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For information

Findings of Trials and Studies Relating to the Harbour Area Treatment Scheme Stage 2

Purpose

This paper briefs Members on the key findings of the series of trials and studies undertaken to ascertain the feasibility of compact sewage treatment technologies and the four options proposed by the International Review Panel[1] (IRP) to implement the Harbour Area Treatment Scheme (HATS) Stage 2.

Background

2. On 25 May 2001, Finance Committee (FC) of the Legislative Council approved $73.6 million for the Administration to conduct the following trials and studies so as to ascertain the feasibility of the four IRP options -

(a) **Compact Sewage Treatment Technologies Trials (CSTTT)** to test the feasibility and effectiveness of compact treatment technologies, particularly the Biological Aerated Filter (BAF) technology, in treating local sewage;

(b) **Environmental and Engineering Feasibility Study (EEFS)** to verify the environmental and engineering feasibility of the IRP options for the development of HATS Stage 2; and

(c) **Study on Procurement Options (SPO)** to review possible contractual arrangements and develop a framework that would help expedite the delivery of the project and to identify the most appropriate means for operating the project.

3. In addition, we undertook to conduct the following two studies using our internal resources to assist in evaluating the way forward for HATS -

(d) **HATS Stage I flow assessment study** to assess performance of the Stage I system for future population and development projections under both dry and wet weather conditions; and

[1] The IRP comprised three local and three non-local experts. They were Prof Leonard K H Cheng, Prof Donald R F Harleman, Dr Albert Koenig, Prof Dd Eng Sebastiano Pelizza, Prof Qian Yi and Prof Rudolf S S Wu.

(e) **Capacity reassessment study for the Stonecutters Island Sewage Treatment Works** (SCISTW) to determine the maximum capacity of the Stage I Sedimentation Tanks at SCISTW and the effect of increased flow on the pollution removal efficiency.

4. In order to enhance the transparency of the study process, a HATS Monitoring Group comprising the three local members of the former IRP[2], four representatives nominated by the Advisory Council on the Environment[3] and three members of the public[4] was formed to oversee the progress. In February and December 2002, we presented two interim reports to Members concerning the progress of these trials and studies. In February 2003, we also invited Members to visit the SCISTW for an on-site briefing on the findings of the CSTTT. By now, all the trials and studies have been duly completed, except for part of the SPO which deals with the development of the contract, tendering and consultancy strategies as well as the associated management, administration and supervision structures for the selected procurement arrangement. This part of the SPO will only commence when the way forward has been decided in the light of the outcome of the public consultation exercise to be held between June and October 2004.

Findings of the trials and studies

Environmental and Engineering Feasibility Study (EEFS)

5. Camp Dresser & McKee International Inc. (CDM) was appointed in November 2001 to undertake the EEFS to verify the environmental and engineering feasibility of the IRP options for the development of HATS Stage 2. Under the scope of the EEFS, CDM has completed the following tasks -

(a) establishing a set of criteria, involving environmental, social, economic, engineering and land resources factors for option evaluation;
(b) conducting field surveys to establish the baseline ecological and hydrodynamic conditions in the harbour area;
(c) setting up a mathematical model to simulate and assess the water quality impacts of the options;
(d) conducting the ecological and human health risk assessment for the discharges;
(e) assessing the environmental and fisheries impacts of the discharges;
(f) identifying potential sites for the new sewage treatment works; and
(g) carrying out the schematic designs for HATS Stage 2.

6. The EEFS has confirmed that all the four options are environmentally

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[2] Prof Leonard Cheng, Dr Albert Koenig and Prof Rudolf S S Wu.
[3] Prof Peter Hills, Prof K C Ho, Dr Ng Cho-nam and Mrs Iris Tam
[4] Mr Chan Bing-woon, Mr Jimmy Kwok Chun-wah and Mrs Josephine Mak Chen Wen-ning

acceptable and technically feasible. In order to provide adequate protection to the harbour water quality in the long term, biological treatment would be required to remove additional organic pollutants and ammonia from the sewage before discharge. Moreover, disinfection would also be required to remove the *E.coli* bacteria in order to reopen the Tsuen Wan beaches. The study has also revealed that, as the Pearl River water has much higher nitrogen to phosphorus concentration, the Southern Hong Kong waters should be Phosphorus-limiting instead of Nitrogen-limiting. To reduce the excessive algal growth potential, the study has recommended the adoption of enhanced-phosphorus removal by increasing the ferric chloride dosage in the chemical treatment process to reduce the phosphorus level of the effluent. On the other hand, it appears that there is no immediate need to provide nitrogen removal in the biological treatment process.

7. Among the four options, which mainly differ in the scale of decentralization, Option A is the preferred option as it performs the best overall in terms of cost, environmental and engineering aspects. The Study has also concluded that, even if the most compact sewage treatment technology is used in the biological treatment process, all the options would require extra land of at least 12 hectares outside the current boundary of the SCISTW. An outline of the configurations of the four options and their cost implications as derived from the EEFS are given in Annex.

<u>Compact Sewage Treatment Technology Pilot Plant Trials (CSTTT)</u>

8. Drainage Services Department (DSD) awarded three trial contracts to three different technology providers in December 2001, with two employing different designs of the BAF technology and one employing the Submerged Aerated Filter (SAF) technology. DSD also appointed CMA Testing and Certification Laboratories, a laboratory accredited under the Hong Kong Laboratory Accreditation Scheme to analyze all samples collected in the trials, and Professor Howard Huang of the Hong Kong University of Science and Technology as the Independent Checker to audit the trial results.

9. The trials have demonstrated that the two BAF systems tested could perform well under local conditions and meet the prescribed standard. On the other hand, SAF could not perform up to the prescribed standard. The trials have also revealed that the satisfactory operation of the BAF systems would depend heavily on the reliability of the on-line instrumentation and control system[5] as well as the technical knowledge and experience of the operators on the respective designs of BAF

[5] BAF technologies are characterized by the requirement of daily backwashing and a very short hydraulic retention time in the biofilters (about 10-20 minutes in each filter). As such, the biological process in the biofilters is very dynamic, and therefore real time monitoring of the BAF performance and operation is of vital importance. This is different from the operation of a conventional activated sludge biological treatment system in which the biological process is usually operated under long sludge age (usually 5-10 days) and much longer hydraulic retention time (about 7 hours). This is because conventional activated sludge technology requires much more space, making the process able to operate under relatively long retention time. Hence, if there is a failure of any equipment or on-line instrumentation in particular, the activated sludge process can be operated manually. However, manual operation of the BAF system would be extremely difficult.

technology. Therefore, competent / skilled operators would be required to ensure the reliable and stable operation of the BAF plants, in particular, during the start-up of the biological treatment process and emergency incidents.

Study on Procurement Options (SPO)

10. The SPO aims to review possible contractual arrangements and develop a framework that would help expedite the delivery of the project, achieve best quality and value-for-money for the proposed works that meet the required standard, and ensure satisfactory control of risk. Maunsell Consultants Asia Ltd. (Maunsell) was appointed to undertake the SPO in March 2002. Having reviewed a wide range of possible procurement arrangements for HATS, Maunsell has identified four main possible procurement options, namely Design-Bid-Build (DBB), Design-Build (DB), Design-Build-Operate (DBO) and Build-Operate-Transfer (BOT).

11. For the sewage conveyance system, as the deep underground tunnels would not require much operation and maintenance upon completion, there is no need to include the "operation" element in the contract. The key criterion is how the construction risks for the sewage tunnels can be effectively managed by suitable mechanisms under the alternative procurement arrangements. Maunsell recommended a DB approach as it offers potential time advantage and provides a clearer contractual interface among the employer, engineer and contractor.

12. For the construction and upgrading of the sewage treatment works, Maunsell has suggested that, if the Government chooses to fund the sewage treatment project directly, then DBO would be the preferred procurement method. The DBO approach would maximize the potential benefits of combined project delivery by the private sector. Compared to DBB/DB, DBO would minimize interface problems, and has greater certainty in completion time, life-cycle costs and design success by utilizing innovative technology available in the wastewater treatment industry. However, if the Government would depart from the traditional funding mechanism for sewerage infrastructure and consider making use of private sector financing, then BOT could be a feasible option.

Stage 1 Flow Reassessment Study

13. This study was prompted by the need to address capacity issues associated with developments in East Kowloon. To determine the capacity constraints of the deep tunnels, a hydraulic model was set up to simulate the sewage flow patterns for the various planning projections provided by the Planning Department for years 2006, 2011, 2016 and "Year X", (i.e. the year when the projected full development scenario is reached. This envisages a population of 5.2 million in the HATS Stage 1 service area compared with 3.5 million in 2000). The results of the hydraulic model simulations indicate that the existing deep tunnels could handle all the sewage generated by the above projected ultimate population in the HATS Stage 1 catchment. There should be no overflows under dry weather conditions and the sewage overflow

to the Harbour due to heavy rainstorms would be very small compared to the volume of sewage handled.

Stonecutters Island Sewage Treatment Works Capacity Reassessment Study

14. As recommended by the IRP, this study is to determine the maximum capacity of the Stage 1 Sedimentation tanks at the SCISTW and the effect of increased flow on the pollution removal efficiency of the SCISTW. The trials have concluded that the maximum flow that could be handled by the sedimentation tanks would be in line with the maximum design flow. By adjusting the flow distribution configuration of the treatment works, the sedimentation tanks were able to handle 10% more flows, but at the expense of a slight deterioration in the effluent quality, which is acceptable.

Summary

15. The trials and studies relating to the planning of HATS Stage 2 are largely completed. The key study reports, including the executive summary and the final report of the EEFS, the Independent Checker's report on the CSTTT, the interim report of the SPO, the report of the Stage 1 flow reassessment and the report of the SCISTW capacity reassessment study have been uploaded to the website www.cleanharbour.gov.hk for public information.

Environment, Transport and Works Bureau
Environmental Protection Department
Drainage Services Department
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GLOSSARY OF TERMS

***Phosphorus-limiting* –** Plants or algae need both phosphorus and nitrogen as nutrients in a certain ratio. Phosphorus-limiting means that phosphorus is comparatively less abundant in the environment. Therefore, by removing phosphorus instead of the more abundant nitrogen, we can prevent excessive growth of plants and algae in waters.

***Nitrogen-limiting* –** Nitrogen-limiting means that nitrogen is comparatively less abundant in the environment. Therefore, by removing nitrogen instead of the more abundant phosphorus, we can prevent excessive growth of plants and algae in waters.

***Biological Aerated Filter (BAF)* –** BAF is an advanced compact biological sewage treatment technology. It has a well-proven record of application in many European countries which are in the cold temperate region. However, it has not been applied in warm areas like Hong Kong nor in handling saline sewage before.

***Submerged Aerated Filter (SAF)* –** SAF is also a compact biological sewage treatment technology recently developed and has been applied successfully in the cold temperate region but not in warmer areas. Like BAF, it has not been applied in handling saline sewage before.

***Design-Bid-Build (DBB) Contract* –** In a DBB contract, the employer would hire an engineer to carry out the detailed design against which the contractor would bid for the construction project.

***Design-Build (DB) Contract* –** In a DB contract, the employer would only provide the initial functional design (or for enhanced DB, preliminary design) against which the contractor will bid for the provision of design and construction services. In this arrangement, the contractor, instead of the engineer/employer, would have to carry out the detailed design.

***Design-Build-Operate (DBO) Contract* –** In a DBO contract, apart from the provision of design and construction services, the contractor would also be required to provide the operation / maintenance service for a certain period (say, 20 years) as required under the contract, while the ownership of the facilities would always rest with the employer.

***Build-Operate-Transfer (BOT) Contract* –** In a BOT contract, the contractor would have to undertake the design, construction, operation and maintenance work, as well as financing the capital investment. The contractor would then operate the plant for a number of years after which the plant will be handed back to the employer.

Annex

Comparison of the Four IRP Options

The four options proposed by the International Review Panel mainly differ by the degree of decentralization. They all involve the use of deep tunnels to convey the sewage, the provision of biological treatment and, if necessary, disinfection, in addition to the current chemical treatment process. The highly treated effluent would then be discharged into the Harbour through short outfall(s). The four options are as shown in the figure below –

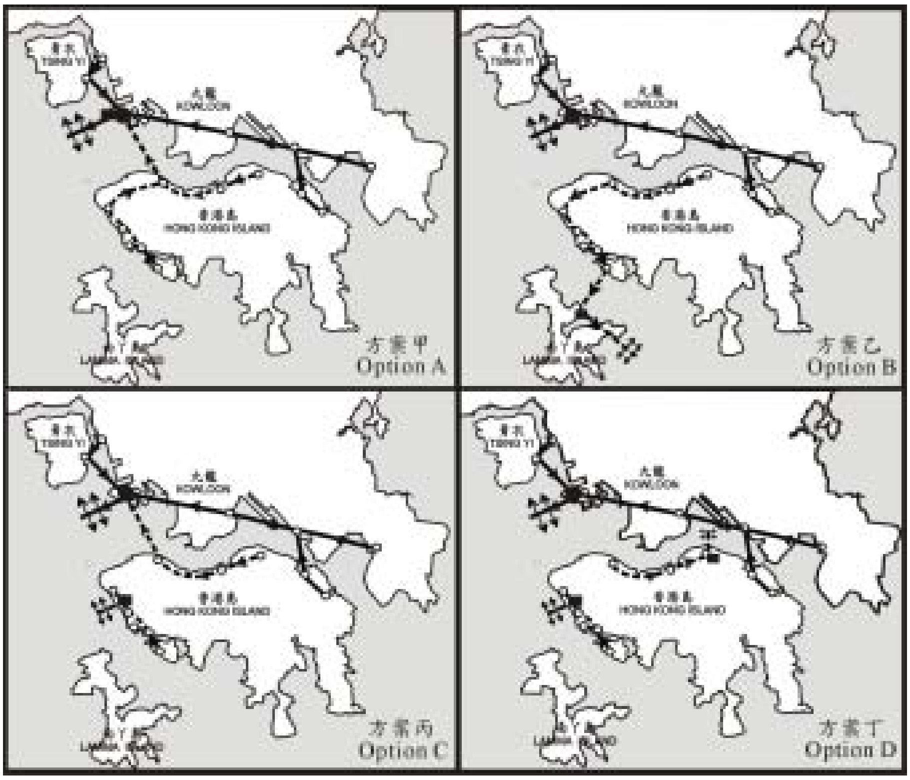

Figure 1 The Four IRP Options for HATS Stage 2

2. As far as sewage treatment works are concerned, Option A involves the expansion of the existing Stonecutters Island Sewage Treatment Works (SCISTW). Option B involves the expansion of the SCISTW and the construction of a new treatment works at the ex-quarry site at Lamma Island. Option C involves the expansion of the SCISTW and the construction of a new treatment works in a cavern to be excavated at Sandy Bay. Option D involves the expansion of the SCISTW and the construction of two new sewage treatment works in caverns to be excavated at Sandy Bay and Braemar Hill, North Point, respectively. The locations of the sewage treatment works sites for the four options identified in the EEFS are shown in Figure 2 and the cost comparisons are provided in Table 1.

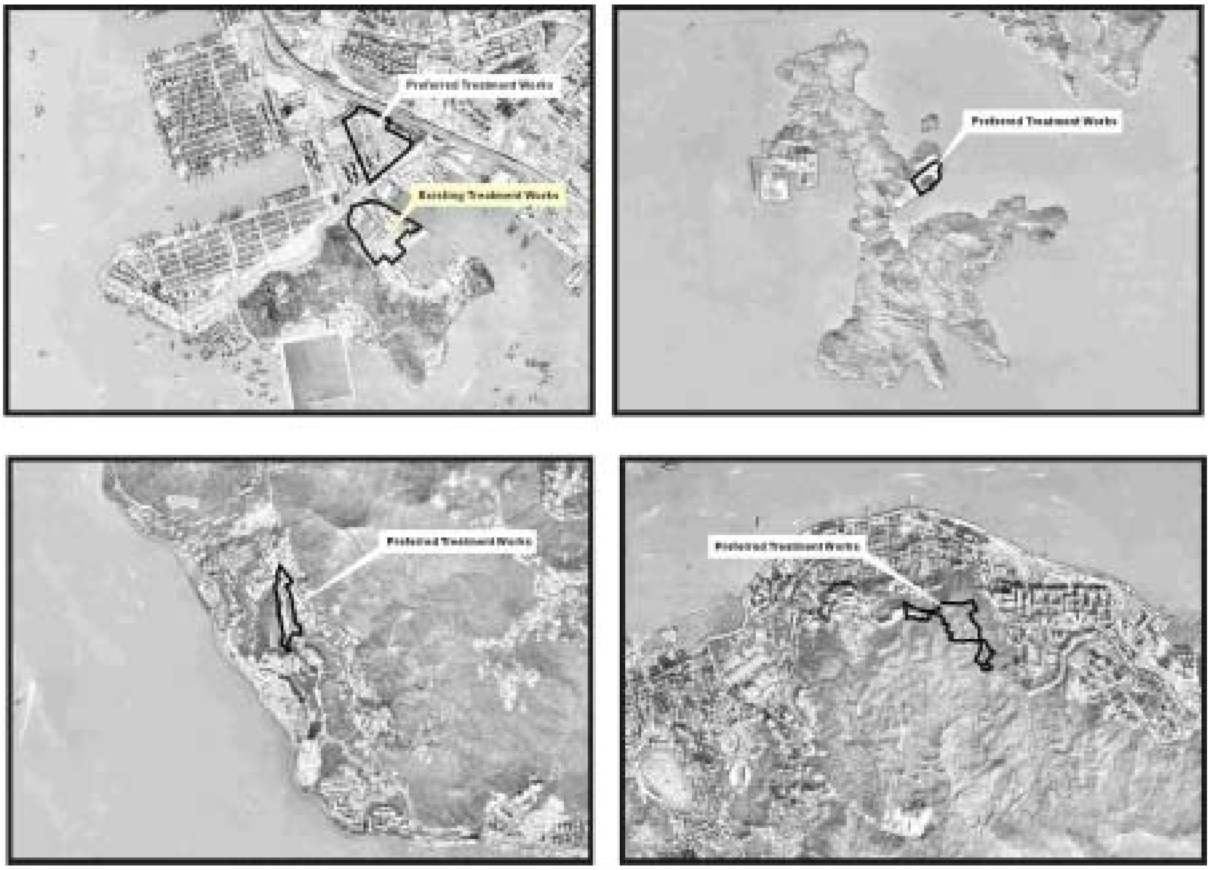

Figure 2 Treatment Works Site at Stonecutters Island, Lamma Island, Sandy Bay and North Point

Table 1 Cost Comparison of the Four IRP Options, Assuming the Provision of Biological Nutrient Removal and Disinfection

	Capital Cost[6] (HK$billion)	Recurrent Cost (HK$billion/year)
HATS Stage 1	8.2	0.32
HATS Stage 2[7]		
Option A	19.1	1.18
Option B	19.2	1.18
Option C	19.5	1.25
Option D	20.1	1.35

[6] The capital cost includes the upgrading of the preliminary treatment works, construction of tunnels and the sewage treatment works. However, this has not included the sludge incinerator which costs around $2.2 billion. The sludge incinerator will form part of the integrated waste treatment facilities to be considered in a separate exercise, as it will need to handle other sludge apart from those generated by HATS.

[7] These cost estimates assume all the steps of the biological treatment process will be provided. If denitrification, i.e. the removal of nitrogen, which is currently included as a step of the biological treatment process on the ground of following the precautionary principle is not to be provided eventually, the capital and annual recurrent cost estimates would be lowered by $1.9 billion and $0.27 billion respectively.

3. The four IRP Options have been evaluated against five main criteria. Viz. environmental, engineering, social, economic and land resources factors. Results of the detailed comparison of the four IRP Options are tabulated in Table 2 below -

Table 2 Performance Comparison of the Four IRP Options

Criteria		Ranking of the Four Options[8]			
		Option A	**Option B**	**Option C**	**Option D**
Environment and Public Health Criteria					
1	Water Quality - Harmful Algal Blooms	All Equal			
2	Marine Ecology	1	4	1	1
3	Fisheries	1	4	1	1
4	Public Health	All Equal			
5	Hazard to the Public	1	1	3	4
6	Air Quality	1	1	3	4
7	Noise	1	1	3	4
8	Terrestrial Ecology	1	1	3	4
9	Landscape and Visual	1	4	2	3
10	Waste Management Implications	2	1	3	4
Engineering / Technical					
11	HATS System Resiliency	4	2	3	1
12	Tunnel / Outfall Construction Risk	3	4	2	1
13	Sewage Treatment Works Construction Risk	1	2	3	4
14	Operational Risk	1	2	3	4
15	Ability to Cope with Change	1	2	3	4
Social					
16	Community Facilities Impact	All Equal			
17	Road Traffic	2	1	3	4
18	Marine Traffic	1	3	1	4
19	Potential Public Concern	1	2	2	4
20	Job Creation	All Equal			
Economics					
21	Total Lifecycle Cost	1	2	3	4
Land Resources / Statutory Land Procedures					
22	Surface Land Resource	1	4	1	1
23	Land Zoning	All Equal			
24	Land Status	1	2	3	4

[8] Ranking 1st performs the best while ranking 4th performs the worst.

4. Option A is the best among the four IRP options. The general comparison of the four options against the five key criteria are summarized below -

a) **Environmental Criteria** – As all the four options have adopted a very high level of treatment, their effects on water quality and public health are almost identical. Nevertheless, as Option B requires the construction of an outfall in the more sensitive southern waters, its impact on fisheries and marine ecology would be potentially higher than the other three options, in the event of mishaps during construction or operation. On the other hand, as Options C and D require the construction of sewage treatment works in caverns adjacent to the residential areas at Sandy Bay and Braemar Hill, these two options are inferior to the other two in terms of air, noise and terrestrial ecological impacts. On landscape and visual impacts, Option B is the worst because it requires surface land for construction of treatment works at the ex-Lamma Quarry whilst the others assume the construction of underground / cavern sewage treatment facilities.

b) **Engineering Criteria** – Option A is a centralized treatment system and therefore the inherent drawbacks would be the need for a more extensive tunnel system and a comparatively lower transfer system resiliency. Nevertheless, the substantially lower construction and operational risk as compared with treatment works in caverns and the higher flexibility to cater for any future upgrading of a centralized treatment system makes Option A more favourable than the other options in terms of engineering performance.

c) **Social Criteria** – As Options C and D require the construction of caverns next to residential areas, the associated traffic impacts would inevitably be higher than the other options. Moreover, as Option A only involves the construction of new treatment facilities adjacent to an existing sewage treatment works while the other options require construction of new treatment facilities on virgin land, it is expected that the potential impacts of Option A on public would be smaller.

d) **Economics –** Construction and operation of sewage treatment works in caverns would be expensive. As detailed in Table 1, the overall capital and recurrent costs of Option A are lower than the other options and therefore it compares favourably with the other options.

e) **Land Resources** –The feasible choice of minimizing surface land take under Option A by building the biological treatment facilities underground makes it the most favourable. As Option B requires surface land at ex-Lamma Quarry for the construction of sewage treatment facilities whilst the others assume construction of underground / cavern sewage treatment works, it is inferior to the other options. Separately, as the statutory land allocation exercise for each additional piece of land will take time, Options B, C & D would be less favourable than Option A.