *Table 5.13* below:

Table 5.13: Landscape and Visual Impact Evaluation Criteria

	Criteria	Score	'Construction / Operation' and 'Afteruse'
1	Implications for landscape planning and designations	+	Positive
		O	Neutral/Insubstantial
		-	Negative – Low
		- -	Negative – High
2	Landscape resources	+	Positive
		O	Neutral/Insubstantial
		-	Negative – Low
		- -	Negative – High
3	Landscape character	+	Positive
		O	Neutral/Insubstantial
		-	Negative – Low
		- -	Negative – High
4	Visual	+	Positive
		O	Neutral/Insubstantial
		-	Negative – Low
		- -	Negative – High
5	**Overall impact**	+	Positive
		O	Neutral/Insubstantial
		-	Negative – Low
		- -	Negative – High

5.9.16 The specific method of evaluation and assessment for each of these elements is set out below.

Implications for Landscape Planning and Designations

5.9.17 A broad review of the landscape planning context is carried and relevant landscape designations are mapped. The compatibility of the proposal with the landscape planning objectives for the study area of each option is then assessed. Compatibility is assessed only against the planning designation that actually covers the site on which the landfill lies. No assessment is made against designations that cover adjacent areas.

Impacts on Landscape Resources

5.9.18 Baseline mapping of landscape resources is achieved by site visit (for land based sites) and desk-top study of topographical maps, information databases and photographs. Locations of principal landscape resources are mapped. Resources are identified predominantly on a qualitative, not quantitative, basis.

5.9.19 The principal elements of the construction works and operational procedures that would cause landscape resource impacts are then identified. (These are outlined in Part A).

5.9.20 A brief overall assessment of the significance of landscape impacts is presented for each option. The significance of impacts is assumed to be a function of the magnitude of the impact and the sensitivity of the landscape resource. Impacts are assessed during construction/operation; during afteruse without mitigation; and during afteruse with mitigation at Year 10. Impacts on landscape resources and landscape character are presented separately.

Impacts on Landscape Character

5.9.21 Baseline assessment of landscape character is achieved primarily by site visit (for land based sites) supported by desk-top study of topographical maps, information databases and photographs. Locations of Landscape Character Areas (LCAs) are mapped. LCAs are areas of consistent and homogenous landscape character.

5.9.22 The principal elements of the construction works and operational procedures that would cause landscape character impacts are then identified. (These are outlined in Part A).

5.9.23 A brief overall assessment of the significance of landscape impacts is presented for each option. The significance of impacts is assumed to be a function of the magnitude of the impact and the sensitivity of the landscape character affected. Impacts are assessed during construction/operation; during afteruse without mitigation; and during afteruse with mitigation at Year 10.

Impacts on Visual Receivers

5.9.24 The 'visual envelope' for each completed landfill is identified. The visual envelope is that area from which any part of the completed landfill can be seen. Identification of the visual envelope is achieved by site visit and desk-top study of topographic maps and photographs to determine visibility of the project from various locations. This is supported by computer analysis of the visual envelope. Visibility contours and sections are not presented.

5.9.25 All principal VSRs within the visual envelope are identified, at an aggregated level. The principal elements of the construction works and operational procedures that would cause visual impacts are identified. (These are outlined in Part B of the Report).

5.9.26 A brief overall assessment of the significance of landscape impacts is presented for each option. The significance of impacts is assumed to be a function of the magnitude of the impact and the sensitivity of the VSR. Impacts are assessed during construction/operation; during afteruse without mitigation; and during afteruse with mitigation at Year 10.

5.9.27 Visual impacts for each VSR group are tabulated and significant impacts are assessed as “Substantial”, “Moderate” or “Slight”. Impacts which are not significant are “Insubstantial”.

5.9.28 When assessing the effect of mitigation measures in reducing the significance of visual impacts, the following assumptions have been made:

- For island landfills, during the construction/operation phase, visual mitigation measures are more effective on VSRs at sea/ground level than on VSRs who view sites from an elevated level. This is because the former will have views screened by progressively vegetated bunds while the latter will see over these bunds into the landfilling areas;
- During the construction/operation phase, visual mitigation measures are more effective on distant VSRs than on those close to the sites. This is because in close views, intrusive details such as seawalls, leachate plants, haul roads, etc are still clearly visible (despite mitigation), whereas the effect of young planting is not as good. In more distant views, intrusive details are not visible in any case, whereas the overall effect of vegetation is more pronounced.

- For island landfills, during the afteruse phase, visual mitigation is generally more effective on distant VSRs than on very close ones. This is because a new island in close proximity to a VSR will have the effect of dramatically changing the character of the view, meaning that mitigation measures such as ground shaping and vegetation cannot possibly remedy this. In more distant views, the effects of mitigation measures such as ground shaping and vegetation are more important in reducing those impacts which do arise.

Illustrations and Graphic Material

5.9.29 The assessments for each potential landfill site are supported by illustrations, showing at a general or approximate level :

- Landscape resources (map, where applicable).
- Landscape character (photograph).
- Landscape planning designations (plan).
- Visual envelope (plan).
- Views of key visual receiver groups (photographs).
- Outline mitigation measures (plan).
- Photomontages will be prepared for each option, showing the completed landfill without mitigation and with mitigation at Year 10 of afteruse. The number of locations from which photomontages are prepared is between 1 and 3, as agreed with Planning Department for each site.

Generic Landscape/Visual Mitigation

5.9.30 This section sets out in broad terms, mitigation measures generic to all landfill sites. Mitigation is specified at a broad level only as it is assumed that it would be developed in more detail at full EIA stage.

5.9.31 Landscape and visual mitigation measures for the landfill sites will generally include:

- Good working practice to reduce impact on surrounding vegetation during construction/operation phase (where applicable).
- Advance screen planting (where possible).
- Mitigation of visual impacts of landfill temporary slope works.
- Progressive restoration to minimise landscape/visual impacts over time.
- Careful location and colour treatment of associated structures (haul roads, leachate plant, engineered slopes and run-off channels).
- Variation in height profile of restored extension.
- Variation in contouring of slopes.
- Re-use as publicly accessible open space linked to nearby hiking trails.
- Re-vegetation to simulate natural shorelines and naturally vegetated hillsides.

5.9.32 Re-vegetation to simulate natural shorelines and naturally vegetated hillsides. (Generally, landscape restoration should aim to achieve natural vegetation patterns and typical mix of ecologically appropriate species, where possible and consistent with other land use requirements to be determined later.)

5.9.33 Each site will be restored to pre-agreed contours, through landscaping and vegetation planting, as shown in the agreed Master Landscape Plan, by the landfill contractor.

5.9.34 To minimise the landscape and visual impact of landfilling operations, the site should be progressively restored, and a vegetation cover established as early as possible. This would also assist in reducing erosion of the capping layer and would minimise infiltration of rainwater.

5.9.35 During the aftercare period, LFG and leachate would continue to be generated within the landfill (albeit leachate at a lower rate) and so the collection and management systems must continue to operate, resulting in a low level of landscape/visual impact.

5.10 Landfill Gas Issues

Introduction

5.10.1 As described in Section 3.8, LFG issues are considered a primary environmental concern in the development of landfill sites. LFG is a flammable and asphyxiating mixture of methane and carbon dioxide, often with trace amounts of toxic volatile compounds. It is a product of the anaerobic decomposition of solid wastes. Explosion can occur when methane in concentrations between 5% and 15% by volume (representing the lower and upper explosive limits, LEL and UEL respectively) is mixed with air in confined spaces and given a source of ignition, such as an electrical spark.

5.10.2 LFG comprises mainly methane and carbon dioxide, both of which are greenhouse gasses. Methane is the more potent of the two gasses, by a factor of around 21. To reduce the greenhouse gas impacts from methane, it must be oxidised (into carbon dioxide) through combustion :

- Direct on-site use of LFG as an energy source, e.g., heating leachate during treatment.
- Using a gas-engine/generator to convert LFG into electricity, e.g., to provide all site electricity requirements.
- Flaring of surplus LFG.

5.10.3 LFG is capable of migrating from its source to the potential target along any permeable media, such as cracks and fissures in the surrounding rock and other preferential paths of least resistance, such as utility routes (trenches and ducts).

5.10.4 Carbon dioxide emissions from waste degradation are considered to be biogenic, rather than anthropogenic in nature. Aerobic degradation of waste (through oxidation, which produces carbon dioxide) is a natural phenomenon and therefore part of the natural process of carbon cycling. For the purposes of assessing greenhouse gas impacts, it has been assumed that all collected methane would be oxidised to carbon dioxide and therefore the process of landfilling would have a neutral impact on greenhouse gas emission.

5.10.5 However, if the combustion of methane produces electricity for off-site use, which would otherwise have had to be generated at a power station by burning fossil fuels, then there would be an overall benefit. This "saving" would be equivalent to the mass of carbon dioxide not produced by burning fossil fuels to generate the electricity provided by on-site generation.

Government Legislation and Standards

5.10.6 There is no primary legislation covering hazards to development caused by LFG. A ProPECC Note, *"Landfill Gas Hazard Assessment for Developments adjacent to Landfills"* (PN3/96) has been issued by EPD. This Note sets out the conditions under which a LFG hazard assessment should be carried out. EPD have also produced a *"Landfill Gas Hazard Assessment Guidance Note"*(EPD TR8/97) which issues further guidance on undertaking LFG hazard assessments. The guidelines recommend that in general, assessment of risks from LFG are required for proposed developments that lie within a 250m "Consultation Zone" around the landfill site.

5.10.7 Chapter 9, of the Hong Kong Planning Standards and Guidelines also includes guidance on siting of developments in the vicinity of landfills. The guidance states that safe distances depend on factors such as the existence of gas control systems, barriers, landfill site configuration and geological conditions. Sections 1.1(f) of Annex 7 and Section 3.3 of Annex 19 of the EIAO Technical Memorandum also refer.

Landfill Gas Sensitive Receivers

5.10.8 LFG sensitive receivers or "Targets" include any enclosed areas where people congregate where landfill gas can accumulate. This includes elements of buildings as well as excavations, tunnels etc. The degree to which such targets are "at-risk" from the effects of landfill gas is a function of the nature and proximity of the waste body, the occurrence of potential routes for LFG migration as well as the specific nature of the target.

5.10.9 During construction of the landfill, the contractor and others working on the landfill would be exposed to LFG hazards. This issue should be addressed by enforcing the contractor (and others working on the landfill) to adhere to strict working protocols and health and safety regulations, as part of their contract. This issue is not considered further at this stage within the SEA.

Generic Landfill Gas Mitigation

5.10.10 The principal approach to mitigating landfill gas impacts is through mitigation at source through effective controls implemented in the landfill design, as described in Section 3.8.

5.10.11 In addition specific measures can be applied to protect Targets, through implementation of a variety of measures defined on a case by case basis according to the specific degree of risk as concluded through a landfill gas hazard assessment as part of an EIA.

5.10.12 Combustion of collected LFG oxidises methane to carbon dioxide, a less potent greenhouse gas, and can be achieved either through flaring the gas and/or utilising it in a gas-engine to generate electricity for on-site and/or off-site use. Raw LFG can also be piped off-site for use by a third party (e.g. as a substitute for "towngas" manufacture).

Evaluation of Landfill Gas Impacts

5.10.13 The evaluation criteria for assessing Landfill gas impacts are shown in *Table 5.14*.

Table 5.14: Landfill Gas Impact Evaluation Criteria

	Criteria	Score	Construction / Operation
1	Distance between the new / extended landfill and SRs	**O**	>500m (precautionary 2 x Landfill gas consultation limit)
		-	250-500m
		- -	<250m (within landfill gas consultation zone)
2	Number of receivers within 250m (i.e. Consultation Zone)	**O**	None
		-	Up to 10
		- -	Over 10
3	Man-made / natural pathways for LFG migration	**O**	None
		-	Pathway near landfill but indirect to SR
		- -	Pathway from landfill and direct to SR
4	Additional utilisation of LFG to reduce GHG emissions	**+**	Potential nearby user of surplus LFG / electricity
		O	No potential users of LFG (other than on-site use)
5	**Overall impact**	**O**	Neutral
		-	Negative – Low
		- -	Negative – High