Annex C4

EIA Reports related to HZMB

Supplementary Information on Comparison between Alignment Options A and C for the Middle Section of Hong Kong Link Road

1 Introduction

1.1 This supplementary information is to respond to the request of the Environmental Impact Assessment of the Advisory Council on the Environment (EIASC) for a detailed comparison on environmental aspects between Alignment Options A and C as presented in the EIA Report for the middle section of Hong Kong Link Road (HKLR). (The section of HKLR between San Shek Wan/Airport-west and Tung Chung/Airport-east is referred to as the middle section in this supplementary information. Three alignment options have been presented in the EIA Report viz. Options A, B and C, as shown on the attached **Figure 1**).

1.2 As pointed out in the EIA Report, Option C involves a tunnel with an eastern portal that will encroach upon the Lantau North (Extension) Country Park. It was considered that this should amount to a vital factor for concluding the option as not feasible, as there is a feasible alternative (Option A) that could avoid such encroachment upon the Country Park.

1.3 After the presentation at the EIASC meeting on 21 September 2009, it was requested that a more detailed comparison be made between Options A and C on environmental aspects.

2 Relevant Key Aspects of Option A (Total length approximately 12.1 km)

2.1 Option A takes the form of a viaduct structure (i.e. trestle-bridge) along the Airport Channel on the southern side of the Airport Island. At the western end of the Channel, the HKLR will run along the Lantau side in order to avoid the critical aviation zone around the runway-tip and to avoid affecting the Government Flying Service (GFS) operations. The spans of this portion of HKLR viaduct will be designed to ensure that the viaduct structure will overpass the headland between San Shek Wan & Sha Lo Wan, without any physical contact. The overall layout of Option A is shown on **Figure 2**.

2.2 The HKLR viaduct will cross the Airport Channel to run along the Airport side as soon as practicable after avoiding the zone critical to the operations of the runway and the GFS.

2.3 The layout of Option A is shown at a finer level on **Figures 3 to 4**, which also highlights relevant key aspects including the following:

(a) As shown in **Inset X** on **Figure 4**, the portion of Option A at/near the western end of the Airport Channel will be designed with larger spans, not only to overpass the San Shek Wan/Sha Lo Wan headland, but also to reduce the number of columns facing Sha Lo Wan. The span-arrangement will also ensure that HKLR could overpass the Sha Lo Wan Pier. A large span is required too for crossing the navigation within the Airport Channel.

(b) The spans of the aforesaid portion of HKLR will be of the order of 100 m to 180 m, and are envisaged to take the in-situ balanced-cantilever bridgeform with haunches. Such spans are substantially larger than spans for the more common precast-segmental bridgeform without haunches, which are practicably up to approximately 75 m. A comparison of the two bridgeforms noted above is shown in elevation on **Figure 4**. After crossing the Airport Channel, the columns of HKLR under Option A will run along the seawall of the Airport Island. As shown in **Inset Y** on **Figure 4**, these columns will all be located above the high water mark.

(c) To summarize, the majority of the columns of the HKLR viaduct in the Airport Channel are not in water. Only about 13 pairs[1] of columns (for the portion of HKLR at/near Sha Lo Wan and across the Airport Channel) are in the water.

(d) At/near Sha Lo Wan, the relevant sensitive receivers are mainly the village houses as shown on **Figure 3**. The majority of these village houses are at least at 300 m away from the Option A HKLR viaduct. For the remaining portion of HKLR along the Airport Channel, there are no significant sensitive receivers nearby, as the village houses (at Kau Liu/Tin Sam) are at approximately 400 m away.

(e) On western side of Lantau, the Option A HKLR is at about 600m away from the village houses at San Shek Wan.

3 <u>Relevant Key Aspects of Option C (Total length approximately 11.8km)</u>

3.1 Option C takes the form of a tunnel through the Lantau hillside. The western portal is located near Sham Wat in order to avoid the village houses at San Shek Wan and Sha Lo Wan, whereas the location of the eastern portal need to avoid the San Tau SSSI and the Hau Hok Wan horseshoe crab breeding site as well as the village houses at Kau Liu/Tin Sam. The layout of Option C and other relevant key aspects are shown on **Figures 5 to 10**.

3.2 Before entering the western portal, the Option C HKLR will take the form of a sea viaduct similar to other portions of HKLR in the western waters. There is no fundamental difference between Options A and C in this regard. Similarly, on the eastern side, after daylighting from the eastern tunnel portal the Option C

[1] The water quality assessment of the EIA of HKLR has in fact assumed more columns in this portion of HKLR (16 pairs in lieu of 13 pairs). This is for conservatism. In fact the water quality assessment results show that even with the larger number of columns, there will not be any adverse water quality impacts.

HKLR will cross the Airport Channel as a viaduct structure similar to the Option A channel-crossing as noted in (2.3) above.

3.3 The western portal will be about 300 m away from the village houses at Sham Wat, whilst the eastern portal will be about 250 m to the village houses at Kau Liu/Tin Sam.

3.4 Relevant key aspects on Option C as highlighted on **Figures 6 to 10** include the following:

(a) As shown in **Figure 7**, the western portal will involve extensive cutting of the Lantau natural hillside because of the steep topography there. Such extensive cutting in order to form a portal is essential for land tunnel construction, as illustrated in photos shown on **Figure 9** for portal-cuttings at construction stage, for various tunnel projects in Hong Kong.

(b) Though measures could be taken to apply extensive landscaping at the portal (see **Figure 10** showing photos of completed landscaped portals for various tunnel projects in Hong Kong), the landform will be altered inevitably, i.e. loss of naturalness is inevitable.

(c) Similarly, extensive cutting and loss of naturalness of the hillside are inevitable on the eastern side too, for the eastern portal. In addition, the eastern portal will inevitably encroach upon the Lantau North (Extension) Country Park, in order to avoid the San Tau SSSI and the Hau Hok Wan horseshoe crab breeding site. (Note: Though there is a small gap between the Country Park boundary and the Lantau shoreline, the gap is inadequate to accommodate the tunnel-portal plus its associated cutting. See cross-section on **Figure 8** showing the above.) Furthermore, should the eastern portal be located in that gap, its level would be too low to enable HKLR to across the Airport Channel with adequate headroom for vessels.

(d) As regards the main tunnelling work between the two portals, it will go through rock strata for the majority of the tunnel length. For such a case, tunnel boring machine (TBM) is not feasible not only because TBM usually requires a larger economy-of-scale in view of the high mobilization & set-up costs involved, but also because HKLR is a dual-3 lane highway. There is no TBM so far available in the world capable of forming a bore through rock strata large enough for a dual-3 highway. If Option C is adopted, the main tunnelling works will be constructed by the drill-and-blast method, which is common for land tunnelling work. Drill-and-blast tunnelling in turn requires processing of the blasted rocks, in order to bring the rocks to sizes of suitable use. Such processing, typically in the form of rock-crushing, will take place outside the tunnel, in this case at both the eastern & western portal sites.

(e) Another special aspect for the Option C tunnel is that neither ends are accessible by road. Conceivably, the only way to dispose the tunnel-excavation materials is to convey them by conveyors/chutes onto barges

berthed against the Lantau shoreline right below the eastern and western portal sites respectively. As shown on **Figure 10**, the existing seabed levels thereat are shallow. As a result, dredging will be required to provide draught needed by the barges. (For such construction barges, the draught required is approximately 4 m. As shown on **Figure 10** the seabed levels available here are approximately -2mPD only.)

(f) Another important aspect for the design of a tunnel is the arrangement for exhaust of traffic emissions within the tunnel. It is envisaged that two ventilation shafts will be required for exhaust of the traffic emissions. As shown on **Figure 6**, since a large proportion of the Option C tunnel is within the Country Park, it would be inevitable for at least one of the ventilation shafts to encroach upon the Country Park even if the ventilation system is designed to locate the ventilation shafts towards the western side as far as possible to avoid the Country Park area.

(g) Furthermore, for practical reasons, hard shoulder cannot be provided within the 3.5k m long tunnel for Option C. This affects the traffic management and operation as well as emergency handling for this important corridor.

(h) Basically, 24 hours ventilation and lighting is required for the tunnel.

4 Comparison between Options A and C

4.1 Air Quality

4.1.1 Operation Air Quality Impact

(a) The operation air quality impacts by Option A have been reported in the EIA Report. For illustration, it should be noted that the assessed 1-hour NO_2 (a vital parameter for operation air quality assessment for a highway project) at the Air Sensitive Receiver (ASR) at Sha Lo Wan is 246 $\mu g/m^3$ for the highest case, at the Assessment Year of 2031. For this 246 $\mu g/m^3$, approximately 17% (i.e. 41 $\mu g/m^3$) is due to emissions from all road traffic; the remaining 205 $\mu g/m^3$ being caused by emissions from PRD, airport, power stations, and other non-traffic related sources.

(b) For Option C, the ASRs at Kau Liu/Tin Sam village are subjected to impacts not only from the portion of HKLR open road outside the eastern portal, but also emissions from the eastern portal itself. (Note: Even if the tunnel ventilation system is designed to emit tunnel-emissions via the shafts rather than via the portals as far as practicable, it is inevitable that a portion of the tunnel-emissions will emit via the portals.) The eastern portal will therefore become an additional point-source. As a preliminary appraisal, the highest 1-hour NO_2 at the Kau Liu/Tin Sam ASR will not be substantially lower than the 246 $\mu g/m^3$ highest figure for the aforesaid Sha Lo Wan ASR. In any case, both cases will be able to meet the AQO limit of 300 $\mu g/m^3$. At the western portal of Option C, the air quality

impact on the ASR at Sham Wat should not differ considerably to that of Option A on the ASR at San Shek Wan as the separation distances from the ASRs for the two options are not different largely, and both cases will be able to meet the AQO limit of 300 $\mu g/m^3$ as well.

(c) The ventilation shafts for Option C will cause air quality impacts to the Country Park and the Lantau hillside area, whereas Option A keeps away from the Country Park and the Lantau hillside completely.

(d) The alignment length of Option A from HKSAR boundary to the Scenic Hill is about 9.4km which is all in viaduct form, whilst the Option C is about 9.1km which include ~5.6km viaduct and ~3.5km tunnel. Thus, basically the total emissions from traffic of both options are more or less the same; except that the emissions from Option C will be concentrated at the ventilation shafts and the portals. Comparing the two options, Option C will require 24-hour lighting and ventilation for the daily operation of the tunnel and hence more energy consumption which will in turn increase the emission of greenhouse gases and air pollutants which is not conducive towards sustainable development; whereas the Option A viaduct (only slightly longer than Option C) will require only night-time road lightings. Hence, the total air pollutants of Option C will be greater than that of Option A.

(e) Overall speaking, there should not be major difference between the two options as regards operation air quality impact, but Option C will generate more greenhouse gases and air pollutants due to the tunnel.

4.1.2 Construction Air Quality Impact

(a) The bridgework for Option A will not involve operations generating substantial amount of dust, whereas the Option C tunnelling work will require extensive portal-cuttings and processing/crushing of rocks at the portal sites, generating construction air quality impact in the form of TSP.

(b) Option A, which does not generate significant TSP in this area, should perform better than Option C as regards construction air quality impact.

4.2 Noise

4.2.1 Operation Noise Impact — Similar to the case of 4.1.1, the performance of the two options should not differ substantially in this regard, because even though the Kau Liu/Tin Sam noise sensitive receiver (NSR) is farther away from Option C compared with the distance of the Sha Lo Wan NSR from Option A, the Option C vent-shafts and portals will in turn cause noise impacts to Kau Liu/Tin Sam, as well as within the Country Park and Lantau hillside. Option C is slightly better than Option A but the difference should not be substantial.

4.2.2 Construction Noise Impact — Similar to the case of 4.1.2, Option A should perform better in this regard as the bridgework does not involve extensive

percussion/rock-crushing work, whereas Option C does involve such activities as well as blasting. Option C also involves transportation of tunnel-excavation materials via conveyors/chutes from the tunnel-portals onto barges berthed near the Lantau shorelines at Sham Wat and San Tau, causing additional construction noise impact.

4.3 Water Quality

4.3.1 Operation Water Quality Impact — Though Option A will involve 13 no. pairs of columns in the water in the Airport Channel, the water quality impact assessment results show that there will not be any adverse water quality impact (even if more columns are assumed for conservatism). It is noted that Option C will involve less columns in the water in the Airport Channel, for the portion outside the eastern portal across the channel. From an overall point of view, Option C is better than Option A but the difference should not be significant.

4.3.2 Construction Water Quality Impact — Whilst Option A will involve the construction of more columns in the water, they are isolated in nature. Any occurrence of sediment loss from the marine piling works at each column site will be smaller in scale compared with the dredging works required under Option C as pointed out in 3.4(e); see also **Figure 10** showing the approximate extent of the dredging work. Such dredging works required under Option C are larger in scale, as a source of water quality impact, than the isolated columns/marine-piles under Option A. Furthermore, these dredging works as well as the construction site runoff from the large cutting works of the portal sites are located in the proximity of Sham Wat Bay and San Tau SSSI, both of which are ecologically important and sensitive (see Section 4.4 below). It is therefore considered that Option A does outperform Option C in terms of construction water quality impact.

4.4 Ecology

4.4.1 Operational Ecological Impact — As shown by water quality impact assessment results in the EIA Report, Option A will not cause any significant changes in water quality parameters (such as suspended solids and dissolved oxygen) in the Airport Channel. The water quality modelling results in the EIA Report also show that Option A will not cause any significant change to sedimentation rate in the Airport Channel. Moreover, Option A will not impinge upon the Lantau hillside at all. Hence there should be no significant impact on ecology under Option A, neither terrestrial ecology nor marine ecology. On the other hand, the eastern and western tunnel portals of Option C will impinge upon the natural Lantau hillside and shoreline, thus causing the following ecological impacts (see **Figures 6 to 8**):

(a) <u>Eastern Portal (near San Tau)</u>

- Loss of approximately 1,500m^2 woodland and destruction of approximately 400 nos. of trees. This woodland is also important for the butterflies in San Tau.

- At least three species of Protected Plant Species have been recorded in the eastern portal area. A rare plant Carex tristachya has also been recorded near the eastern portal.

- A rare bird species Emerald dove Chalcophaps indica had also been recorded near the eastern portal, which is considered vulnerable in China Red Data Book. The woodland to be impacted at eastern portal is their major habitat.

- The nearby San Tau Fung Shui Wood is an important habitat containing food plant species for butterflies.

(b) Western Portal (near Sham Wat)

- Loss of approximately 1.2 ha woodland and destruction of approximately 3,000 nos. of trees. (Woodland >1 ha is considered as important habitat under Note 2, Appendix A, Annex 6 of EIAO-TM.)

- The western portal is located about 500 m to the north of Sham Wat mudflat, which has been confirmed as one of the horseshoe crab nursery sites on North Lantau shore. The dredging works at the western portal may affect the Sham Wat intertidal mudflat and estuary. Furthermore, the horseshoe crabs nursery site would be impacted by Option C, with the workfront brought closer to Sham Wat Bay.

It is obvious that Option C will cause much greater operation ecological impact (as regards terrestrial and inter-tidal ecology) than Option A.

4.4.2 Construction Ecological Impact – The foregoing appraisal on ecological impact for operation phase is also relevant to that for the construction phase, except that Option C will cause more construction impact on marine ecology as well (besides terrestrial and inter-tidal ecology), due to the earthworks and dredging works required for the portal construction as noted in 3.4(d) & (e). In this regard, both construction site runoff and dredging locations will cause significant impacts on marine ecology, as the earthworks and dredging on eastern side will be close to the rare seagrass species at San Tau SSSI, whereas the earthworks and dredging on western side will be close to the entrance of the ecologically valuable Sham Wat Bay (mudflat thereat being the horseshoe crabs nursery site and habitat of mangroves & intertidal species).

4.5 Landscape & Visual

4.5.1 Operation Phase

(a) As assessed in the EIA Report, Option A with its viaduct structure in the Airport Channel will cause moderate impact on visual sensitive receivers

(VSRs) along the Airport Channel, notably the Sha Lo Wan village, with mitigation measures.

(b) For Option C, the tunnel portals will result in extensive cuttings at the scenic hillside as well as damages to the natural coastlines near San Tau and Sham Wat. The ventilation shaft within the Country Park may also be a visual intrusion on the naturalness of the Country Park. Even if large scale landscape measures are applied, extensive loss of naturalness of the hillside would be inevitable and visible. See attached **Figures 7 and 8** showing photomontages on the portals, as well as **Figure 10** showing photos on completed landscaped portals illustrating the above. Hence, even though Option C could obviate the visual impact noted in (a) above, its western portal will cause moderate visual impact to VSRs in the western waters whilst its eastern portal will cause moderate visual impact to VSRs at/around the eastern portion of the Airport Channel.

(c) In addition, the portal cuttings of Option C tunnel will inevitably damage ~1.3 ha woodland and require the felling of approximately 3,400 nos. of trees in total. The landscape resources (including woodland, shrubland and grassland) and the landscape character areas (including coastal upland, hillside landscape and the natural shoreline) around the tunnel portals will be affected.

(d) Overall speaking, Option C will not perform better than Option A from landscape & visual point of view at operation phase. In particular, it should be noted that Option C will cause damage to the natural hillside and shoreline, whereas Option A will not.

4.5.2 Construction Phase — As shown in the photos on **Figure 9**, the construction of land tunnels will require extensive site installations at portal areas. Also, the landscape impact described in 4.5.1 above applies to both operation phase and construction phase. The conclusion in (a) on operation phase is applicable to construction phase too.

4.6 Cultural Heritage

4.6.1 For both operation and construction phases, Option A will perform better than Option C as regards Cultural Heritages, as the former will not touch the Lantau area whereas the latter will affect the Tung O Ancient Trail (see attached **Figure 6**).

4.7 Waste Management

4.7.1 Operation Phase — No difference between the two options as regards waste management.

4.7.2 Construction Phase — Option A will perform better than Option C as regards waste management, as the latter will involve a tunnel which will generate

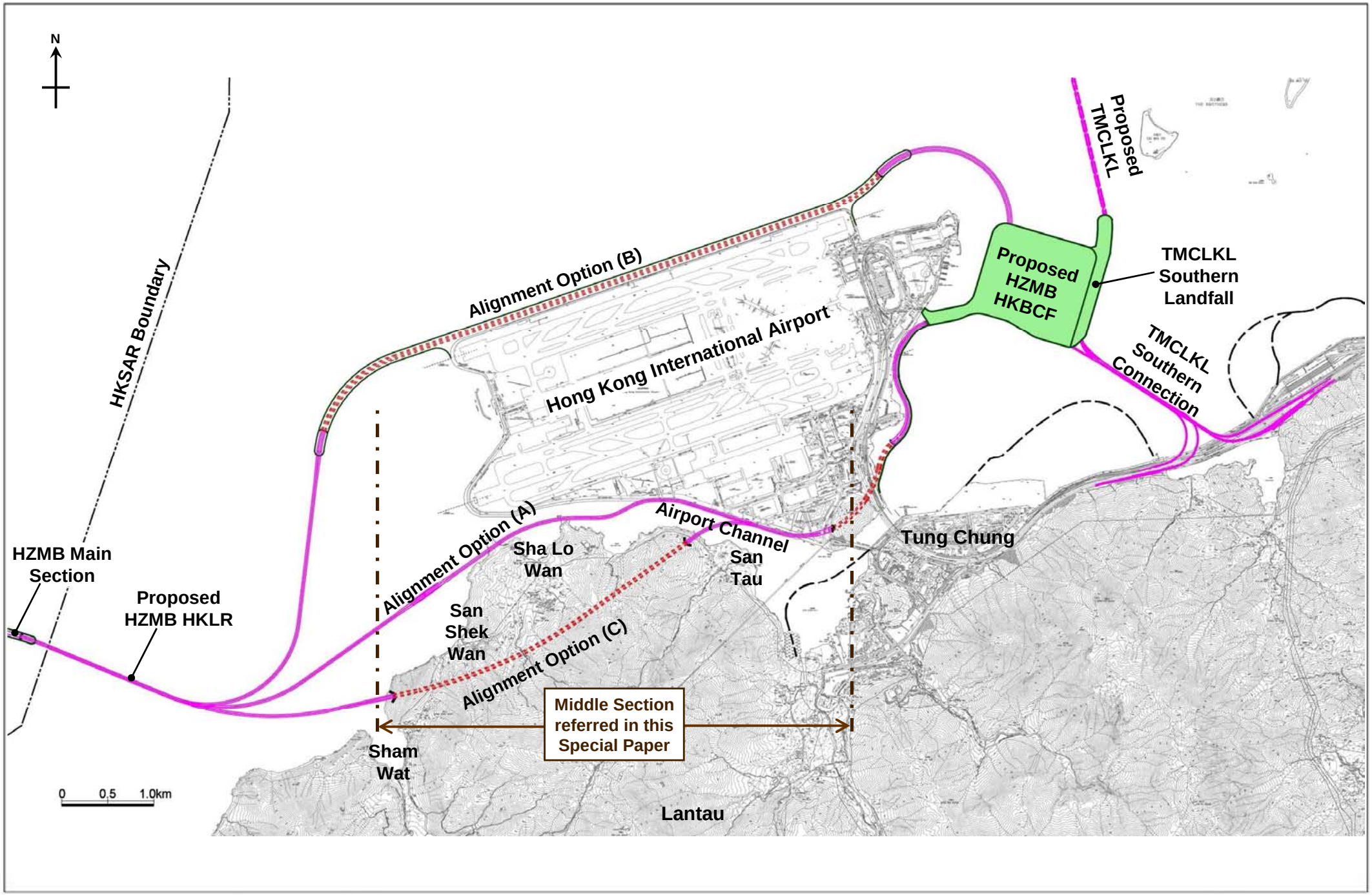
approximately 2Mm³ of waste materials. In addition, Option C will involve seabed dredging as well.

4.8 Conclusion

4.8.1 The comparison between Option A and Option C on various environmental aspects as explained in the foregoing section is recapitulated below:

Environmental Aspect		(✔ denotes the option with better performance)	
		Option A	Option C
Air	Operation	(No substantial difference but Option C will increase greenhouse gases emission due to the tunnel)	
	Construction	✔	
Noise	Operation		✔
	Construction	✔	
Water	Operation		✔
	Construction	✔	
Ecology	Operation	✔	
	Construction	✔	
Landscape & Visual	Operation	(No substantial difference)	
	Construction	(No substantial difference)	
Cultural Heritage	Operation	✔	
	Construction	✔	
Waste	Operation	–	
	Construction	✔	

4.8.2 In view of the above, it should be concluded that the overall performance of Option A is better than that of Option C from environmental points of view.



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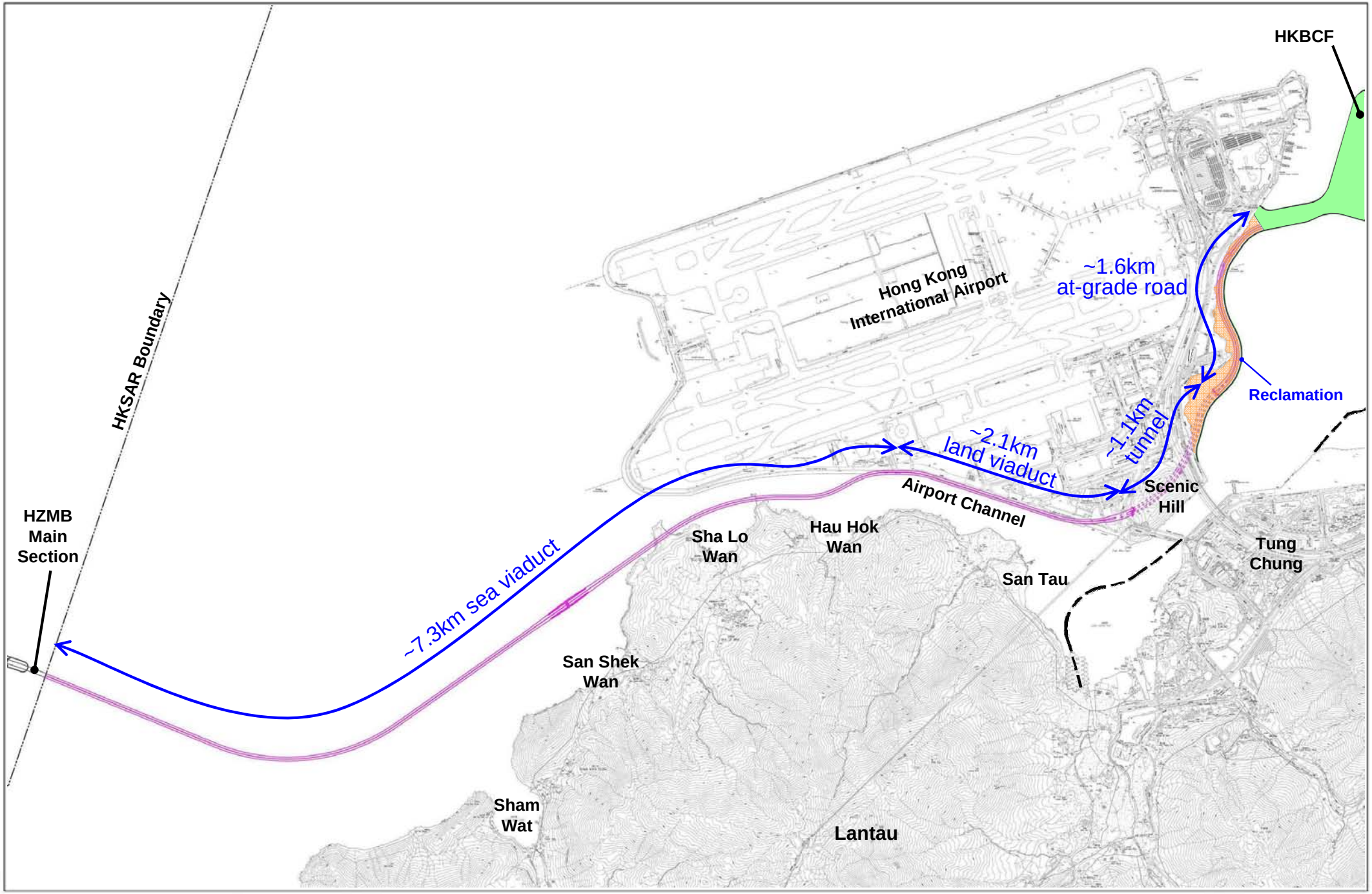
Drawing Title

HKLR Alignment Options

Annex C4-Figure 1



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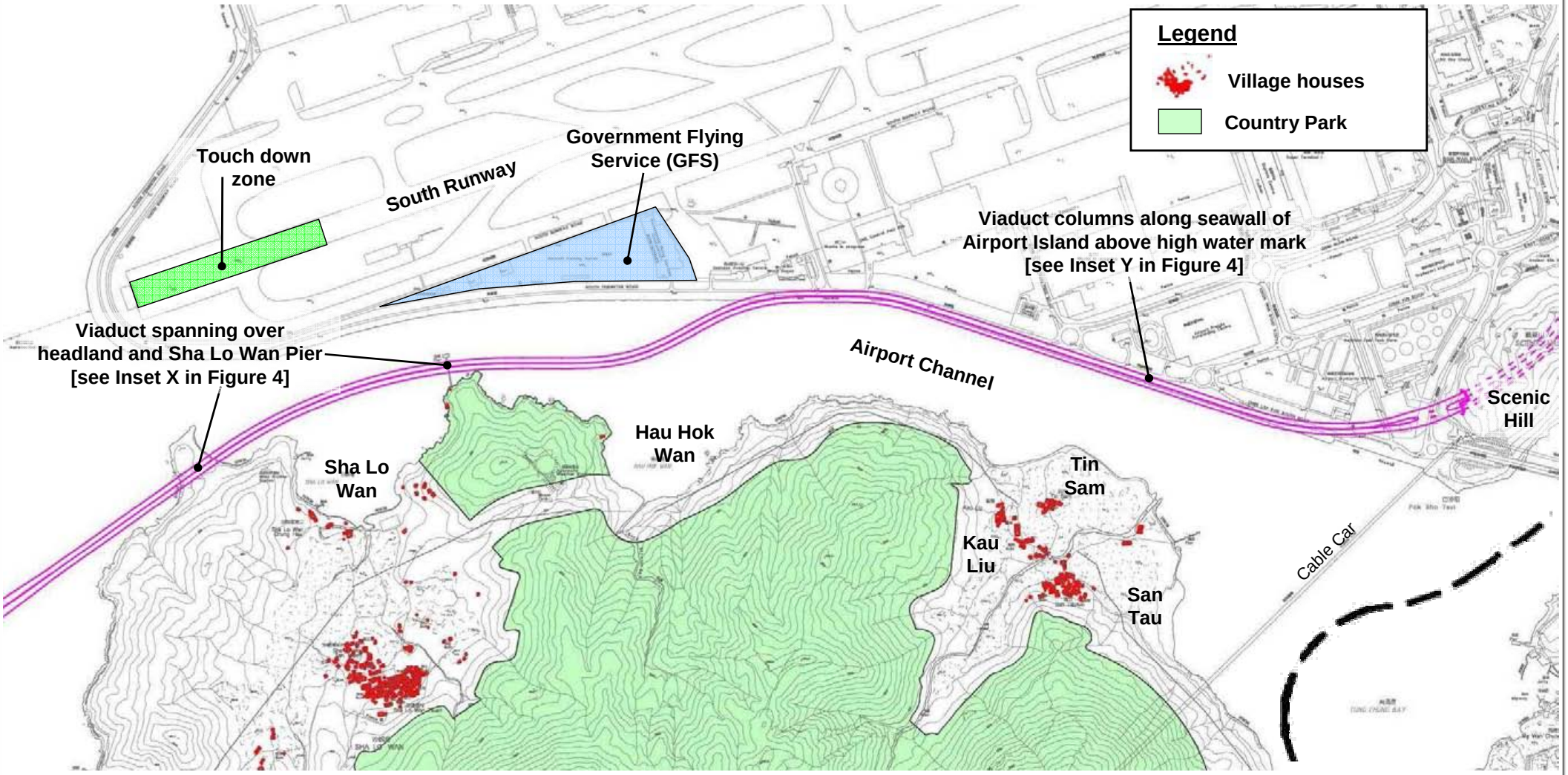
Alignment Option A – Overall Layout

Annex C4-Figure 2



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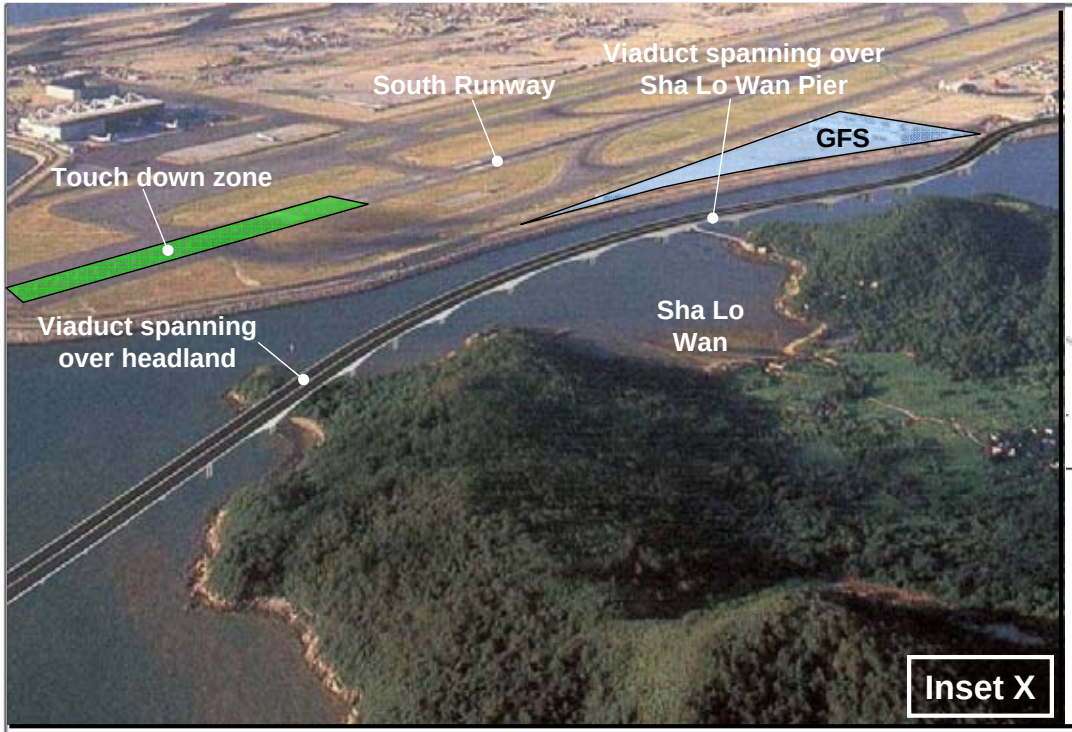
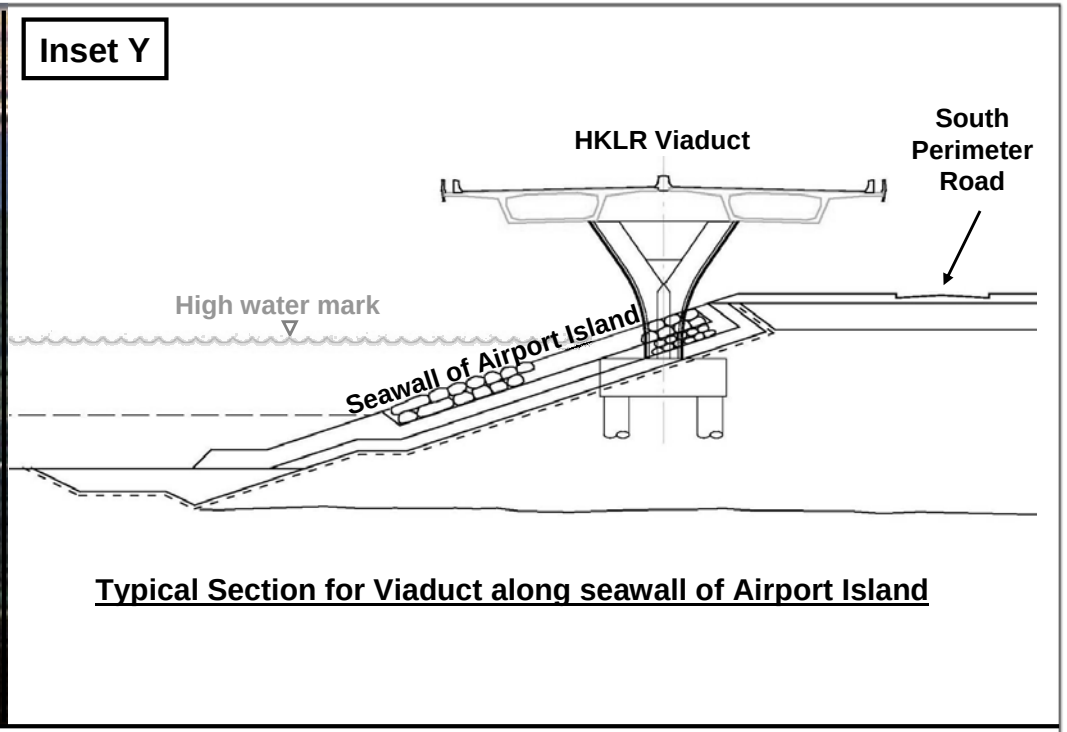
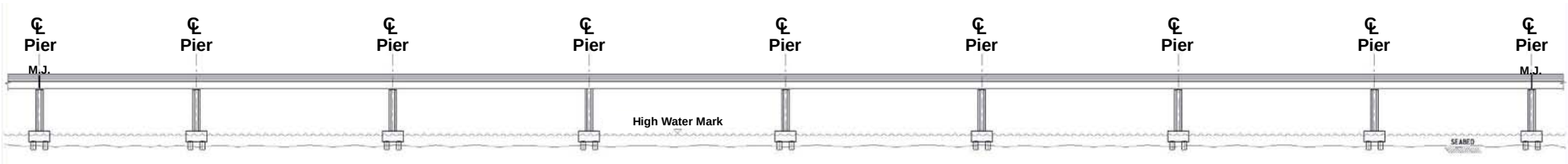
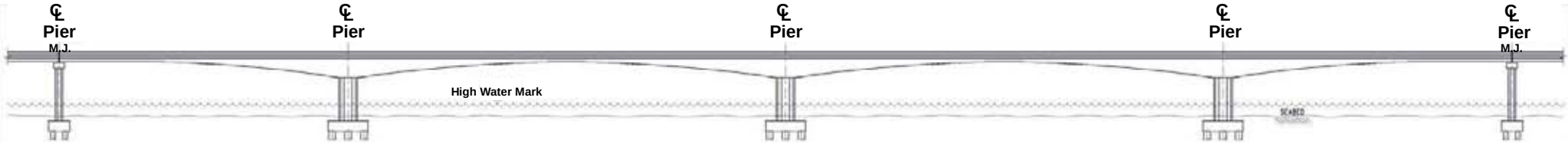




Typical Section for Viaduct along seawall of Airport Island



Typical Elevation for Viaducts with Spans up to ~75m without haunches



Typical Elevation for Viaducts with Larger Spans of ~100m to ~180m with haunches

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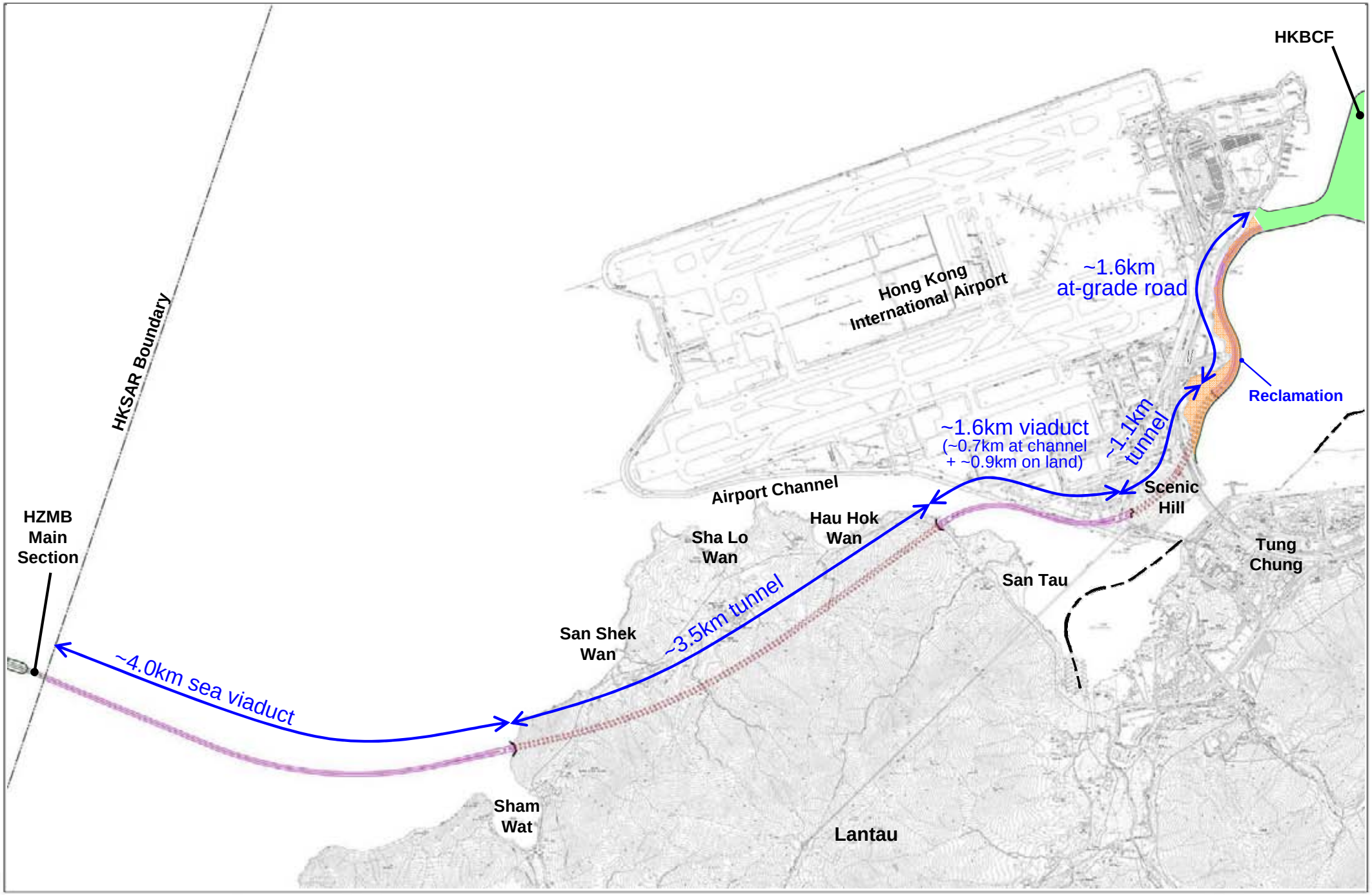

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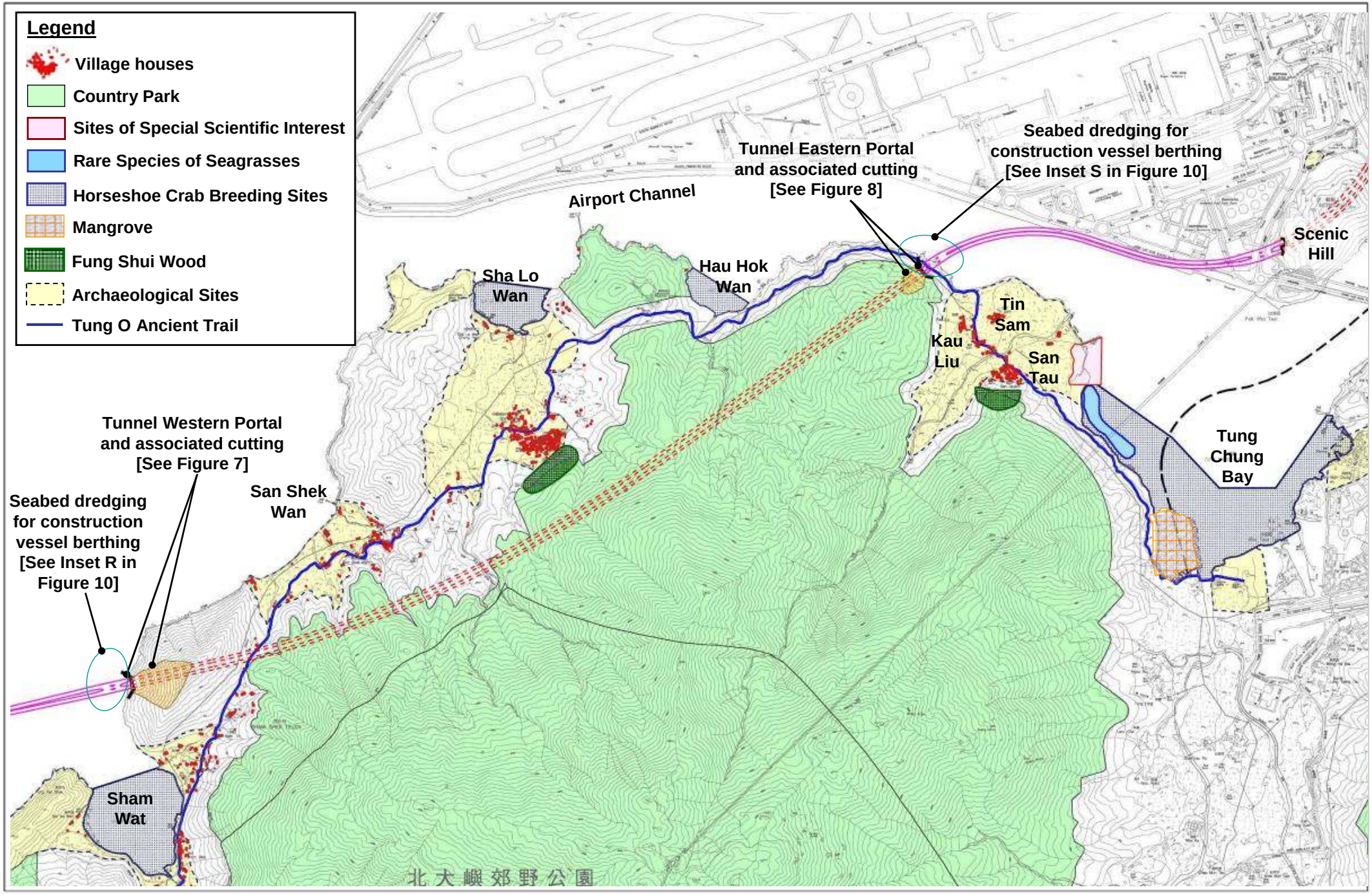

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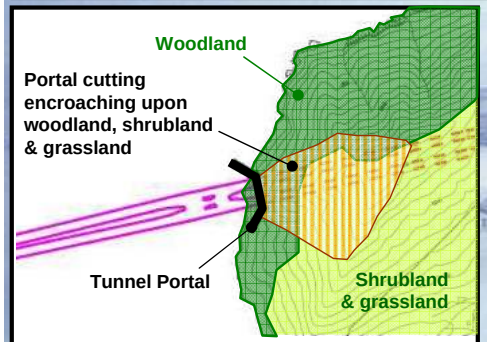
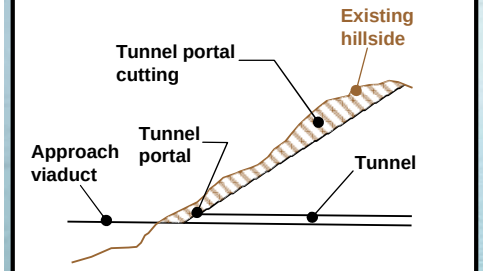
Alignment Option C – Details (Sheet 1)

Annex C4-Figure 6

Western Tunnel Portal near Sham Wat



Part Plan at Western Tunnel Portal



Section of Western Tunnel Portal

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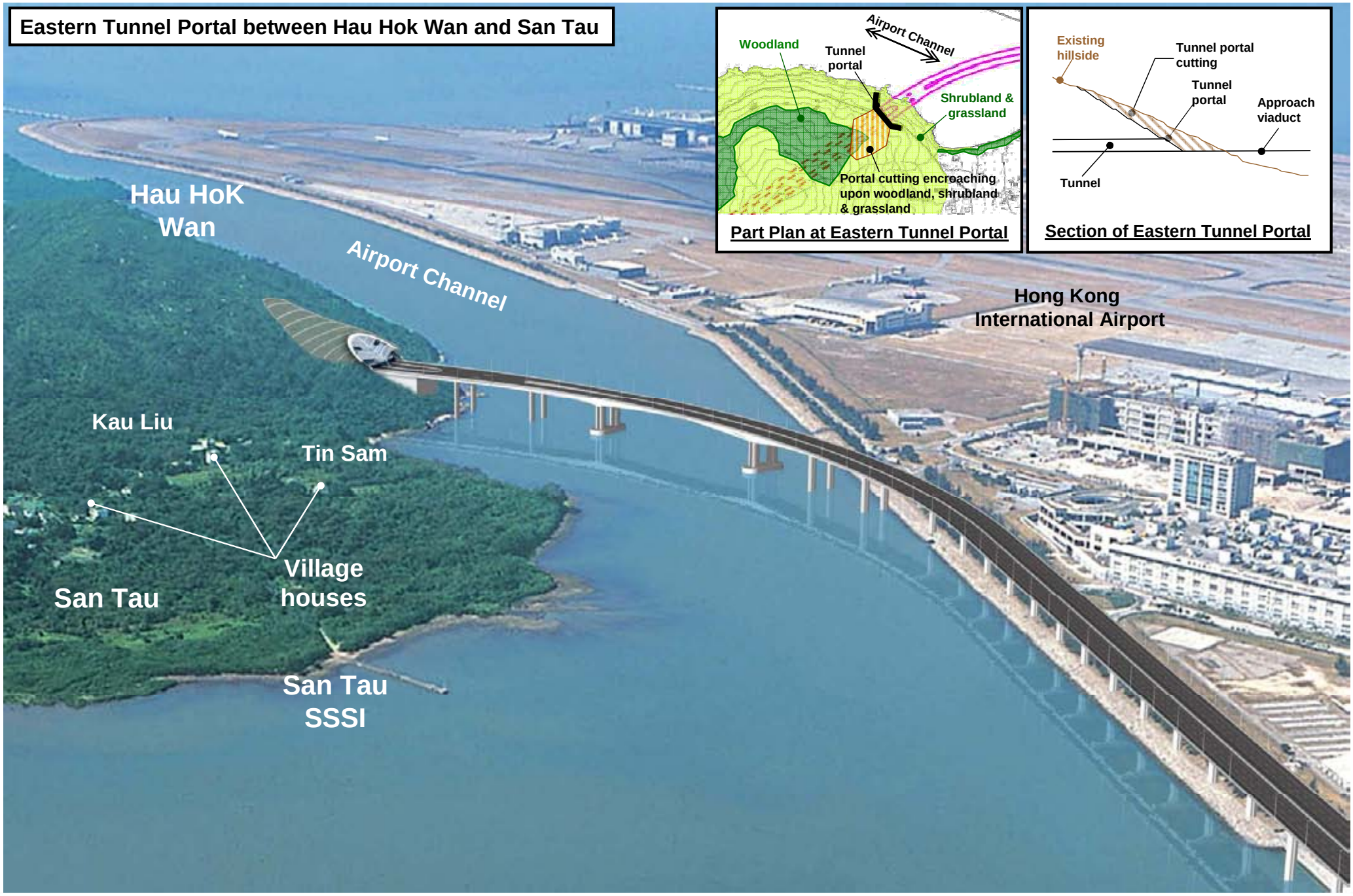

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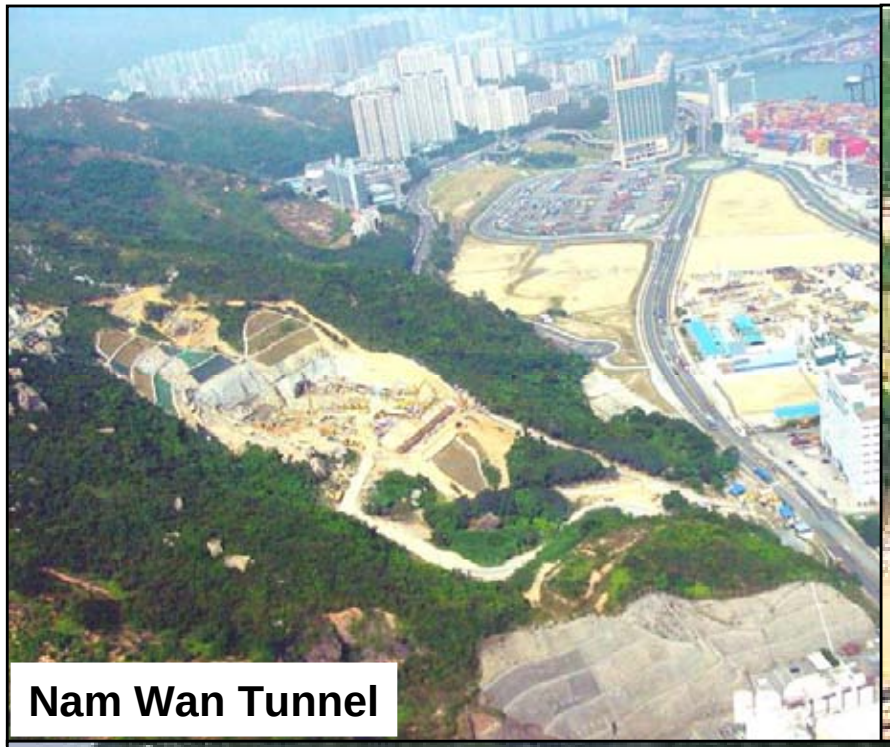
Alignment Option C – Details (Sheet 3)

Annex C4-Figure 8

Tunnel-portal Cuttings at Construction Stage – Photos of Previous Projects



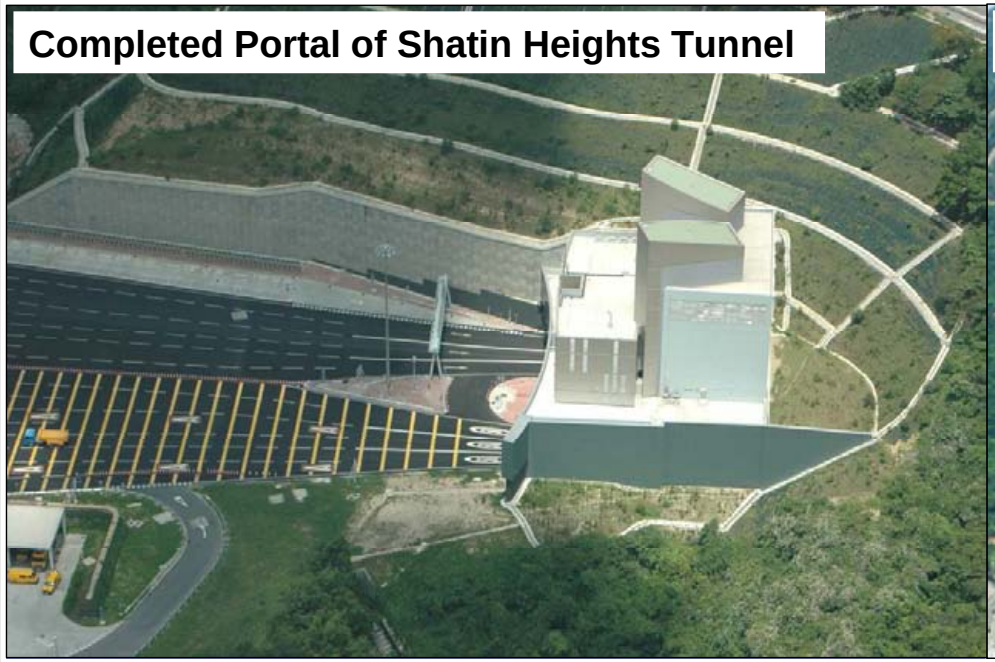
Nam Wan Tunnel

Tai Lam Tunnel

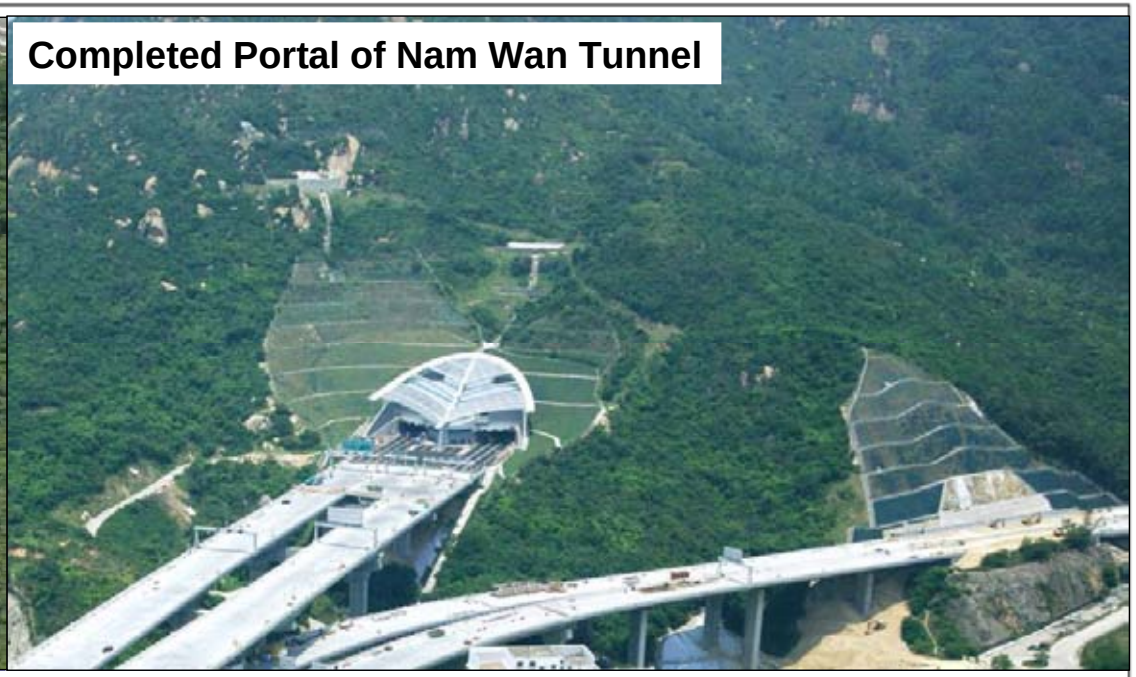
Eagle's Nest Tunnel

Shing Mun Tunnel

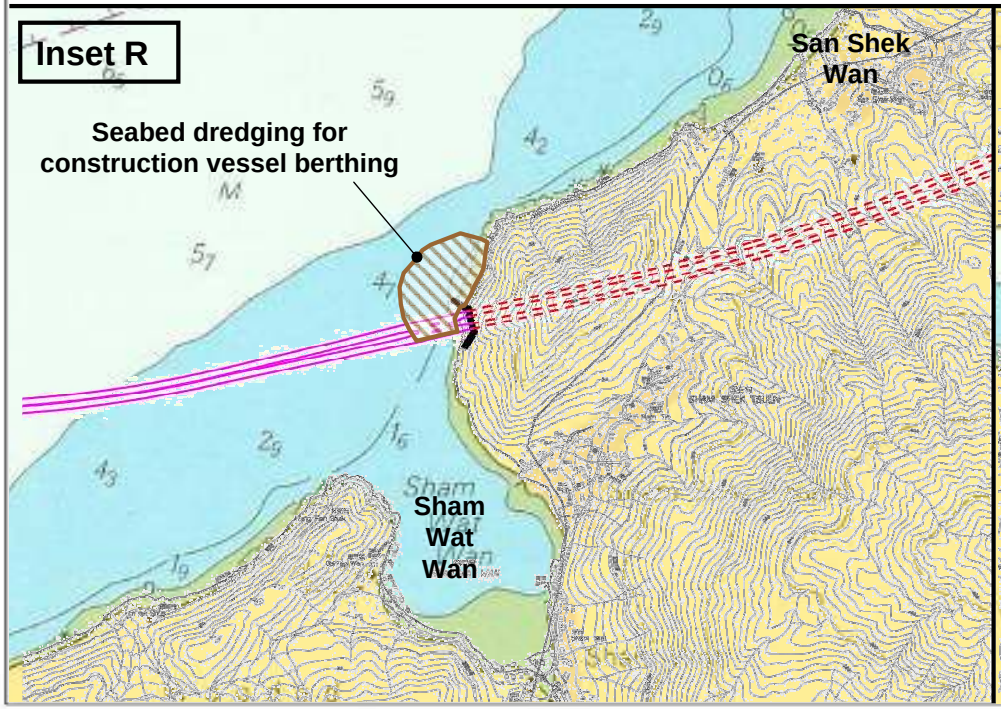
Completed Portal of Shatin Heights Tunnel



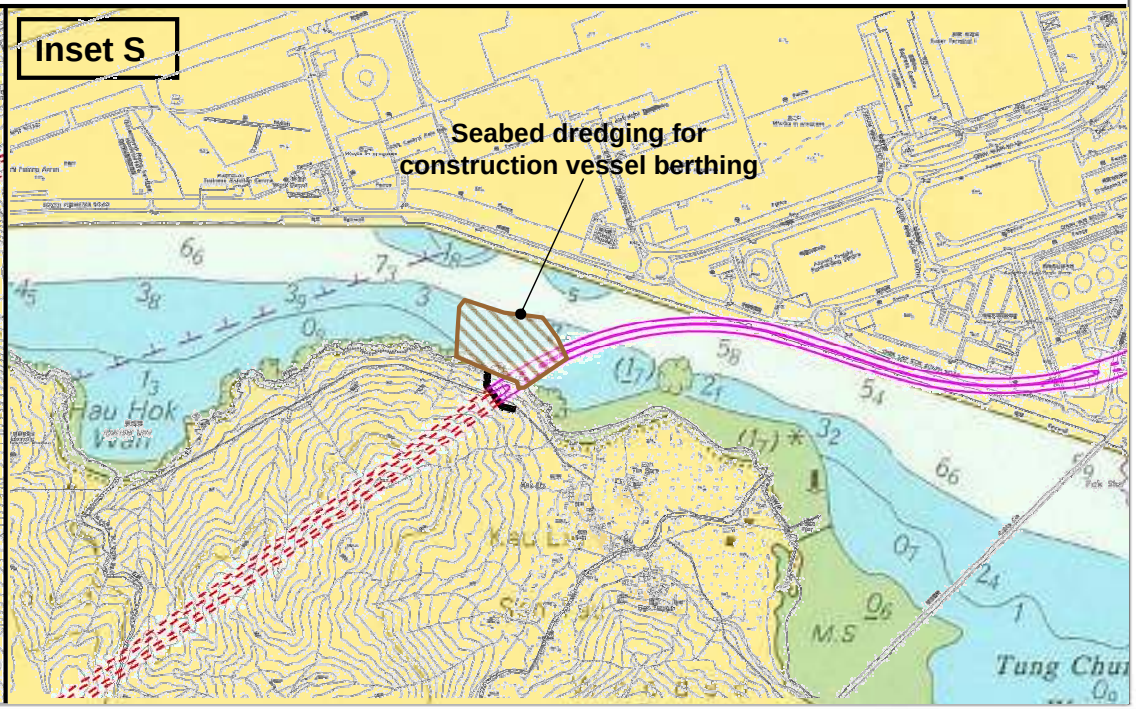
Completed Portal of Nam Wan Tunnel



Inset R



Inset S



路政署 HIGHWAYS DEPARTMENT 港珠澳大橋香港工程管理處 Hong Kong - Zhuhai - Macao Bridge Hong Kong Project Management Office	ARUP 奧雅納工程顧問 Ove Arup & Partners Hong Kong Limited	Drawing Title: Alignment Option C – Details (Sheet 5)	Annex C4-Figure 10