transfer stations including KBTS would be required to handle more privately collected municipal solid waste and the deficit in the capacity of the existing KBTS would increase accordingly.

7.5.5.6 In view of the waste quantities predicted above and the factors discussed in Section 7.5.4, the proposed RTS will handle the municipal solid waste generated from the catchment of the existing KBTS and the waste arising from Sai Kung district after closure of SENT landfill. According to the estimation presented in **Tables 7.6 to 7.8** above, the required capacity of the new RTS would be in the range of 3000 tpd to 3700 tpd in year 2016 depends on the degree of achievement of the waste reduction targets.

7.5.6 T*raffic Impact*

7.5.6.1 As noted from the operation of the RTS, it will handle a total capacity of 3000 tonne per day, a peak generation of 600 veh/day has been assumed in the traffic model and distributed onto the adjacent traffic network.

7.5.6.2 In order to handle the significant volume of traffic generation from the RTS and a Public Filling Barging Point (PFBP) located immediate next to it, the improvement scheme is as described following:

(i) Hoi Bun Road should be widened and extended beyond Hoi Yuen Road to form a junction with Wing Yip Street.

(ii) Reversion of How Ming Street from one-way westbound to one-way eastbound, and provision of a two-way connection to Hoi Yuen Road.

(iii) Extension of Hoi Bun Road to Wing Yip Street to provide an access road to the future PFBP (with maximum trip generation scenario of 2400 veh/day) and Refuse Transfer Station (peak generation of 600 veh/day) located between Wing Yip Street and Hoi Yuen Road.

7.5.6.3 The additional traffic volume from the RTS and PFBP that distributed onto the adjacent junction has been assessed and the results indicated that they would operate satisfactorily in all design years. Hence, the result of the capacity assessment indicates that there should be no insurmountable traffic problem associated with the RTS and PFBP.

7.5.7 *Implementation Programme*

7.5.7.1 For the preliminary programme prepared at this stage, it is note that the new RTS site will not be formed until year 2009 and construction work could only be commenced after that. In view of the substantial civil, structural and E&M works required, it is expected that commissioning of the facility will be in around year 2012. It is important that the development programme of the RTS should tie in with the major framework of solid waster management to ensure un-interrupted service to the community.

7.6 Application of Automated Refuse Collection System (ARCS) in SEKD

7.6.1 *Introduction*

Background of the Study

7.6.1.1 This section outlines the potential application of ARCS in the South East Kowloon Development, mainly for the residential development in both public and private sectors. This section concentrates on the disposal of domestic waste from the residential development. The application to commercial area will be similar to the residential. However, there will be no

coverage of construction and industrial waste, which in fact will be quite limited in the South East Kowloon Development anyway.

7.6.1.2 There will be a number of benefits in the application of Automated Refuse Collection System within the South East Kowloon Development. However, there will be a number of issues, technical as well as institutional, that have to be examined closely before a wider application of the system can be proposed. This section will discuss these issues for the Automated Refuse Collection System to allow the proposal can be brought forward, if necessary, subsequently.

7.6.2 The Related Guidelines

Guidelines

General Waste Management, Reception and Transfer Facilities

7.6.2.1 *Hong Kong Planning Standards and Guidelines (HKPSG) – Chapter 9 Environment* lists out the policy objectives of waste management and the standards and guidelines for waste reception and transfer facilities including public dump and barge loading areas.

7.6.2.2 A Refuse Collection Point (RCP) is required to serve the needs of each population of 20,000 persons or areas within a distance of 500 metres. In industrial and commercial areas, or in areas where adequate private facilities are or will be available, this level of provision may need to be adjusted to suit anticipated needs. Director of Food and Environmental Hygiene Department should be consulted on detailed requirements.

7.6.2.3 RCPs should be sited so as to minimise disruption to traffic or the creation of traffic safety hazards. RCPs should therefore not be located on trunk or primary distributor roads, on steep roads, or locations where turning trucks may create traffic problems.

7.6.2.4 Due to the difficulties in finding suitable sites for RCPs especially in the built-up areas, RCPs should be incorporated in large-scale developments and redevelopments of both public and private sectors, wherever possible. To reduce the need for waste handling and minimise potential nuisance problems, appropriate waste collection and handling facilities should be included in these large-scale developments and redevelopments in future.

7.6.2.5 Waste reception and transfer facilities should be sited so that any adjacent development is very well buffered. For facilities handling the reception and disposal of dusty or odoriferous wastes, special precautions should be taken to avoid nuisance to surrounding areas. Note should be taken of prevailing wind direction and subsequent potential for nuisance.

7.6.2.6 In South East Kowloon Development, provision has been made accordingly to the HKPSG requirement. At this stage, it is proposed to maintain these Refuse Collection Points, firstly due to some uncertainty on the implementation of ARCS and secondly to provide location for collection of bulky items. Should the ARCS be more commonly applied in the South East Kowloon Development, the provision of RCP to HKPSG's requirement may be subject to a further review.

Design Guidelines by Hong Kong Housing Authority

7.6.2.7 In addition, the Hong Kong Housing Authority has produced a Design Guide, *Automated Refuse Collection System (ARCS) Planning Guidelines.* These guidelines include recommendations for the scale of developments for which ARCS should be provided, and the limitations for the system. These include the requirements, such as:

- The system must not serve commercial centres or public works buildings;

- Junk collection points to be provided in accordance with the *Guidelines for Refuse Collection in Public Housing Estates*; and
- Outdoor refuse inlets to be provided in the vicinity of every two buildings.

7.6.3 *Details of Automated Refuse Collection System*

Previous Cases of Application

7.6.3.1 Automated Refuse Collection Systems (ARCSs) have been quite common overseas. They have been implemented in Europe, North America and Japan for more than 20 years. The application is not only confined to residential development but has also been applied in hospitals (for which stringent requirements will be imposed on the disposal treatment), offices and hotels.

7.6.3.2 In Europe, the system has been used extensively, in particular in Sweden, where recycling is a priority. However, Swedish (and European) population centres are generally made up of predominantly low-rise buildings. The waste collection and with recycling techniques would not so applicable to the high-rise environment in Hong Kong.

7.6.3.3 In Asia, Japan, in particular, has adopted widespread ARCS applications with quite advanced technology. As Japan is similar to Hong Kong in terms of residential density with a predominance of high-rise buildings, this has provided the most relevant overseas experience for Hong Kong. Other Asian countries, such as Singapore and Taiwan, have also been developing ARCS in the past five to ten years.

7.6.3.4 In Japan, the use of ARCS has been applied on a variety of development scales, even up to a small township with a built up area of 200 hectares. Pipeline diameters ranging from 300mm to 600mm has been adopted for this latter project. In view of the large catchment area and the length of the ARCS pipe routing, additional substation was installed en-route.

7.6.3.5 There are, however, some differences between the Japanese experience and the proposals for SEKD. This affects direct comparisons with and application of the Japanese experience. In Japan, there have been cases where a large site is developed and managed by a single party. As such, the issues relating to funding and operation arrangements could be resolved more easily.

7.6.3.6 Also, although Japan has adopted recycling methods in their ARCS applications, the recycling in Japan is concentrated more on separating combustible and incombustible materials to facilitate the use of the incinerator rather than on re-using waste materials. In Hong Kong the recycling efforts have focused on separating paper waste, aluminium cans and PET bottles (the typical 3 coloured bins in public areas) from general waste. Hence, this would require a different approach to recycling management/methods.

7.6.3.7 To date, there are limited numbers of ARCS applications in operation in Hong Kong. The ARCS was first implemented in Hong Kong in the headquarter building of the Hong Kong and Shanghai Banking Corporation in Central, in 1986. The Housing Authority (HA) first introduced pilot ARCS installations to housing estates in 1995. Apart from initial teething problems, all applications have proved satisfactory.

Comparison with Traditional Waste Collection Methods

7.6.3.8 Traditionally refuse is disposed of and stored temporarily in refuse rooms within buildings. The waste would normally be collected by private waste collectors, then transported to a refuse transfer station / shed for compaction and containerization, and finally disposed of to a landfill site. This inevitably results in odour and hygiene nuisances.

7.6.3.9 Whilst the initial capital costs involved in adopting the ARCS method instead of the conventional waste storage and collection methods may be considerable, ARCS has major environmental benefits. Examples of the advantages of ARCS are to be seen in the following areas:

- Reduced odours, hygiene, and hazards;
- Reduced visual intrusion of waste bins and refuse bags;
- Reduced traffic volume of refuse collection trucks if the system can be applied on a more global basis; and
- Reduced local noise and air pollution in the collecting and disposal process.

7.6.3.10 However, it should be noted that ARCS is not capable of handling bulky items such as discarded furniture. Provision of space for disposal of large items must still be allowed for in residential areas.

7.6.3.11 A comparison of the ARCS and the conventional manual collection method is given in the **Table 7.9** as follows:

Table 7.9 ARCS versus Conventional Waste Collection Methods

Issues	Automated Refuse Collection System	Conventional Waste Collection Methods
Installation Costs	Significant installation cost with a costing of about HK$ 6,000 per flat for public housing; cost for private housing could be even greater, depending on the layout and configuration of buildings.	Practically nil; apart from nominal provision of refuse chute and collection point.
Operations & Maintenance Costs: i) Staff costs; and ii) Energy costs.	i) Technical staff required; and ii) Additional energy & maintenance costs for plant.	Manual labourers required for collection. Currently, labour cost is not much higher than that for an ARCS system, as there is a strong cost competition for refuse collection.
Land Issues	Land required for central RCS and easement for pipe routing (when passing through private land) required.	Area set aside for refuse collection with vehicular access (normally making use of emergency vehicular access) required at each collection point.
Risks of breakdown	Apart from teething problems in the initial period, the 2 ARCS pilot schemes in Hong Kong work reasonably well. In the event of breakdown, contingency plans are available, according to the system configuration.	No real risk.
Possibilities for Recycling	Whilst options are available for recycling, the success will depend on the public education to help sort materials at source.	Current recycling conducted at source by cleansing contractors.
Environmental issues: • Odours; • Volume of waste; and • Road traffic.	More environmentally friendly. • Odours removed; • Waste compacted, greatly reducing overall volume; and • Vehicles only visit RCS.	No environmental benefits. • No provision for odour control; • Waste remains uncompacted; and • Vehicles visit collection points of buildings daily.
Phased construction	Forward planning required.	Nothing particular
Flexibility	Not feasible unless planned for initially.	Nothing particular
Junk collection points	Junk collection points still required, but collection is by demand only.	Junk collection points to be separate from general refuse; collection by demand.

7.6.3.12 In the long term, if the land is available with proper planning from the onset, environmental issues and operation costs suggest that the use of ARCS is preferable.

Basic Principles of ARCS

7.6.3.13 The system collects and handles refuse in a totally concealed manner. Residents/users deliver waste to disposal inlets in designated areas (on each floor of high-rise buildings, and in strategically positioned points outside buildings). Refuse may be temporarily stored in the storage unit, after which the refuse is automatically sucked by vacuum at a pressure of up to 0.6 bar and transported through underground ducting to a central collection station/unit. The air vacuum which delivers waste from the temporary storage units permits transport of up to $0.8m^3$ of refuse per sequence. At the central collection station / unit, refuse is automatically separated from the air stream, compacted into containers and loaded onto trucks, without ever being handled by human hands. ARCS takes the waste to the trucks, rather than bringing the trucks to the source of the waste.

Alternate Vacuum Truck System

7.6.3.14 For less densely built areas and for low-rise buildings, the vacuum truck system is the best solution.

7.6.3.15 In this case, the refuse rooms in the building are equipped with closed tanks, interconnected by a system of pipes which leads to docking points. These are located such that the vacuum truck which empties the tanks by suction has no need to circulate among the buildings. The refuse chutes in the buildings operate as usual, and can be combined with disposal inlets in the external open space. The vacuum truck system is easily adapted for possible recycling.

7.6.3.16 In general, this will cater for a smaller scale of development and will have the disadvantage of the collection/suction process carried out in a non-concealed manner. With the general high density development in Hong Kong, this system, which is more applicable in western countries with low density may not be so suitable in Hong Kong.

7.6.3.17 This method has been applied to low density development in other countries. Apparently, this may not be so applicable in Hong Kong due to difference of development density.

Common Components of ARCS

7.6.3.18 A number of ARCS suppliers/contractors who have been on the approved list for provisioning ARCS to the Housing Authority have been contacted, with discussions held. It has been observed that the systems do not differ significantly among different suppliers.

7.6.3.19 **Drawing No. 22936/AR/001** illustrates the major components of this pneumatic refuse transportation system. The main components will be described briefly as follows:

Refuse Inlets

7.6.3.20 Refuse inlets are of bucket type to prevent excessively large objects entering the system. In accordance with *Building (Refuse Storage and Materials Recovery Chambers and Refuse Chutes) Regulation*, the mouth of the hopper shall have a clear opening having dimensions of not less than 250 x 150mm and not more than 350 x 250mm. The mouth remains completely open or completely closed, and will not open of its own accord. When closed, dust and fumes are to be prevented from escaping. These inlets are the same whether for conventional methods or ARCS. It has to be recognised that some residents have certain reluctance to deposit the refuse into the chute themselves, particularly if there is a bin available nearby.

7.6.3.21 Red, amber and green LED lights will indicate availability of the inlet for refuse disposal. These lights can be used at a later date as part of recycling schemes. The inlet will be locked, electro-magnetically or otherwise, when the discharge valve is opened.

7.6.3.22 Indoor refuse disposal inlets are provided on each floor of residential buildings. In addition, outdoor refuse inlets in the vicinity of buildings and non-residential areas can be provided externally if there is a need. These outdoor inlets may not to be in prominent locations, and are to be away from entrances, commercial centres, or gathering places such as play areas to avoid abuse of the inlets.

Refuse Gravity Chutes

7.6.3.23 Gravity refuse chutes shall comply with the *Building (Refuse Storage and Materials Recovery Chambers and Refuse Chutes) Regulation*. Chutes shall be vertical with no bends (except at the bottom if necessary), and shall be smooth internally, lined with glazed wire or impervious tubes. Chutes are to have an internal diameter of 450mm or greater. Chute walls are to be brick or concrete, at least 100mm thick. The chute should be lined acoustically to reduce any noise for any materials travelling inside the chute.

7.6.3.24 Access for inspection and cleansing of the chutes is provided through hopper doors. The doors are equipped with key switches to signal to the system and are electrically operated by solenoid locks on each floor.

7.6.3.25 Air extraction facilities are provided at the top of all refuse chutes. To reduce possible odour, a set of roof extraction and activated cabin filter will be installed at the ventilation vent of the refuse chute at roof.

7.6.3.26 A negative air pressure can also help to maintain inside the refuse chutes to prevent odours escaping through disposal and air inlets.

Temporary Refuse Storage

7.6.3.27 At the bottom of gravity refuse chutes at the ground floor (or even underground if there is a need in planing) of each building, temporary refuse storage and discharge facilities are provided. Refuse is automatically sucked from refuse storage facilities in turns, as the delivery system cannot deliver waste from all buildings simultaneously. Apart from allowance for temporary storage of refuse (of up to one hour) while the system awaits the time slot for each particular building, these temporary storage units are also sized to allow for non-operating hours of the ARCS (from, say, 11p.m. to 7a.m. next day).

7.6.3.28 Temporary storage units are equipped with material dampers, level detectors and control modules. Sensors will be provided to indicate the amount of the materials stored in the temporary storage units.

Refuse Delivery Device

7.6.3.29 Refuse transportation pipes/ductworks (refuse conveyance pipes), which are laid underground, deliver waste from the temporary storage units to the refuse collection centre. The refuse is conveyed by means of an air vacuum, driven by exhaust fan to achieve transport velocities of up to 30m/s or 108km/hour inside the refuse conveyance pipes. Suction will be by air required at a rate of up to 500m^3/min.

7.6.3.30 To cater for a 25 – 50 years design life for the pipeworks, the mild steel pipes will be coated with bitumen for better corrosion protection. In the newly reclaimed area of South East Kowloon Development, the jointing included spacing and details has to allow for possible settlement. The pipework will be strong enough to cope with the suction pressure. Typical pipe thickness will be about 15 – 20mm, which may be increased to 25 – 50mm at bends location.

7.6.3.31 Buried pipes should have a sufficient cover, say minimum of 800mm cover under roads, 600mm cover elsewhere. There should be at least 100mm clearance between refuse conveyance pipes and other utilities. In exceptional circumstances, the refuse pipes may be exposed above ground. The pipes can be aligned at a maximum gradient of 20° uphill (and a preferred maximum of 40° downhill).

7.6.3.32 Whilst it is desirable to accommodate the pipework within a dedicated utility duct, the pipe can be located in a trench, similar to other utilities. Routing is easier with directly buried mains, with greater location flexibility. However, the use of dedicated ducts provides easier access for maintenance and will provide a longer life compared with direct buried pipes.

7.6.3.33 The following table will serve as a guidance on the piping network to suit the required number of household and the size of the site to be served:

No. of Flats Served	Distance of Conveyance (m)	Diameter of Pipe (mm)
16,000 – 32,000	1500 – 2,500	500/600
3,200 – 16,000	800 – 1,500	300/400
320 – 3,200	400 – 800	150/250

7.6.3.34 It is noted that a minimum size of 500mm is adopted for ARCS used in housing sites. We also suggest that the same minimum size of 500mm to be allowed at this stage for the scheming work until the time when we may have proven case of reduced pipe diameter to cater for small scale development.

7.6.3.35 The longest distance travelled by the pipeworks between stations will be about 2 – 2.5 km.

7.6.3.36 For buried mains, or utility ducts without continuous access, inspection chambers with double sealed covers are to be located at not more than 100 metre intervals, near to junctions, and at locations such as bends where there is a risk of blockages.

Refuse Collection and Packaging Device

7.6.3.37 The recommended footprint area for refuse collection stations varies slightly from one ARCS manufacturer to another. But generally, despite ARCSs being installed by different suppliers, the systems are very similar, presumably as they are supplied under the same tender/contract terms of the Housing Authority. Their operation principles and application are similar with minor variations in the individual plant components. The refuse is delivered from the refuse conveyance pipes to the Refuse Collection Station (RCS), which consists of the following components:

- A refuse separator, which separates the waste from the transportation air stream. A filtering facility at the refuse collection station/unit removes dust from the transportation air stream after leaving the refuse separator;
- A refuse compactor, which compacts the refuse into containers;
- Refuse containers, for storing and transporting the refuse without any need for direct handling of the waste, and without exposure of the waste to the air. Each container can be loaded with 8-10 tonnes of refuse which is then transported to landfill sites for disposal;
- A dust filtering facility;
- Air blowers with silencers; and
- A de-odorising facility whereby activated carbon filters and/or water scrubbers as a means of deodorization remove odours carried by the transportation air stream from entering the atmosphere.

7.6.3.38 The whole system is controlled by logic controllers to satisfy the needs of different buildings, for maximum efficiency.

7.6.3.39 Space will be allowed within the plant for the refuse storage, compaction and container, and hence a minimum headroom of some 7 – 8 m will be required.

Exhaust Air

7.6.3.40 The air discharged from the plant will be a main environmental concern and has to be well addressed to derive the maximum benefit of the system. The odour problem will mainly be associated with the release of hydrogen sulphide gas.

7.6.3.41 Odour problem associated with hydrogen sulphide is caused by the release of molecular hydrogen sulphide gas. The rate of release depends on many factors, including pH, temperature, turbulence, ventilation conditions, etc. For the refuse collection, the major odour source would be the exposed surface of the refuse and the discharge of air discharged from the ARCS plant.

7.6.3.42 To ensure the achievement of the air quality requirement, the exhaust from the system will pass through the following means:

- A System Collector removes larger particles in the air stream to prevent clogging the downstream equipment;
- A Wet Scrubber removes most of the remaining particles when air passes through the fan. The odour from the fan discharge will be removed by means of an agent such as caustic soda;
- A chemical or ozone treatment will reduce odour and the accumulation of bacteria. This can be further improved by injecting ammonia solution into a catalytic deNO_x reactor to remove the NO_x contained in exhaust air; and
- An acoustic louvre and silencer will be provided for noise reduction through air in/out openings.

The experience from the housing sites indicates that there is no odour issue for the air discharged from the ARCS. In fact, the ARCS will control odour better than the conventional system and the RCP as the operation will be carried out in a concealed or within an indoor environment.

7.6.3.43 As a precaution, air discharge outlets will be located away from sensitive areas such as domestic block facades and fresh air intakes.

Hong Kong Specific Conditions

7.6.3.44 Unlike the application of ARCS in temperate countries, due to the high ambient temperatures in Hong Kong the temperature of the transported refuse can rise to a level at which the performance of the de-odorising media may be adversely affected. Therefore, wet or water scrubbers with appropriate chemical dosing must be specified in order to achieve sufficient odour removal.

7.6.3.45 Hong Kong household waste is typically high in moisture, resulting in the likelihood of agglomerates forming inside storage facilities. Subsidiary air inlets to facilitate loosening up of refuse agglomerate are to be provided, but must only open during refuse collection (by vacuum action) in order to prevent the leaking of odour from the system. In addition, foul liquid associated with the process will be collected in containers and disposed together with the refuse. Others means such as mechanical auger can also be employed for loosening the refuse

agglomerates. Filtering facilities shall be provided to remove dust particles from the refuse transportation air stream after leaving the refuse separator to prevent clogging the downstream equipment and contaminating the environment.

Operation and Maintenance of the Plant

7.6.3.46 Since ARCS can only collect refuse from individual buildings once at a time, sufficient refuse storage must be provided for each building (generally at ground level) to receive refuse dumped into the disposal inlets while the system is collecting refuse from other buildings.

7.6.3.47 Calculated provision of sufficient capacity for temporary refuse storage will allow residents to dump the refuse into the ARCS at any time. The refuse will be accumulated in a building storage unit until the time of being sucked into the transportation ductworks. The whole system will be properly monitored by surveillance to avoid any accident.

7.6.3.48 The ARCS will only be operated at certain hours of the day (something of the order of 12-16 operation hours per day). The time remaining will allow opportunity for routine maintenance of the plant, if required.

Contingency Plans for Possible Breakdown

7.6.3.49 Whilst the system is quite reliable, as evidenced in the other projects in use in Hong Kong as well as overseas, there may be a need to devise contingency measures in the event of a system breakdown or blockage. The most straightforward method of combating system failure is by providing emergency outlets at each of the temporary storage facilities at each building and at each non-residential inlet. In the event of failure elsewhere in the system, waste can be removed manually from these storage facilities as in any conventional waste collection system, until the problem has been resolved.

7.6.3.50 In the event of blockage or breakdown in any part of the system, the contractor shall isolate, as far as practicable, only the parts concerned to allow the central plant to continue serving other parts of the system and clear the problem immediately. In case of breakdown of the whole ARCS or prolonged shutdown of any part of it, the contractor shall operate the refuse diversion facilities inside ground floor refuse chambers, manually collecting the refuse and disposing the collected refuse to dumping sites.

7.6.3.51 If 2 plant serves several different phases or "clusters" of SEKD, there is greater operating flexibility. Each phase or cluster will have a dedicated refuse collection plant and switchover interconnections will be provided between plants. Therefore should key equipment for any single plant be down, the relevant line can be connected to the equipment for an adjacent line via a line switchover device during repair. Thus no phase or cluster should ever be without an operating ARCS.

Cost of Automated Refuse Collection System

7.6.3.52 The cost depends on a number of factors such as the length of the pipeline, scale of the system and the capacity required. The following order of cost per flat for an ARCS installed for a housing estate comprising of high rise tower block with a total flat size of 3,000 to 6,000 is indicated:

Items	HK$ per flat
Capital Cost	$5,000 - $6,000
Operation and Maintenance	$25 - $35/month

7.6.3.53 The cost of ARCS is more sensitive to the number of housing blocks than to the number of flats involved. Research by HA has concluded that ARCS is not so cost-effective if applied to fewer than 2,400 units. Although there is insufficient data in Hong Kong from which to draw a conclusive correlation, it can be reasonably deduced that the cost per unit is anticipated to be reduced if the units supplied by one ARC System increases. Hence, it will be more economic to be adopted for high rise buildings, as in the case of public housing at South East Kowloon Development.

Operation and Maintenance Costs

7.6.3.54 The main operating costs for ARCS arise from the energy requirements for cooling exhaust air and for providing the suction vacuum for transporting the waste. These are of course costs that are not required in the conventional waste collection systems. However, there may be certain cost savings resulting from a reduction in collection vehicles required, and distances vehicles to travel if a global application is to be made. This transport cost varies according to whether a single central refuse collection centre or several separate collection centres are adopted.

7.6.3.55 Staffing for operations will generally consist of a minimum of two technicians operating at a 2 shifts system between the hours of 7 a.m. and 11 p.m. This again presents a cost saving over conventional methods where cleansing contractors are required in all buildings. However, currently the labour cost for refuse collection is not high as there has been strong competition in the labour market. This will put less incentive to adopt ARCS.

7.6.3.56 Due to the relative technical complexity of the ARCS system, maintenance costs could run higher than for conventional collection methods.

Land Requirement

7.6.3.57 Generally, a footprint area of 300 – 700 sq. m. is required for each plant area of ARCS serving each separate phase or cluster of development. With the ARCS serving additional catchments, the required footprint has to be increased, but by not so much as the proportional increase in capacity. However, combining catchments means the pipe size and length and proportional operation costs will increase. To economise the land usage, putting a central refuse collection system servicing a large catchment in the vicinity (several phases or clusters) is preferred.

7.6.3.58 The plant is fully enclosed and will adopt measure, such as acoustic treatment, dust filtering and de-odorising facilities. The location of the plant should be located well away from the population centre to avoid any psychological effect to the residents of the development lot, despite the fact that the quality of the exhaust air is quite acceptable. However, the use of this principle may have the undesirable result of additional pipe runs.

7.6.3.59 Routing of pipes or ducts is a further land consideration and potential complication. Underground pipes/ducts should be routed to avoid other utilities.

Possibility of Waste Recycling

7.6.3.60 It is widely accepted that we will try to recycle the materials not only to conserve the materials but also to reduce the need to identify means of disposal of waste material. This is particularly true in Hong Kong as the current land fill site will be close to capacity in the near future. To achieve this, the co-operation from the public will be required. Since 1995, the Housing Authority's cleansing contracts require contractors to segregate recyclable materials from household refuse.

7.6.3.61 The technology for automatically sorting mixed refuse into recyclable and non-recyclable or combustible components is available. However, adding waste sorting technology will

inevitably increase the overall costs and land requirements of installing the ARCS at SEKD. In addition, automatically sorting 300 tonnes per day of mixed disposed refuse collected possibly generated from SEKD at the collection point could prove impractical. Recycled material collected from an estimated 300 tonnes/day will be dirty and could require further treatment, thus reducing its market value. For these reasons, it is considered preferable to continue sorting at source.

7.6.3.62 The most efficient solution would be separation by the users. There are different methods for such separation:

Option 1 - Separate Refuse Inlets in Residential Buildings

7.6.3.63 Apparently, this may be the simplest for the user. However, this will require a greater space on each floor of each building to accommodate different inlets. Appendix B of AP/RSE Practice Note 98 indicates examples of layout plan for Refuse Storage and Material Recovery Chambers and rooms with provision of 3 additional bins for paper, aluminium and plastics on top of the normal provision for municipal waste.

7.6.3.64 There is only a potential problem of putting into the wrong inlets by the residents if more than one inlet is available.

Option 2 - Colour Classified Bags Delivered to a Single Refuse Inlet

7.6.3.65 The use of bag (which has to be obtained through sale) has been used as a means of waste minimisation in some countries. However, it will take some time before this can be introduced in Hong Kong. The distribution/sale of bags will also represent another potential problem. This is considered not so practical at this stage as there is doubt whether the public will adhere strictly to the use of different bags.

Option 3 - Different Times of Day Allocated to Disposal of Different Types of Waste

7.6.3.66 The use of the LED red, amber and green lights can be adapted to alert the user as to what category of waste the system is ready to receive. This option is open to problems as people arriving at the refuse inlet at the different times of the day may opt not to wait until a suitable time to dump their waste, resulting in mixed refuse at all times of day.

7.6.3.67 If this option is implemented then education of the public using the system is of paramount importance, in order to ensure maximum materials are recycled, and these materials are not polluted with general waste. Because this method uses only one system of pipes, it is possible, to adapt the ARCS at a later date, following public education, to implement this method.

Option 4 - Including a Single Conventional Waste Refuse Room in Each Building Specifically for Disposal of Recyclable Materials

7.6.3.68 Likewise, this option is open to abuse as users may not choose to go the extra distance to the recyclable waste storage area, resulting in a loss of recyclable materials. This option is also considered unattractive as it reinstates the need for trucks to visit each building regularly to collect the recyclable materials. Although recyclable refuse is generally cleaner and less odorous than general waste, and as such the number of collection trucks required should be less than one a day, the need for collection trucks to individual buildings removes one of the main advantages of ARCS.

Option 5 - Waste segregation Dealt with by Cleansing Contractors at Source prior to Dumping Refuse into the Refuse Chutes

7.6.3.69 On the existing operating ARCS systems here in Hong Kong, in Wah Sum Estate and Shek Yam East estate, this option of door-to-door collection and disposal of refuse by cleansing contractors is still practised. Waste segregation is therefore dealt with by these cleansing contractors before the refuse is dumped into the refuse chutes. It is envisaged that this practice will continue at these estates until residents get sufficiently used to the recycling concept to practise segregation of refuse reliably. The obvious negative of this option is the continued need for cleansing contractors, which again removes one of the main advantages of ARCS.

7.6.3.70 The majority of these options are open to potential problems as people may fail to separate their waste products properly. Public education is essential in any recycling choice.

7.6.3.71 All the options will not readily be successful in view of the time taken for public education. The first option is a simple option, but takes up some spaces for separating refuse inlets. The third option of using different times of the day for different type of wastes also appears to be feasible. The recycled materials, which are more odorous, will be put in the bin adjacent to the chute until the specific times for the collection of recyclable materials

7.6.3.72 Another less satisfactory variation is a variation of the fourth options. Separate inlets are provided at ground level (in a dedicated refuse room or external to the building), but attached to the ARCS pipe network. Although this requires sufficient public awareness and co-operation for the user to separate and carry their recyclable waste to the ground floor, it is appealing in its simplicity. There is also flexibility for future extensions in this option, as additional inlets can easily be installed at a later date. If for example the system initially takes only one category of refuse in the building chute, additional disposal units installed at ground level at a later date can handle further waste categories.

7.6.3.73 A solution to facilitate recycling is not readily available as this requires the willingness of the public to co-operate and hence a public awareness of the benefits of recycling. It is noted that the conventional system of separate waste facilities for recyclable and non-recyclable materials requires the same public awareness and co-operation.

7.6.4 *Application to Public Housing*

Current Planning Guideline

7.6.4.1 Public housing estates are subject to separate provision standard and design criteria for refuse collection. The major provision of refuse collection in public housing estates currently include:

- Refuse Storage Chambers: standard provision incorporated in each domestic block which provide sufficient daily storage. Depending on the size of the individual block, one refuse bin with a minimum area allowance of 2.5m² should be provided for every 50 flats;
- Refuse Storage Areas: temporary holding areas designed to accommodate the storage of refuse bins awaiting collection. The location should aim to minimise nuisance to the public and the estate tenants living nearby and should be within the shortest distance practicable from the domestic blocks they serve;
- Refuse Collection Points in Buildings: a totally enclosed structure which allows entry of RCVs for collection of refuse generally associated with commercial centres. They are normally built as part of the commercial centres provision. A minimum area of 16m x 8.5m inclusive of bin storage should be provided; and

- Junk Collection Points: a separate storage area for those items which cannot be handled by the normal refuse collection service. They can be an independently designed structure or combined with the refuse storage chamber or refuse storage area. Normally, an estate with 4,000 flats or less would require one junk collection point of 20m² minimum. An estate with 4,000 flats or more would require two junk points of 20m² each or one of 40m² minimum.

7.6.4.2 There are two basic options in the conventional planning of layouts to satisfy the daily refuse collection needs in public housing estates:

- Option 1 (Provision of Refuse Storage Areas)

  As a general rule, Refuse Storage Areas (RSAs) should be provided at suitable locations, preferably off-street, to serve two or more blocks. These RSAs should be accessible to refuse collection vehicles. Adequate space for lay-bys and/or turning circles should be provided. RSAs should be suitably located to minimise nuisance to the public and the tenants in the blocks nearby. In general, they should be located not more than 100m and not less than 20m from the adjacent domestic blocks.

- Option 2 (Block by Block Collection)

  This should only be applicable to exceptional cases where, e.g. the site topography is such as to make it impossible for a RSA to be provided to serve two or more blocks. In such cases, clearly defined vehicular access should be provided up to the refuse storage chambers, with adequate manoeuvring and parking space for the refuse collection vehicles.

7.6.4.3 In all cases, the access route for Refuse Collection Vehicles in public housing estates should be clearly defined by a suitable choice of materials, use of pavement kerbs and/or landscape features to differentiate the vehicular access from the pedestrian areas of the estate.

Introduction of ARCS by Housing Authority

7.6.4.4 The ARCS was first implemented in residential development in Hong Kong by the Hong Kong Housing Authority (HA) as follows:

Location	Estate	Commissioning Date
Fanling Area 47B	Wah Sum Estate	December 1995
Shek Yam	Shek Yam Phase I Estate	July 1996

7.6.4.5 The systems installed have proved sufficiently satisfactory for the Housing Authority to endorse a proposal to adopt this new form of refuse collection, ARCS, as a standard provision for future public housing estates including rental and Home Ownership Scheme estates.

7.6.4.6 Hence in September 1998, the Building Committee of Housing Authority has issued a policy to adopt ARCS for all housing estates above a certain size, completed in or after January 2001, subject to the conditions and constraints as follows:

- To optimise initial and recurrent costs, ARCS should only be installed on estates with 2,400 or more domestic units;
- ARCS can only be adopted where there is sufficient land space available to accommodate and provide access to one or more (as required) central refuse collection stations;
- Central refuse collection stations should be remote from residential blocks to minimise psychological and environmental impacts;
- Central refuse collection stations must be located near the load centre in order to minimise travel distance of refuse and enhance operation efficiency;
- Sufficient space/pipework must be available below ground to accommodate the large diameter underground transportation ducting or pipework;

- ARCS is not practical in rocky terrain which results in excessive initial costs;
- ARCS is not practical in very congested sites where there is no space to accommodate or provide access to the refuse collection station; and
- Excessively sloping sites pose difficulties as the maximum permissible duct gradient is 20 degrees uphill and 40 degrees downhill.

7.6.4.7 Despite the additional installation and maintenance costs, Automated Refuse Collection System for domestic blocks is regarded as a preferred provision to create a better sanitary environment. Since the decision by Housing Authority, the Automated Refuse Collection System will be installed in the following public housing estates in the forthcoming few years. The experience built up from the 2 trial sites by Housing Authority has been incorporated in the production of the guideline, Planning Brief and Design Guide (ref. B Th-CF 103/404). The system adopted in future will comply with these guidelines, which will be updated as necessary to incorporate the latest technology and application experience in Hong Kong.

Table 7.10 Implementation of ARCS by Housing Authority

Name of Estate	Cost of Supply of ARCS System (HK$ Million)	Tender Date	No. of Flats Served	No. of Housing Blocks	No. of Flats/Block	Cost per Flat (HK$)
Shatin Area 14B	30.8	5/1999	4,816	18	267.56	6,385
Tin Shui Wai Area 110	29.8	6/1999	5,760	14	411.43	5,177
Tseung Kwan O Area 74	23.8	6/1999	4,717	10	471.70	5,051
Lai Chi Kok	17.7	6/1999	3,434	5	686.80	5,164
Tin Shui Wai Area 106	26.7	7/1999	3,330	9	370.00	8,010
Tsing Yi Area 10	20.8	11/1999	4,113	7	587.57	5,071
Tseung Kwan O Area 73A	36.1	10/2000	6,640	9	737.78	5,450
					Average	**5,760**

Note: For discussion purpose, we do not consider the effect of time on the cost of ARCS as the inflation (deflation) rate between May 1999 and October 2000 is considered insignificant.

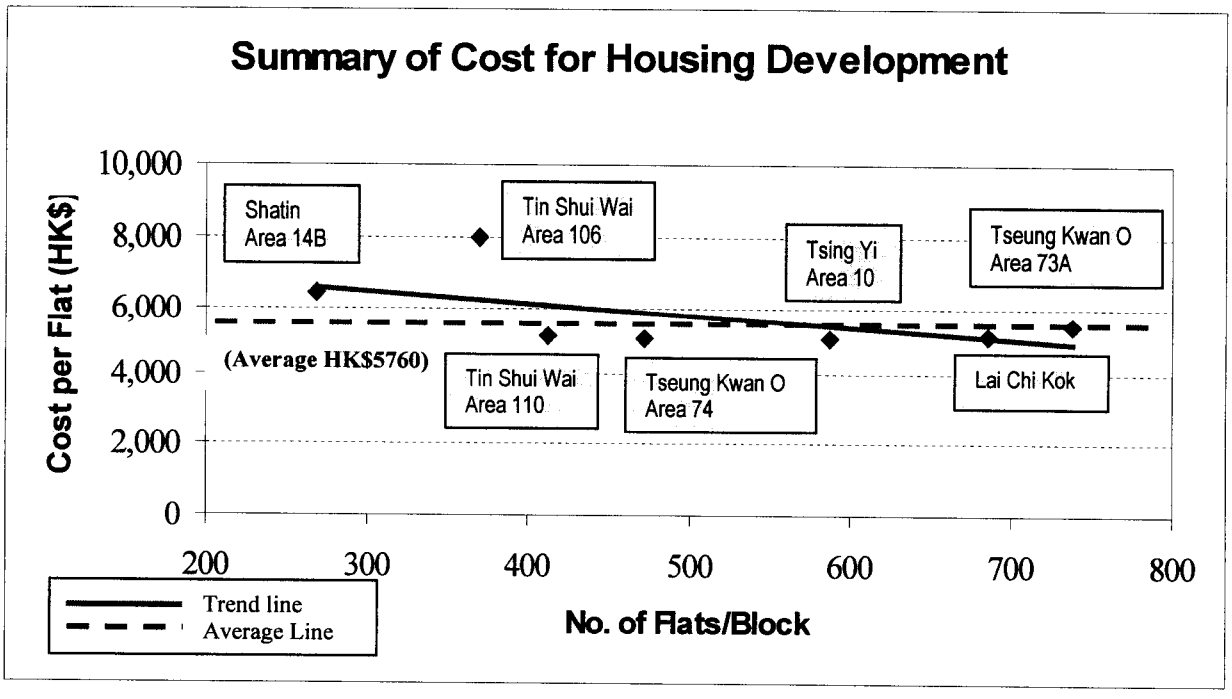

Figure B Summary of Cost for Public Housing Estate

7.6.4.8 A graphical representation has been made to show possible relationship between the number of flats of the building and the cost per flat. Whilst the relationship is not very clear as the costing may also be affected by timing/competitiveness of the tender, it can be observed that in general the cost per flat will be increased for less flats per housing block. The cost per flat at Tin Shui Wai Area 106 has been significantly over the normal as the flat number per block is lower. The same trend has also been observed for housing estate at Shatin Area 14B.

Public Housing Development at South East Kowloon

7.6.4.9 At South East Kowloon, the public housing will be distributed in the following areas:

Table 7.11 Public Housing at South East Kowloon Development

	Area	Area (ha)	No. of Flats	Population	Use*
Area 1 in North Apron area of former Kai Tak Airport	1A	3.5	4,874	12,810	Public Rental
	1B	6.3	7,710	23,804	Public Rental
	1C	4.8	5,138	16,442	HOS/PSPS
	1D	5.7	4,656	14,899	HOS/PSPS
Area 4 at the runway and at the area occupied by Kai Tak Approach Channel	4B	2.5	2,109	6,580	Public Rental
	4C	2.3	1,921	6,992	HOS/PSPS
	4E	2.8	3,106	9,351	Public Rental
	4F	1.4	1,189	3,709	HOS/PSPS
	4K	1.5	1,276	3,980	HOS/PSPS
	4L	1.8	1,913	5,969	Public Rental
	4M	2.1	2,245	7,006	HOS/PSPS
	4R	1.2	1,300	4,102	HOS/PSPS
Area 5 at the Kowloon Bay Area	5J	3.7	3,199	9,582	HOS

*Note: The use is only tentative at present and will subject to change.

7.6.4.10 The first list (Phase 1) at the North Apron area of former Kai Tak Airport will be developed initially with a target population intake in 2005/2006.

7.6.4.11 For the second batch of public housing sites, the dates are scheduled to be around 2007 – 2011. However, there is some uncertainty at this time of the exact date of the development, particularly as it involves reclamation work.

7.6.4.12 It is noted that most of the sites will have a flat number of over 2,400 (shown hatched above).

Implementation Issues for Public Housing

7.6.4.13 In view of the past successful experience of installing and operating ARCS within various scales of public housing estates by the Housing Department, it is envisaged that no particular technical problem will be encountered. Based on the experience in past projects, on incorporating ARCS into the main building contract, the system can be expanded further to serve sites of over 10,000 flats to enjoy the economy of scale.

Location of the Plant

7.6.4.14 In allocating sites for RCSs, the following will be considered:

- For mixed Rental and HOS estates, the RCS should preferably be in the rental portion;
- To maximise land use efficiency, it is not recommended that RCSs are stand-alone structures; and

- RCSs should be in non-domestic buildings, with proper access and parking. In Area 1, the area close to Kwun Tong Bypass will be a suitable choice, despite the longer pipe routing.

Contracting Strategy

7.6.4.15 There are currently four approved suppliers of ARCS listed by the HA. This is in line with the current scale of use of ARCS in Hong Kong. It is anticipated that as ARCS becomes more widely used and accepted, a greater number of suppliers may enter the Hong Kong market. There is, after all, a potential market of some 50,000 public flats per year (even though excluding private development), which at an estimated HK$6,000 per flat will amount to HK$300 Million capital cost spent on ARCS annually.

7.6.4.16 The current HA housing contract includes for the supply and installation of ARCS, with two years of Operations and Maintenance (O & M). The supplier is required to list and provide the cost of the spare parts for O & M. There is provision in the current contract for a change in contractor after the 2 years operation and maintenance period. The existing/new supplier may tender out the O & M service, using the agreed rates for spare parts given in the initial contract.

Scale and Phasing of the ARCS

7.6.4.17 Generally, the system can be installed in stages, if necessary, in line with the housing estate development with additional inlet conduits installed in conjunction with the housing block completion. Based on the experience built up, there is little technical difficulty in installing a larger plant capable of serving 10,000 flats, if there is a demand.

Funding for the ARCS

7.6.4.18 Although adoption of ARCS to serve a bigger site or more flats appears to be the more cost-effective as the long term solution, the funding arrangements need to be sorted out.

7.6.4.19 The use of an ARCS to serve more than one public estate will lead to the issue of cost apportionment in both capital as well as operation/maintenance costs. For 2 or more public housing estates, all of them on a rental basis, the overall estate management responsibility will solely rest with the Housing Authority. The cost of apportionment can be more easily dealt with.

7.6.4.20 However, if the public estates will not, in the long term, be managed by the Housing Authority, there will be the issue of cost splitting. In fact, it is unlikely that the government will take on board the operation of the ARCS. A service provider has to be appointed and the operation financed by the residents. For HOS housing, the responsibility of estate management will eventually be separated from the Housing Department. The situation of finding an institutional/regulatory framework will be quite similar to the case of private ownership.

Suggested Scheme for Public Housing at South East Kowloon Development

7.6.4.21 As given in **Table 7.11**, the public housing at South East Kowloon Development is mainly located in 2 areas, Area 1, Area 4 and Area 5.

Zone P1 (covering Area 1)

7.6.4.22 For the public estates at Area 1, there is a possibility that a single plant be installed to cover the whole public estates in order to achieve an economy of scale. The plant can be installed at the area close to existing Kwun Tong Bypass, as illustrated in **Drawing No. 22936/AR/032**.

7.6.4.23 However, a plant capable of serving over 22,000 flats has not been so well established in Hong Kong, although there has been proven case elsewhere. As such, it may be less risky in proposing 2 plants for the Area 1, covering Areas 1A/1B and Areas 1C/1D respectively with each of plant catering for a site size of about 11,000 flats, as illustrated in **Drawing No. 22936/AR/042**. In addition, as Areas 1A/1B are currently designated for public rental and Areas 1C/1D designated as HOS/PSPS, there is less problem of institutional/regulatory framework of formulating the cost splitting.

7.6.4.24 The two plants can also be interlinked together to provide additional contingency means in the event of plant breakdown.

Table 7.12 Summary of Zone P1 Distribution Network

Planing Area	Use*	Area (ha)	Population	No. of Flats	No. of Block	No. of Flats/Block	Total Population for of each Zone	Total No. of Flat for of each Zone
1A	Public Rental	3.5	12,810	4,874	7	696	67,955	22,378
1B	Public Rental	6.3	23,804	7,710	9	857		
1C	HOS/PSPS	4.9	16,442	5,138	8	642		
1D	HOS/PSPS	5.2	14,899	4,656	11	423		

*Note: The use is only tentative at present and will subject to change.

Zone P2 (covering Areas 4)

7.6.4.25 For public estates at Area 4, the housing estates are generally more separated than in the case of Area 1. The number of flats per site is also reduced as this area is not so densely developed as in the North Apron area. It is proposed tentatively at this stage that one/two plant can serve all these developments to allow an economy of scale as illustrated in **Drawing Nos. 22936/AR/033** and **043**. As noted above, the development in this zone will be sometime later and this will allow opportunity to review this proposal in the light of:

- Proven experience of a big plant serving over 10,000 flats;
- Formulation of a institutional/regulatory framework; and
- Confirmation of the designated use as public rental/Home Ownership Scheme/Private Sector Participation Scheme.

Table 7.13 Summary of Zone P2 Distribution Network

Planing Area	Use*	Area (ha)	Population	No. of Flats	No. of Block	No. of Flats/Block	Total Population for of each Zone	Total No. of Flat for each Zone
4B	HOS/PSPS	2.5	6,580	2,109	5	422	47,689	15,074
4C	HOS/PSPS	2.3	6,992	1,921	4	480		
4E	Public Rental	2.8	9,351	3,106	4	776		
4F	HOS/PSPS	1.4	3,709	1,189	4	297		
4K	HOS/PSPS	1.5	3,980	1,276	4	319		
4L	Public Rental	1.8	5,969	1,913	3	638		
4M	HOS/PSPS	2.1	7,006	2,245	5	449		
4R	HOS/PSPS	1.2	4,102	1,315	3	438		

*Note: The use is only tentative at present and will subject to change.

Zone P3

7.6.4.26 Site 5J, which is relatively remote from Area 4 can be served by a separate plant see **Drawing No. 22936/AR/034**.

Table 7.14 Summary of Zone P3 Distribution Network

Planing Area	Use*	Area (ha)	No. of Block	No. of Flats/Block	Population	No. of Flats
5J	HOS/PSPS	3.7	10	384	9,582	3,071

*Note: The use is only tentative at present and will subject to change.

7.6.4.27 In addition, we have also proposed a plant to serve with Area 4 and Area 5 together see **Drawing No. 22936/AR/035**. However, this will require more pipework to be lay underneath Road D5 (distance of pipework still within the limit of 2 km). There is also the issue of implementation timing to be considered.

Table 7.15 Summary of Zone P2-P3 Combined Network

Planing Area	Use*	Area (ha)	Population	No. of Flats	No. of Block	No. of Flats/ Block	Total Population of each Zone	Total No. of Flat for this Zone
4B	Public Rental	2.5	6,580	2,109	5	422	57,271	18,130
4C	HOS/PSPS	2.3	6,992	1,921	4	480		
4E	Public Rental	2.8	9,351	3,106	4	776		
4F	HOS/PSPS	1.4	3,709	1,189	4	297		
4K	HOS/PSPS	1.5	3,980	1,276	4	319		
4L	Public Rental	1.8	5,969	1,913	3	638		
4M	HOS/PSPS	2.1	7,006	2,245	5	449		
4R	HOS/PSPS	1.2	4,102	1,300	3	438		
5J	HOS/PSPS	3.7	9,582	3,071	8	384		

*Note: The use is only tentative at present and will subject to change.

7.6.4.28 The above schemes are preliminary and the final locations will be subject to the layout planning by Housing Authority.

7.6.5 *Application to Private housing*

7.6.5.1 Private residential housing will be undertaken by private developers and the population accommodated in public and private at South East Kowloon Development will be approximately equal. In general, the sites in South East Kowloon Development granted to private developers will be smaller in scale than the public housing, with the exception of Area 2A, which has a railway depot at the ground level.

Current Statutory Regulation

7.6.5.2 The two main statutory measures affecting the waste disposal in the private housing will be the *Hong Kong Planning Standard Guideline* as well as the B*uildings (Refuse Storage and Materials Recovery Chambers and Refuse Chutes) Regulations*.

7.6.5.3 The provision of refuse collection facilities in private residential, commercial and composite commercial/residential building developments should comply with the *Buildings (Refuse Storage and Materials Recovery Chambers and Refuse Chutes) Regulations*. Under these regulations, the minimum floor space requirements for refuse storage chambers and the need to provide vehicular access are specified according to the scale of development.

7.6.5.4 The floor space and vehicular access requirements of refuse storage chambers under the *Building (Refuse Storage and Materials Recovery Chambers and Refuse Chutes) Regulations* are summarised in **Table 7.16**. For residential or composite commercial/residential developments with a total usable floor space (UFS) of 13,200m² or more, and commercial developments with a total UFS of 39,600m² or more, vehicular access to refuse storage chambers will be required with adequate ingress and egress for a refuse collection vehicle customarily used by the collection authority. This would facilitate refuse collection to be carried out within the development to minimise environmental nuisance. For small scale developments, household waste is hauled to a nearby Refuse Collection Point (RCP) which will serve a wider area. Household waste at the Refuse Collection Point will then be collected by refuse vehicles operated by Environmental and Food Hygiene Department.

Table 7.16 Summary of Requirements of Refuse Storage Chambers in Private Residential Building Developments

Description of Building	Total Usable Floor Space (UFS)	Description of Storage Chamber	Minimum Floor Space of Storage Chamber
Residential Building	1,320m² or more but less than 13,200m²	Storage chamber	Total UFS in m² divided by 440
	13,200m² or more	Storage chamber with vehicular access	

7.6.5.5 The current plan produced in the town planning part of this study has made provision of Refuse Collection Points. It is noted that the area required for Refuse Collection Point is considerably less than that requirement for a ARCS plant. At this stage, we suggest to retain these Refuse Collection Points as there is also the need for Junk Collection Point in any event.

Current Application

7.6.5.6 There is very limited application of ARCS within private residential development in Hong Kong. Refuse collection is only facilitated by means of a refuse chute inside the residential buildings. Refuse is normally collected by contractor appointed by the estate management company and/or the Association of Incorporated Owners.

7.6.5.7 Despite the environmental benefits, the use of ARCS has not been applied to private sector. The main factors affecting the implementation will be as follows:

Proven Use in Hong Kong

7.6.5.8 The ARCS has only been applied in Hong Kong only quite recently. There is still some reservation on the system. To this, invitation for a site visits to the 2 proven cases of housing estates (Wah Sum and Shek Yam East) will help to reduce the worry of the private developer.

Cost

7.6.5.9 The cost installation per flat will certainty be significantly increased over the public estate, as the density is generally less than that for public sector. For example, a typical high rise private housing block will only have 8 flats (or even less) per floor, which is considerably less than 16 (or even 20/24) flats per floor as adopted by public housing. As cost per floor is almost fixed, the cost will thus be some 2 – 3 times over that for the public housing case. The cost for low rise low density development will even be greater.

Land Area

7.6.5.10 Additional land is required for the flat as well as at the ground level of each building to accommodate the temporary storage. The 300 sq.m. will represent 3% of the site with a site area of 1 ha, which is considered as large site within the context of Hong Kong. (For

reference, the site to be put in the land sale programme in year 2001 – 2002 will be of the order of 5 ha only). Currently the government is considering granting of bonus GFA for the use of private development. A Joint Practice Note for this purpose is being presued jointly by Buildings Department, Lands Department and Planning Department to encourage the use of more environmental friendly buildings.

Public Concerns

7.6.5.11 Whilst the trend is improving, the environmental concerns by the public are not so high as in other countries. Until the time when there has been higher public expectation on environmental aspects, there is less incentive for the developer to adopt the use of ARCS in the private property development.

7.6.5.12 The private developers will have to be convinced that the environmental benefits will offset the additional costs if the use of ARCS is to be widely adopted.

7.6.5.13 A Joint Practice Note has recently been issued jointly by Buildings Department, Lands Department and Planning Department to encourage the use of more environmental friendly buildings. There will be incentives to improve environmental performance by eliminating the gross floor area and site coverage calculation for:

(a) Balconies;
(b) Wider common corridors and lift lobbies;
(c) Communal sky gardens;
(d) Communal podium gardens;
(e) Acoustic fins;
(f) Sunshades and reflectors; and
(g) Wing walls, wind catchers and funnels.

7.6.5.14 The ARCS is yet to be under the above types of features. It will be reasonable to expect that similar exemption of GFA may be considered in future if the environmental benefits can be demonstrated. Currently the government is considering granting of bonus GFA for the use of private development. A Joint Practice Notes is currently jointly being considered by Buildings Department, Lands Department and Planning Department to encourage the use of more environmental friendly buildings.

Scale of Development

7.6.5.15 There are generally fewer flats per floor in private developments, resulting in greater individual costs per flat of the ARCS. We have made enquiries to different suppliers of ARCS in Hong Kong. There is no established rigid requirement for a minimum scale of development to be served by ARCS. However to achieve an economy of scale, the application of ARCS will require some minimal scale of residential development, noting that the capital cost of the whole system may amount to a cost of about HK$10 million. It is reasonable to conclude that the 2,400 flats, as recommended by the guideline set by Housing Department, will be a reasonable starting point for the introduction.

7.6.5.16 It is not considered cost-effective to apply ARCS to low-rise buildings although a number of externally located public hoppers, connected to the ARCS, could be used for such areas, reducing or removing the need for collection trucks.

7.6.5.17 A "vacuum truck" system can be considered for low-rise buildings. Individual buildings or houses could be provided with refuse chutes, or refuse rooms serving a number of units, interconnected by pipes to docking points. A vacuum truck empties the stored waste at docking points by suction. This removes the need for refuse vehicles to circulate amongst buildings, or for residents to carry their waste long distances to a single conventional collection point. It also maintains the environmental advantages of a sealed waste system. It

would, however, rely on the developer in accepting some capital costs of the system as well as the suction service by a service provider.

Details of Site at South East Kowloon Development

7.6.5.18 The different sites to be developed in South East Kowloon Development for private residential development are listed in the following table:

Table 7.17 Summary of Private Residential Developments in SEKD

Planning Area	Area (ha)	No. of Flats	Population
1K	2.4	1,612	4,659
2B	1.8	583	1,685
2C	2.8	1,824	5,270
2D	3.2	2,154	6,226
2E	1.6	1,085	3,135
2F	1.9	1,292	3,734
3A	1.1	574	1,660
3B	2.2	1,171	3,384
3C	1.2	462	1,335
3D	1.4	539	1,559
3E	1.1	447	1,292
3F	1.3	503	1,455
3G	1.0	378	1,093
3H	1.0	395	1,143
3J	1.3	515	1,490
3K	1.7	1,163	3,362
3M	1.1	736	2,128
3N	1.7	1,129	3,264
3P	1.1	715	2,067
3Q	1.8	1,226	3,544
3R	1.2	1,219	3,523
3S	0.8	802	2,317
3V	1.7	1,708	4,935
4A	2.6	763	2,204
4D	1.5	618	1,786
4G	1.9	751	2,172
4H	1.6	632	1,825
4J	1.6	641	1,853
4S	1.5	1,009	2,917
5C	3.5	1,404	4,057
5E	1.5	1,022	2,954
5G	3.9	2,626	7,588
5H	1.5	1,124	3,249

Note: Rows hatched are large sites for which the use of ARCS can be considered to be used independently.

7.6.5.19 It can be seen that only about 3 sites will be sufficiently large to justify the implementation of ARCS. However, some sites can be combined together to allow for the application of ARCS, requiring the use of the 'centralised' plant to serve multi-sites.

Separate Refuse Collection Stations for Each Cluster of Development

7.6.5.20 Irrespective of the potential institutional/regulatory framework problem, we have made proposal of location of centralised plant to serve more than one site, taking into account the proximity of sites and timing of development. The zoning of different sites to be served by different ARCSs is outlined in the following drawings covering different areas.

Drawing No.	Title
22936/AR/021	Automated Refuse Collection System Zoning Distribution
22936/AR/022	Automated Refuse Collection System Zone P1 Distribution Network
22936/AR/023	Automated Refuse Collection System Zone R4 Distribution Network
22936/AR/024	Automated Refuse Collection System Zone R5 & R6 Distribution Network
22936/AR/025	Automated Refuse Collection System Zone R7 & R8 Distribution Network
22936/AR/026	Automated Refuse Collection System Zone R9 & P2 Distribution Network
22936/AR/027	Automated Refuse Collection System Zone P3, R10 & 11 Distribution Network

7.6.5.21 Separate RCSs keeps collection stations close to the refuse sources, minimising the lengths of duct or pipe works required. This approach requires a number of different areas to be allocated for each separate RCS. The ARCS will be split into a number of areas to serve cluster of sites, based on the following factors:

- Type of housing, e.g. ARCS plant has been allocated at the public housing clusters of public housing estates;
- Staging of development – another ARCS system has been proposed to some Areas 2A and 1K, which will be developed at the similar time scale; and
- Limit of the plant to serve the residential area, such as length of the pipeworks and the maximum distance of the pipeworks.

7.6.5.22 We have identified a number of sites to be possibly designated as a Refuse Collection Station as follows:

Zoning Distribution	Area	Area (ha)	Population	No. of Flats	Total Population for of each Zone	Total No. of Flats for of each Zone
Zone R4	1E	3.2	7,778	2.691	31,104	10,762
(Private Development)	1K	2.6	4,659	1,612		
	2A	16.0	18,667	6,459		
Zone R5	2B	1.8	1,685	583	20,050	6,938
(Private Development)	2C	2.8	5,270	1,824		
	2D	3.2	6,226	2,154		
	2E	1.6	3,135	1,085		
	2F	1.9	3,734	1,292		
Zone R6	3A	1.1	1,660	574	18,302	6,333
(Private Development)	3R	1.2	3,523	1,219		
	3S	0.8	2,317	802		
	3T	3.0	3,663	1,267		
	3V	1.7	4,935	1,708		
	4A	2.5	2,204	763		
Zone R7	3B	2.2	3,384	1,171	17,900	6,192
(Private Development)	3C	1.2	1,335	462		
	3D	1.3	1,559	539		
	3E	1.1	1,292	447		
	3F	1.3	1,455	503		

Zoning Distribution	Area	Area (ha)	Population	No. of Flats	Total Population for of each Zone	Total No. of Flats for of each Zone
	3N	1.7	3,264	1,129		
	3P	1.1	2,067	715		
	3Q	1.8	3,544	1,226		
Zone R8	3G	0.9	1,093	378	9,216	3,187
(Private Development)	3H	1.0	1,143	395		
	3J	1.3	1,490	515		
	3K	1.7	3,362	1,163		
	3M	1.1	2,128	736		
Zone R9	4D	1.5	1,786	618	10,553	3,651
(Private Development)	4G	1.9	2,172	751		
	4H	1.6	1,825	632		
	4J	1.6	1,853	641		
	4S	1.5	2,917	1,009		
Zone R10	5A	9.8	2,671	924	27,485	9,511
	5C	3.5	4,057	1,404		
	5E	1.5	2,954	1,022		
	5G	3.9	7,588	2,626		
	5H	1.5	3,249	1,124		
	5K	4.3	6,966	2,411		
Zone 11 (Hospital Site)	5L					

7.6.5.23 In the proposal, the sites earmarked for ARCS plant will be designated as unidentified uses in the planning layout as there is some uncertainty of the resolution of the institutional issues at this stage. The scale of each phase of the system will be known prior to construction such that space can be allowed.

Phasing of Installation of ARCS

7.6.5.24 If the same refuse collection plant is to handle the waste from different phases, allowance for later phases can be accommodated with the provision of valves on branches of refuse conveyance pipes. As future phases are developed, new conveyance pipes can be connected to the branches and the valves opened accordingly. The central collection plant must be sized to accommodate the waste from all phases, which means a good understanding of the scale of all proposed phases of development must exist from the date of initial construction. It is understood that with only one phase of development using the ARCS, operating hours will be kept to a minimum, subject to the allowance of the temporary storage capacity. Once several phases are connected to the RCS operating hours can increase such that the total volume of refuse can be well accommodated.

Incentives for Use in Private Developments

7.6.5.25 If the ARCS has to apply to the SEKD private developments similarly as for the public developments, land has to be set aside specifically for the RCS for the private development. Alternatively, if land allocated to the ARCS can be exempted from GFA accountability, the incentive for implementing ARCS will be greater. If this is not the case, however, allocating a minimum of 300 sq. m to a RCS will be seen as a substantial loss of GFA for smaller sites.

The developers will be resistant to the incorporation of ARCS unless driven by the market force.

7.6.5.26 Apart from the accountability of GFA, there is a concern in the layout planning locating a RCS structure above the ground. Whilst consideration can be given to the use underground RCSs, this will increase construction costs further.

7.6.6 *Wider Application of the Automated Refuse Collection Station*

More Centralised Plant

7.6.6.1 There is obviously an advantage in the economy of scale in capital/operation cost in providing ARCS to serve more than one site. Also, servicing a large catchment area (i.e. several phases or clusters of development) with a single central RCS will help to economise on land usage. A comparison of centralised and decentralised ARCS is given in the following **Table 7.18**:

Table 7.18 Separate RCSs versus Central RCS

Issue	Separate Refuse Collection Stations	Single Central Waste Collection Station
Cost: • Staffing; • Vehicles; • Pipe works; and • Energy.	• Greater overall numbers of staff; • Relatively more vehicular traffic; • Savings in pipe lengths; and • Shorter distance.	• Slightly fewer staff; • Reduced vehicular traffic; • Greater distance for pipes to travel; and • Higher for the distance traveled by vacuum pipe.
Operation & Maintenance	Same number of plants housed separately; additional staff and additional wear and tear on vehicles.	Same number of plants housed together; slight reduction in staff, reduction in wear and tear on vehicles.
Risks of breakdown	In event of breakdown collection by vehicles is required.	In the event of breakdown system interconnections to reduce any downtime.
Planning of work	Planning on a less global process.	Very careful and detailed planning of contract strategy in planning the work.

7.6.6.2 There are two different approaches to accommodating phased development with ARCS which will be discussed in more details in subsequent sections:

- Separate Refuse Collection Stations for each development phase or cluster; and
- A single Refuse Collection Station (RCS) for the entire development.

Connection to Refuse Transfer Station

7.6.6.3 SEKD will fall within the current catchment area of the existing Kowloon Bay Transfer Station (KBTS) located to the west of SEKD in Kowloon Bay. A new Refuse Transfer Station (RTS) is proposed in SEKD to handle the municipal solid waste generated from SEKD and the catchment of the existing KBTS.

7.6.6.4 The proposed RTS is located in Area 6C outside the existing Kwun Tong Ferry Pier with an area of about 2 hectares. The main activities of the RTS will be operated in an enclosed structure like other newly built RTSs in the territory. The proposed RTS is provided with marine access with a berthing length of about 200m. With the implementation of the effective odour control measures adopted in other RTSs, adverse environmental impacts are not expected.

7.6.6.5 There are advantages to be gained from installing direct, automatic connections to the RTS. This solution removes the need for any collection trucks entering the SEKD site, and with that removes any associated visual, odour or vehicle emission pollutants. Due to the relatively long distances between the most remote building blocks and the proposed RTS location, additional

substation will be required, from which a direct connection can be made to the RTS. This connection would be via a number of parallel 600mm diameter conveyance pipes taking the collected refuse to the RTS.

7.6.6.6 Finding a route for these 600mm conduits and simultaneously accommodating other essential utilities could prove difficult. Soil cover is quite limited in many cases. However, the potential difficulties with laying these pipes and the additional associated costs must be weighed against the benefits of reduced traffic and associated pollution, improved operating efficiency and reduced operation staff requirements.

7.6.6.7 Complications will arise in cost-splitting where different types of housing, or different ownership arrangements (whether rented or privately owned) apply. This will be discussed in the following section.

7.6.6.8 This mega scheme, if implemented, will by means of expanding/adding new plant and extending the pipeworks in line with the phased development. As the development will be phased for a time span of over 10 years, consideration will have to be given in the contract strategy to be adopted in that:

- A contract let in early stage to cover the whole development – This may be difficult as it takes time to resolve the institutional issues; and
- Splitting the different plant/pipeworks in different contract packages, noting the possible incompatibility of the spare parts.

Expansion to Neighbouring Sites

7.6.6.9 Given the environmental advantages of the ARCS, it would be beneficial and would enhance overall efficiency if neighbouring sites such as Urban Renewal projects could also adopt ARCS. Unfortunately, if expansion of a particular ARCS is to be accommodated it must be anticipated at the initial construction phase, such that the RCS (or substation and connections to RTS) can be expanded as necessary once the new developments come on line. In other words, if future developments are to be incorporated into the ARCS of SEKD, sufficient space and facilities must be provided from the start at the central RCS/substation.

7.6.6.10 If future system additions are anticipated, section valves can be installed in strategic locations on the pipe network for later developments.

7.6.6.11 Whilst there is nothing to prevent neighbouring developments from constructing independent Automated Refuse Collection Systems, this will require more detailed planning in a separate study.

7.6.7 *Institutional and regulatory issues*

7.6.7.1 This section will give an overview of the institutional and regulatory issues which will affect directly the feasibility of the implementation.

Funding of Refuse Collection

Current Practice

7.6.7.2 Current normal practice is for the collection of refuse within a development to be carried out by a contractor appointed by the estate management or the Incorporated Association of Owners. The cost of the refuse collection is covered by part of the estate maintenance fee collected monthly, which also covers other services to the residents such as provision of

lighting, building services, security services in public areas as well as the operation and maintenance of lifts, amongst a number of other items.

7.6.7.3 The subsequent collection at the refuse collection point and disposal of the refuse is handled by the Food and Environmental Hygiene Department.

Funding the ARCS within a Residential Developments

7.6.7.4 If the ARCS is applied to a private development, the operation and maintenance is likely to be financed as part of the estate management fee. The charge rate on estate maintenance fee is likely to be based on the floor area, which has been taken as a reflection of the number of the people to be accommodated within a flat and hence the amount of refuse to be disposed. On the other hand, payment on the basis of weight of refuse has been advocated in other countries as a means of encouragement of waste reduction.

7.6.7.5 If the ARCS is installed within one site, the demarcation will be similar. However, should an ARCS applied to a multiple sites with different ownership, the responsibility of installing and operating the plant is yet to be determined.

Parties Responsible for the Implementation of the Scheme

7.6.7.6 It appears that a service provider has to be identified to be responsible for the installation and operation/maintenance of the ARCS plant. An important aspect is the determination of the duration of franchise right. There is a similar case of appointing a service provider to provide cooled water service for the Centralised Water-cooled Air-conditioning system at South East Kowloon Development, as managed by Electrical and Mechanical Services Department and Environment and Food Bureau.

7.6.7.7 Whilst this service provider can be within government establishment, it appears that there is no set-up, in terms of manpower establishment, and charge collection facilities, etc, readily available. Water and drainage services in the SAR currently are provided by the government, as a service provider. This may not be a popular method, as there have been concerns of the incentive to control costs and investment decisions are based on political consideration. As such, the use of private resources may be more likely.

7.6.7.8 The service provider can be a private entity operated under the stipulated regulatory framework. The party may even be a quasi-governmental organisation formed, such as Hospital Authority or Urban Renewal Authority. However, it appears that this use is not so favoured as that will require more complicated legislative procedure in establishing a separate statutory body.

Land Administration Issues

7.6.7.9 The implementation of the ARCS concept within new development areas can be made if provision for ARCS dedicated land can be incorporated within the overall master development plan that is prepared for the new development areas. The pipework for ARCS will pass through both private and public land, if a centralised plant is to be adopted.

7.6.7.10 Occupation of land for the pipework may be via a new statutory control mechanism similar to the following. A new Ordinance may need to be set in place by the Government to confer the necessary rights and easements to a future ARCS service provider for the purpose of construction, maintenance and operation of the ARCS scheme. Reference can be made to the following for the creation of easement within private lot for accommodating different types of utilities piping network

(i) Sewage Tunnels (Statutory Easements) Ordinance Cap 438

Provides for the creation of statutory easements and other rights upon land in favour of the Government for the purpose of construction, maintenance and operation of underground sewage tunnels (at least 30 meters below ground level).

(ii) Electricity Networks (Statutory Easements) Ordinance Cap 357

Pursuant to this Ordinance, the Public Utility Company is empowered to enter private property for the purpose of constructing and maintaining the network and to create a statutory easement.

(iii) Telecommunication Ordinance Cap 106

Pursuant to this Ordinance, the Telecommunication Authority and holders of a licence under the Ordinance are empowered to place and maintain a telecommunication line and posts in, over or upon any land interests.

Deed of Mutual Covenant

7.6.7.11 In relation to all buildings in the SAR which have been sold under title, a Deed of Mutual Covenant (DMC) is usually entered into by the developer of the land, the manager of the land appointed by the developer and the first purchaser of a unit within the development. The Deed of Mutual Covenant regulates the rights and liabilities of the owners of the building and the management of the building. It also binds successors in title to the original parties. It will also be necessary to ensure that adequate provision be made under the Deed of Mutual Covenant related to new buildings.

7.6.7.12 The management and operation of the provision of ARCS will then have to be reflected in the Deed of Mutual Covenant for each respective building. A Deed of Mutual Covenant may also be used to ensure that the responsibility and costs of refuse collection are adequately defined and distributed. If it is decided that ARCS will be adopted in a private building, the use will be subsequently binding to successive owners and tenants by the DMC. A DMC for the entire SEKD could enforce the installation and operation of the ARCS, and define the general terms for funding the system.

Charging Mechanism

7.6.7.13 The refuse collection for the private lot to public dump is a service currently provided by Food and Environmental Hygiene Department to the community. The funding is provided by the rates collected, which will reflect the floor area and hence possibly the amount of refuse, for the public. The use of ARCS may well change this mechanism as the service provider has to be financed independently. A possible concept will be the service provider will be reimbursed by the residents it serves, through the housing management or otherwise. At the same time, the residents paying/contributing to the operation/maintenance of the ARCS will enjoy some rebate on the rate charged by the government in return to avoid double charging. Similar application is made for Discovery Bay where the rates have been reduced as to reflect the curtailment of the normal service that the government will normally provide.

7.6.7.14 ARCS is, unlike the case of traditional refuse collection, where there is sufficient market force in the price setting mechanism. Having established technical viability, the biggest challenge to the successful implementation of Automated Refuse Collection System relates to the price charging schemes of the service provided by the ARCS taking into account their fairness, billing accuracy and the often divergent incentives to invest in equipment upgrades and efficiency under the different types of ownership.

7.6.7.15 Normally, the supplier will also be responsible for subsequent operation and maintenance, in a similar manner to the lift operation.

7.6.7.16 As the service provider has some form of monopoly, price regulation is a key feature of regulation. The price control of long-term cost will thus be a main concern in the private housing sector.

7.6.7.17 The tariff to be paid to the ARCS service provider has to be based on the following:

- Operation and maintenance cost of the system - the cost structure and the demand structure will be evaluated. Of particular interest is appropriate of fixed cost to various users;
- Evaluation of the cost of the refuse collection by manual method and the saving on refuse trucks;
- Acceptance level of the residents including aspects such as reliability of supply and customer service quality; and
- Reasonable financial return to the capital cost of the plant installed to provide more incentive to the use, taking into account the staged and phased installation and operation.

Price Increase

7.6.7.18 To allow the phased installation, the service provider will be given an initial operation right until the time when the final phase of the plant is installed and operated for at least 2 years. In view of the long span of time, allowance should be made in the institutional framework to allow the possible price increase in future to allow for inflation. To this, reference has to be made to the existing profit control scheme currently adopted in Hong Kong.

7.6.7.19 Broadly speaking, there are a number of forms of regulation. Firstly, under rate-of-return regulation, firms effectively are guaranteed a return based on the amount of allowable assets (KMB, CLP, HEC) or capital. Despite its administrative simplicity, its linkage of return to the firm's asset has the well-known incentive problem in excessive investment.

7.6.7.20 Secondly, a CPI – X form of regulation, (CPI relates to the Consumer Price Index), which can also include a Y-factor to control for extraordinary cost (such as fuel cost) changes faced by the service provider, which are then passed through to consumers. In this case the formula is % ? P = % ? CPI – X + Y. It is acknowledged that there are better incentive features for this. However, the application has to be carefully considered as the practical application of:

- Setting the initial prices;
- Determining the X factor; and
- Dealing with uncertainties and unpredicted changes.

7.6.7.21 The appropriate framework for price regulation will take into consideration the following aspects:

- Estimations of required capital and operating expenditure;
- The levels of service and performance demanded by end-users;
- Choice of index of inflation – would some cost index be more appropriate than the retail price index, noting the bulk expenses will be energy and staffing;
- Efficiency estimations;
- Length of payback period of investment;
- Cost-pass-through of changes in uncontrollable costs;
- Built-in incentives for improvements in efficiencies, service performance as well as meeting environmental and safety standards;
- The role for interim reviews in dealing with uncertainties that are not covered by inflation indexing and cost-pass-through; and
- The appropriate time between price reviews and the process bearing in mind the prevailing social and political acceptance.

7.6.7.22 Overall speaking, the following factors will be the key elements:

- Fairness to the residents;

- Benefits of the scheme to the public; and
- What is the likely price mechanism if an open competition is allowed.

7.6.8 *Application*

7.6.8.1 The above discussion outlines the application to residential development within SEKD, which constitutes the bulk of the land use. The application to commercial use is expected to be similar.

7.7 Impacts Summary

7.7.1 Wastes generated during the construction stage of the development would generally include construction and demolition (C&D) material, chemical waste, and workforce waste. With the implementation of practicable waste management measures, the associated impacts are not considered to be an insurmountable environmental constraints.

7.7.2 Waste generated during the operational stage is mainly municipal solid waste. It is estimated that the total waste (i.e domestic and C&I waste) generated from SEKD would increase from 95 tpd in year 2005 to 434 tpd in year 2018. Together with the municipal solid waste generated from the existing catchment of KBTS, the capacity of the existing KBTS would be exceeded in year 2006. Based on the future waste arising estimated in this study, a new RTS with capacity in the range of 3000 to 3700 tpd and with marine access is proposed in Area 6C of SEKD to serve the SEKD and the existing catchment of KBTS. The proposed RTS site is located at more than 300m from existing and planned residential uses. With the implementation of practicable mitigation measures adopted in other newly built RTSs in the territory, adverse environmental impact associated with the operation of the proposed RTS is not expected. The proposed RTS is a Designated Project under Schedule 2 Part I:G.2 of the EIAO, a detailed EIA should be carried out by the future project proponent and approved under the EIAO to confirm that there will be no insurmountable environmental impacts associated with the construction and operation of the RTS.

7.7.3 There is no major difficulty on technical grounds, as evidenced by the application of the Automated Refuse Collection System to 2 public housing estates in the pilot scheme. The use of ARCS for combined sites will have institutional and financial issues to be resolved, though not insurmountable. South East Kowloon Development, being a newly developed area, will provide better opportunity of applying the ARCS than in other developed and congested areas. As such, an institutional framework should be formulated to target for a wider application. A further study, based on the initial findings of this report, is recommended to allow the implementation to follow.