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Shenzhen Western Corridor - Investigation and Planning

Working Paper on Method to Rank Alignment Options (Endorsed 5 Oct)

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1. INTRODUCTION

1.1 Project Background

The Shenzhen Western Corridor (SWC) is a dual-3 lane carriageway with hard shoulders linking the proposed Deep Bay Link (DBL) to the section of SWC within the boundary of the Mainland. The proposed highway would be the fourth boundary road crossing providing relief to the traffic congestion at the existing boundary crossings.

The responsibility for implementing the portion of the SWC within Hong Kong Special Administrative Region (HKSAR) shall rest with the Government of the HKSAR (HKSARG). However, before this division of responsibility was determined, the Mainland authorities had already conducted some engineering feasibility studies on the SWC since 1995. In this regard, a number of different alignment options for the SWC had been considered. As regards the structural form of the crossing, the investigation mainly covered the elevated structure option and only few covered the tunnel option.

The HKSARG had also conducted a series of studies on this fourth boundary road crossing and in this process, several landing points of the SWC on the HKSAR coastline had been examined.

On 21st August 2001, Highways Department (HyD) of the HKSARG commissioned Ove Arup & Partners Hong Kong Limited (Arup) as the Consultants to carry out the Investigation and Planning Assignment of Shenzhen Western Corridor under Agreement No. CE 39/2001.

1.2 Objective of this Working Paper

The objective of this Working Paper is to present the ranking method to be used for assessment of the alignment options for SWC in the Working Paper on Alignment Options (Deliverable no. 1 required in the Brief) to identify the preferred option. Eighteen factors including civil engineering, environmental, marine, land use, implementation programme and cost are identified. For each of the factors, a rating method is proposed. In order to take account of the relative importance of the factors, weights will be applied to the factors to produce a weighted rating.

1.3 Nomenclature and Abbreviations

AMO	Antiquities and Monument Office
Arup	Ove Arup and Partners Hong Kong Limited
CLP	China Light and Power Co. Ltd.
DBL	Deep Bay Link
DBL-I&PD	Deep Bay Link - Investigation and Preliminary Design
HKSAR	Hong Kong Special Administrative Region
HKSARG	Government of the HKSAR
HTL	Hutchison Telecommunications (Hong Kong) Ltd
HSK NDA	Hung Shui Kiu New Development Area
HyD	Highways Department
PCCW	Pacific Century Cyberworks
SWC	Shenzhen Western Corridor
TPDM	Transport Planning and Design Manual
WSD	Water Supplies Department

2. RANKING PROCEDURE

2.1 Factors

The factors influencing the identification of the preferred alignment option are summarised below:

f1	Highway alignment
f2	Drainage impact
f3	Utilities impact
f4	Construction practicability
f5	Construction traffic management
f6	Traffic Operation
f7	Noise impact
f8	Air quality impact
f9	Water quality impact
f10	Ecology impact
f11	Fisheries impact
f12	Waste
f13	Cultural heritage impact
f14	Hazard to life
f15	Landscape and visual impact
f16	Marine impact
f17	Land use impact
f18	Programme
f19	Cost
f20	Public perception
f21	Hung Shui Kiu New Development Area

2.2 Rating of factors

Ratings are given on a 5-point scale to each alignment option under each of the above factors, with higher scores for the better options. The relative importance of the factors is taken into consideration by applying weights to the rating factors. The rating of each factor is multiplied with the applied weight to give the weighted rating. The overall rating of each alignment option is then obtained by summing up the weighted ratings of all the factors. The options are ranked in accordance with the overall ratings and the option with the highest overall rating is recommended as the preferred alignment option for the SWC.

3. DEFINITIONS OF FACTORS

f1 *Highway alignment* – refers to the quality of the alignment geometry (horizontal and vertical) that can be achieved.

f2 *Drainage impact* – refers to the impact on the existing drainage of the study area, and areas upstream and downstream of the study area, due to the construction of the alignment options.

f3 *Utilities impact* – refers to the landscape and visual impact on the existing major utilities in the study area due to the alignment options.

f4 *Construction practicability* – refers to the degree of difficulty in construction of the alignment options.

f5 *Construction traffic management* – refers to the ease with which the alignment option can be constructed whilst maintaining existing traffic flow during construction stage.

f6 *Traffic operation* - refers to traffic management, traffic plans during emergency, future operation of the corridor, and the facilities necessary to support the intended operations.

f7 *Noise impact* – refers to the impact due to noise generated by the alignment options during construction and operation stage after practical mitigation measures.

f8 *Air quality impact* – refers to the impact due to air emissions generated by the alignment options during construction and operation stage after practical mitigation measures.

f9 *Water quality impact* – refers to the potential water quality impact resulting from the alignment options and any associated dredging and reclamation work.

f10 *Ecology impact* – refers to the adverse impact on ecology due to the alignment options during construction and operation stage. The following sub-factors are considered:

- intertidal impacts,
- terrestrial impacts, and
- sub-tidal impacts.

f11 *Fisheries impact* – refers to the potential impact on fisheries due to the alignment options during construction and operation stage. This includes the following sub-factors:

- capture fisheries,
- oyster culture, and
- pond fisheries.

f12 *Waste* – refers to the potential impacts due to waste generated during construction of the alignment options.

f13 *Cultural heritage impact* – refers to the impacts on identified archaeological sites due to the alignment options.

f14 *Hazard to life* – refers to the potential hazard consequent from certain construction activities and during operation stage due to the alignment options.

f15 *Visual and landscape impact* – includes:

- the effect on the existing vegetation,
- the visual impact of the alignment options on the existing landscape character, and

- the potential for mitigation of the impacts through careful design of engineering structures and incorporation of landscape treatments, or by the capacity to reprovision affected amenity facilities within other parts of the study area.

f16 *Marine impact* – refers to the impact on marine facilities and marine traffic due to the alignment options. This is considered to be made up of:

- Loss of navigational water space – the loss of effective water area required to manoeuvre vessels due to the alignment options.
- Loss of anchorage space – the loss or reduction of water areas presently used for anchorage due to the alignment options.
- Disruption during construction – the disruption caused by marine based construction plants and their sequence of work during construction period. The impact may be measured by examination of the most disruptive situation which occurs at any time, and the length of time for which disruption occurs.
- Risk to marine traffic – the risk to marine traffic due to obstructions in the sea caused by the construction of the alignment options.
- Risk of structure against ship collision – the risk of the proposed structures of the alignment options due to collision by marine crafts after incorporation of practical ship collision protection measures where necessary.

f17 *Land use impact* – refers to the effect of the alignment options on the existing land use, planned land use and future development potential of the assessment area.

f18 *Programme* – refers to the time required for gazette & objection, detailed design and construction of the alignment options.

f19 *Cost* – includes:

- Construction cost – the cost required to construct the alignment, including any practical environmental mitigation measures and ship collision protection measures.
- Resumption cost – the cost required to resume or reduce the land lots, allocations, reserves etc. that clash with the alignment options added with any associated reprovisioning or rehousing costs necessitated by the project and deducted with any potential redevelopment gain from land sale revenue of resumed site not used by the SWC. The cost will be adjusted to the date of the construction cost.
- Operating/Maintenance cost – the cost required to operate and maintain the alignment, including the annual recurrent operating costs of regular cleaning, lighting and ventilation (if any) etc. and the average annual recurrent maintenance costs of the carriageways, structures, landscaping, environmental mitigation measures and ship collision protection measures, if any. The estimated annual operating and maintenance cost will be adjusted to the date of the construction cost and multiplied by 50 years to obtain the operating/maintenance cost of the alignment option.

  It is considered that although the design life of highway structures is 120 years, the actual life of the structures may be shorter than 120 years due to redevelopment requirements, changes in bridge/tunnel technologies or some unforeseeable reasons.

  Also it would be unreasonable to assume that bridges/tunnels at 120 years from now would be operated/maintained in a similar way as present so that the annual operating and maintenance cost would remain similar (after adjustment for inflation and conversion to net present values).

A value of 50 years is therefore chosen as a time scale to convert the annual operating and maintenance cost to the operating/maintenance cost which would be combined with the construction and resumption costs to produce a total cost value suitable for the comparison of the alignment options.

f20 *Public perception* – refers to the views of the interested/affected parties of the public on each of the alignment options. The interested/affected parties include:

- environmental groups, and
- local residents.

f21 *Hung Shui Kiu New Development Area* - refers to the connectivity of the highway alignment to the development area and the impacts to the area due to the alignment options.

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4. WEIGHTING CRITERIA

Obviously the factors listed in the previous section have different levels of importance in the decision of the best alignment. Some factors are more important than others and therefore should be assigned greater relative weights in the overall assessment of the alignment options. This section proposes an importance-weighting approach that classifies the factors into three levels. The three levels are assigned relative weights of 6, 3 and 1 respectively.

The highest level factors are those which are considered to be essential. Given the special characteristics of Shenzhen Western Corridor, which is to be constructed jointly by Mainland and HKSAR to achieve an agreed opening year of 2005, the f18 programme and f4 construction practicability (which links to the risk in programme) factors are most important. Similarly, factor f14 hazard to life, which is an assessment of the risk to hazards, is also of utmost importance. The factors which fall into this level are therefore:

f4 Construction practicability
f14 Hazard to life
f18 Programme

The next level factors are those which are important. The factors which fall into this level are:

f1 Highway alignment
f6 Traffic operation
f7 Noise impact
f8 Air quality impact
f9 Water quality impact
f10 Ecology impact
f11 Fisheries impact
f12 Waste
f13 Cultural heritage impact
f15 Landscape and visual impact
f16 Marine impact
f19 Cost
f20 Public perception
f21 Hung Shui Kiu New Development Area

The base level factors are the general factors that can normally be dealt with in the design, particularly so in this project where the impacts of these factors are not significant. They include the following:

f2 Drainage impact
f3 Utilities impact
f5 Construction traffic management
f17 Land use impact

Obviously all of these factors have their roles in the decision making and cannot be ignored. However, given the circumstances of the route, they are not considered to have a large influence on the choice of alignment.

5. RATING METHOD

5.1 f1 Highway alignment

The quality of the geometry (horizontal and vertical) of each alignment option is considered.

For each alignment option, the individual segments of straight lines, circular curves and spiral curves along the carriageway centreline are identified and the lengths, radii and gradient of the segments are measured.

(1) Horizontal alignment

- A good horizontal alignment should have short overall length between end points with gentle large radii curves along the length. The best horizontal alignment would ideally be a straight line drawn between the start and destination points. An indicator s_h of the performance of the horizontal alignment would be:
- for straight line segments,

  s_h = segment length L
- for circular segments,

  s_h = {segment length L times maximum[1, (desirable R_d / segment radius R)] }
- for spiral segments between straight lines and circles,

  a mean value between indicators of straight line and circular segments is taken as a measure, i.e.

  s_h = {segment length L times maximum[1, ½ [1 + (desirable R_d / segment R)]] }
- A value of 350m is chosen as the desirable radius R_d for this comparison exercise.
- The overall performance of horizontal alignment is assessed by the total sum S_h of the above indicators for all segments of the alignment.
- A 5-point rating scale is used to rate the alignment options under this sub-factor. The rating scale is defined by assigning 5-points to the alignment option which has the minimum S_h value and zero point to any option which has an S_h value equal to or greater than 1.5 times the minimum S_h value. Intermediate ratings are obtained by linear interpolation and are equal to: 5[3 - 2 (S_h) ÷ (minimum S_h)], rounded to the nearest integer.

(2) Vertical alignment

- A good vertical alignment should have short overall length between end points with low gradient along the length. The best vertical alignment would ideally be a straight line with zero gradient drawn between the start and destination points. An indicator s_v of the performance of the vertical alignment would be:
- for straight line segments,

  s_v = {segment length L times maximum[1, (segment gradient G / desirable gradient G_d)] }

  A value of 3% is chosen as the desirable gradient G_d for this comparison exercise.
- for crest curve segments,

  s_v = [segment length L times (desirable K_{dc} / segment K)]

A value of 100 is chosen as the desirable K_{dc} for this comparison exercise.

- for sag curve segments,

  s_v = [segment length L times (desirable K_{ds} / segment K)]

  A value of 37 is chosen as the desirable K_{ds} for this comparison exercise.

- The overall performance of vertical alignment is assessed by the total sum S_v of the above indicators for all segments of the alignment.

- A 5-point rating scale is used to rate the alignment options under this sub-factor. The rating scale is defined by assigning 5-points to the alignment option which has the minimum S_v value and zero point to any option which has an S_v value equal to or greater than 1.5 times the minimum S_v value. Intermediate ratings are obtained by linear interpolation and are equal to: $5[3 - 2 (S_v) \div (\text{minimum } S_v)]$, rounded to the nearest integer.

The rating for each selected alignment option under f1 Highway alignment factor is calculated by summing the ratings of horizontal and vertical sub-factors and spread on a 5-point scale by dividing 2.

5.2 f2 Drainage impact

The impacts of each of the alignment options on the storm water drainage of the study area, and areas upstream and downstream of the study area, are considered. Impacts on the sewerage system are considered under f3 Utilities impact.

Ratings are given to the alignment options based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** below:

Table A: 5-point rating scale and interpretation

5-point rating scale	Interpretation
0-1	severe impact
2	high impact
3	moderate impact
4	low impact
5	minimal impact

5.3 f3 Utilities impact

After examination of the utilities drawings which have been obtained from the various utilities authorities/undertakers, it is found that the utilities in the study area which may be affected by the alignment options include water mains from WSD, power cables from CLP, telephone cables from PCCW and street lighting cables from HyD.

Ratings are given to the alignment options based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.4 f4 Construction practicability

This factor deals with the degree of difficulty of the construction of the alignment options. The following sub-factors are considered and rated to derive the rating of the factor:

(1) Degree of temporary works (including access roads)

(2) Special plants and specially trained skilled labour

(3) Additional land during construction

(4) Interfacing at both ends of the crossing

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described below:

5-point scale	Interpretation			
	sub-factor (1)	sub-factor (2)	sub-factor (3)	sub-factor (4)
0-1	Extensive	Special plants + skilled labour	Large area (>100% of permanent land resumption)	severe impact
2	Large	Above average	Above average	high impact
3	Average	Average	Average	moderate impact
4	Less	Below average	Below average	low impact
5	Minimal	Typical plants + normal labour	Small area (<10% of permanent land resumption)	minimal impact

The rating for each selected alignment option under f4 construction practicability factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the sum with the no. of sub-factors.

5.5 f5 Construction traffic management

The traffic impacts due to the alignment options during construction stage are considered.

The following key issues are considered to determine the ratings of each alignment option:

- Junction capacity assessment – this factor evaluates whether the nearby junctions would operate with sufficient capacity under the "with construction traffic" situation.
- Road capacity assessment – its main purpose is to find out whether the surrounding road network would have adequate capacity to accommodate the expected traffic volume.
- Pedestrian facilities – consideration will be given to pedestrian safety in the vicinity of the works area.
- Cost-effectiveness of traffic management schemes – where construction traffic may contribute to road or junction deficiency, improvement schemes would be conceived to overcome the problems.
- Traffic-related environmental issues – this factor includes vehicle stop-start situations as well as possible traffic calming measures.
- Inconvenience to the local community – investigations will be made to minimise adverse impacts to the local community.

A 5-point rating scale is used, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.6 f6 Traffic operation

The performance of each alignment option with respect to traffic management, traffic plans during emergency, future operation of the corridor as well as the facilities necessary to support the intended operations are qualitatively assessed.

A 5-point rating scale is used, with higher scores for the better options. The interpretation of the rating scale is described below:

5-point rating scale	Interpretation
0-1	very poor performance
2	poor performance
3	satisfactory performance
4	good performance
5	excellent performance

5.7 f7 Noise impact

The impacts due to noise generated by the alignment options during construction and operation stages after practical mitigation measures are considered.

The following procedure is used to determine the ratings of each alignment option:

- Noise modelling is undertaken at selected Noise Sensitive Receivers (NSRs) along each of the alignment options for both unmitigated and mitigated scenarios.
- Each option is comparatively assessed using the unmitigated base case and the number of dwellings that will be affected as well as the size of the exceedance of the HKPSG criteria at each NSR.
- A package of practical mitigation measures is estimated for each alignment option. Details of the practical mitigation measures will be used in the assessment of the options under f15 Landscape and visual impact factor and f19 Cost factor.
- The number of affected dwellings and the size of the exceedance of the HKPSG criteria at each NSR after practical mitigation measures (i.e. the mitigated case) are estimated for each alignment option.
- A 5-point rating scale is used, with higher scores for the better options. Interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.8 f8 Air quality impact

The impacts due to air emissions generated by the alignment options during construction and operation stages after practical mitigation measures are considered.

The following procedure is used to determine the ratings of each alignment option:

- Air quality modelling is undertaken for each of the alignment options, based on estimated emission data of the traffic flow figures for the Year 2021 given in the Traffic Impact Assessment Update (Final) Report (May 2001) of Agreement No. CE 109/98 Deep Bay Link Investigation and Preliminary Design.
- Each option is comparatively assessed. The number of Air Sensitive Receivers (ASRs) that will be affected by each option and their air quality, based on the AQO NO_2 hourly criterion (300μg/m^3), is identified.
- A 5-point rating scale is used, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.9 f9 Water quality impact

The water quality impacts due to construction and operation of each of the alignment options are considered.

Ratings are given to the alignment options based on a 5-point scale, with higher scores for the options with less impact. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.10 f10 Ecology impact

The impacts of each of the alignment options on the existing key terrestrial and marine ecological resources within the study area during construction and operation stages are considered. This includes the following sub-factors:

(1) intertidal impacts,

(2) terrestrial impacts, and

(3) sub-tidal impacts.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

A percentage distribution of 50%, 30% and 20% will be applied to the ratings under sub-factors (1), (2) and (3) respectively to reflect the focus on the intertidal zone where bird foraging, horseshoe crabs, seagrasses and mangroves are the key issues in consideration of ecology impacts. The rating for each alignment option under f10 Ecology impact factor is calculated by summing up the individual ratings after percentage distribution for each of the above sub-factors.

5.11 f11 Fisheries impact

The impact on fisheries of each alignment option within the study area during construction and operation stages is considered. It is made up of:

(1) capture fisheries,

(2) oyster culture, and

(3) pond fisheries.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

The rating for each selected alignment option under f11 Fisheries impact factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the sum with the no. of sub-factors.

5.12 f12 Waste

The potential impacts due to waste generated during construction of each alignment option are considered.

Ratings are given to the alignment options based on a 5-point scale, with higher scores for the options with less impact. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.13 f13 Cultural heritage impact

Impact to identified archaeological site due to each alignment options is considered. Ratings are given to the alignment options based on a 5-point scale, with higher scores for the options with less impact. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

5.14 f14 Hazard to life

Hazard impact during both construction and operation stages for each alignment option is considered. The sub-factors will include:

(1) potential hazard during construction stage – which will consider the potential hazard resultant from overnight storage of explosives with the storage location in close vicinity of populated areas.

(2) potential hazard during operation stage – which will consider the potential hazard to vehicles using the corridor.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

A percentage distribution of 30% and 70% will be applied to the ratings under sub-factors (1) and (2) respectively. The rating for each alignment option under f14 Hazard to life factor is calculated by summing the individual ratings after percentage distribution for each of the above sub-factors.

5.15 f15 Landscape and visual impact

The following sub-factors are considered and rated to derive the rating of the factor:

(1) impact of the alignment option, incorporated with the practical environmental mitigation measures and the ship collision protection measures, if any, on the existing landscape elements, character and quality in the context of the site and its environs,

(2) impact of the alignment option incorporated with the practical environmental mitigation measures and the ship collision protection measures, if any, on the existing views, visual amenity, character and quality of the visually sensitive receivers' views (including also the views of drivers and passengers of the vehicles using the corridor) within the context of the site and its environs, and

(3) potential for mitigation of the impacts through careful design of engineering structures and incorporation of landscape treatments, or by the capacity to reprovision affected amenity facilities within other parts of the study area.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described below:

5-point rating scale	Interpretation	
	sub-factors (1), (2)	sub-factor (3)
0-1	highly significant impact	very low potential
2	significant impact	low potential
3	moderate impact	moderate potential
4	slight impact	high potential
5	insignificant impact	very high potential

The rating for each selected alignment option under f15 Landscape and visual impact factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the sum with the no. of sub-factors.

5.16 f16 Marine impact

The following sub-factors are considered and rated to derive the rating for the factor:

(1) loss of navigational water space,

(2) loss of anchorage space,

(3) disruption during construction,

(4) risk to marine traffic, and

(5) risk of structure against ship collision

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options.

For sub-factors (1) and (2), the rating scale is defined by assigning 5-points to the alignment option which has the minimum loss in area or length, and zero point to any option with a loss greater than or equal to the larger of (the maximum loss or twice the minimum loss). Intermediate ratings are obtained by linear interpolation.

For sub-factors (3), (4) and (5), the interpretation of the rating scale is described below:

5-point rating scale	Interpretation	
	sub-factor (3)	sub-factor (4), (5)
0-1	severe impact	maximal risk
2	high impact	high risk
3	moderate impact	moderate risk
4	low impact	low risk
5	minimal impact	minimal risk

The rating for each selected alignment option under f16 Marine impact factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the no. of sub-factors.

5.17 f17 Land use impact

The following sub-factors are considered and rated to derive the rating of the factor:

(1) effect on existing land use,

(2) effect on planned land use, and

(3) effect on future development potential of the assessment area.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

The rating for each selected alignment option under f17 Land use impact factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the sum with the no. of sub-factors.

5.18 f18 Programme

The time required for gazette & objection, detailed design and construction of each alignment option is estimated and compared.

A 5-point rating scale is defined by assigning 5 points to any alignment option that can be programmed to operate by 2005 or earlier, and zero point to any alignment option which cannot be programmed to operate by end of 2007. Intermediate ratings are obtained by linear interpolation.

5.19 f19 Cost

For each alignment option, the following costs are estimated and summed to derive the total cost of the alignment options:

(1) construction cost,

(2) resumption cost, and

(3) operating/maintenance cost.

The rating scale is defined by assigning 5 points to the alignment option which has the minimum total cost and zero point to any option which has a total cost greater than or equal to 1.5 times the minimum total cost. Intermediate ratings are obtained by linear interpolation and are equal to:

$5\times[3 - 2 \text{ (total cost)} \div \text{(minimum total cost)}]$, rounded to the nearest integer.

5.20 f20 Public perception

The perception of each alignment option by the interested/affected parties of the public is considered. It is composed of the following sub-factors:

(1) perception by environmental groups – assessment will be based on the information gathered from the meetings with the environmental groups.

(2) perception by local residents – assessment will be based on the information obtained from public consultations carried out in Yuen Long and Tuen Mun.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in **Table A** in sub-section 5.2.

The rating for each alignment option under f20 Public perception factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the sum with the no. of sub-factors.

5.21 f21 Hung Shui Kiu New Development Area

The effects of the alignment options on Hung Shui Kiu New Development Area (HSK NDA) are considered. The factor is composed of the following sub-factors:

(1) connectivity of the highway alignment via DBL to HSK NDA.

(2) impact to HSK NDA due to the alignment option.

Ratings are given to the alignment options under each of the above sub-factors based on a 5-point scale, with higher scores for the better options. The interpretation of the rating scale is described in the following table:

5-point rating scale	Interpretation	
	sub-factor (1)	sub-factor (2)
0-1	no connectivity	severe impact
2	poor connectivity	high impact
3	fair connectivity	moderate impact
4	good connectivity	low impact
5	excellent connectivity	minimal impact

The rating for each alignment option under f21 HSK NDA factor is calculated by summing the individual ratings for each of the above sub-factors and spread on a 5-point scale by dividing the sum with the no. of sub-factors.

6. SENSITIVITY TEST

6.1 Introduction

The ranking method presented in this Working Paper has been discussed in detail in the Engineering Working Group meeting held on 5th October 2001. There have been a lot of discussions on the factors, the relative weights and the concept of the ranking method during the meeting, which was attended by representatives from various Government departments with different professional backgrounds and different viewpoints. The method was basically accepted by the members after incorporation of the comments received at the meeting. However, there were opinions that the weights of some factors should be varied from the values mentioned in Section 4. There were also opinions that the percentage distribution of the total weight among various groups of factors including engineering, environmental, etc. should be varied slightly to see if the change would affect the final results.

A sensitivity analysis will therefore be included in the assessment of the alternative alignment options to test the invulnerability of the recommended alignment. The analysis will consist of two separate parts:

(1) First part: by varying weights of some factors

(2) Second part: by varying the percentage distribution of the total weight

A table showing the individual weights of the factors and the percentage distribution of the total weight among various groups of factors in the base case is shown below:

Factor		Weight
f1	Highway alignment	3
f2	Drainage impact	1
f3	Utilities impact	1
f4	Construction practicability	6
f5	Construction traffic management	1
f6	Traffic operation	3
f7	Noise impact	3
f8	Air quality impact	3
f9	Water quality impact	3
f10	Ecology impact	3
f11	Fisheries impact	3
f12	Waste	3
f13	Cultural heritage impact	3
f14	Hazard to life	6
f15	Landscape and visual impact	3
f16	Marine impact	3
f17	Land use impact	1
f18	Programme	6
f19	Cost	3
f20	Public perception	3
f21	HSK NDA	3
Sum		**64**
% on Engineering (factors f1 to f6)		23.4%
% on Environmental (factors f7 to f15)		46.9%
% on Marine (factor f16)		4.7%
% on Land (factor f17)		1.6%
% on Programme (factor f18)		9.4%
% on Cost (factor f19)		4.7%
% on Public perception (factor f20)		4.7%
% on HSK NDA (factor f21)		4.7%

6.2 Sensitivity test by varying individual weights of some factors

The weights of the following factors will be varied independently, resulting in 16 different combinations including the base case (where all four factors remains unchanged):

(1) f4 Construction practicability factor: the weight is reduced from 6 to 3

(2) f9 Water quality impact factor: the weight is increased from 3 to 6

(3) f10 Ecology impact factor: the weight is increased from 3 to 6

(4) f19 Cost factor: the weight is increased from 3 to 6

6.3 Sensitivity test by varying the percentage distribution of the total weight among various groups of factors

The percentage distribution of the total weight will be varied in the following scenarios:

(1) The percentage of the “Engineering + Cost + Programme + HSK NDA” group of factors (i.e. f1 to f6, f18, f19 and f21) is increased to 60% of the total weight.

(2) The percentage of the Environmental group of factors (i.e. f7 to f15) is varied between 40% and 60% of the total weight.

In each of the above scenarios, the surplus/deficit resulting from the variation will be distributed to the other factors in proportion to their individual weights in the base case scenario.