AECOM Transportation

土木工程拓展署
CEDD Civil Engineering and Development Department
New Territories East Development Office

Agreement No. CE 10/2014 (CE)
Development of Anderson Road Quarry Site –
Investigation, Design and Construction

Development of Anderson Road Quarry Site – Rock Cavern Developments Environmental Impact Assessment Executive Summary

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1 INTRODUCTION

1.1 Background

1.1.1 The engineering feasibility study of the Anderson Road Quarry (ARQ) Development in East Kowloon has been conducted under the Agreement No. CE18/2012 (CE) "*Development of Anderson Road Quarry - Investigation*" (the FS) to ascertain the feasibility of implementing the development proposal. The FS was classified as a designated project under the Schedule 3 of the Environmental Impact Assessment Ordinance (EIAO). Hence, as a part of the study, an environmental impact assessment (EIA) report titled "Development of Anderson Road Quarry" has been submitted and approved under the EIAO (Register: AEIAR-183/2014) on 28 July 2014.

1.1.2 Community engagement was conducted under the FS and public views were collected. There was no strong view from the public on the cavern development and some of the LegCo members recommended promoting business opportunity or educational purposes in making use of the cavern. It was recommended in the FS to construct and operate cavern development within the boundary of the ARQ Development.

1.1.3 The FS had therefore covered the proposed cavern developments for (i) quarry exhibition centre and (ii) commercial use which are identified as designated projects (DPs) by virtue of item Q.2, Part I, Schedule 2 of the EIAO, "Underground rock caverns". The approved Schedule 3 EIA Report of the FS had already reviewed the potential environmental impacts of the proposed cavern developments and concluded that no insurmountable environmental impacts are expected from the cavern developments. Nevertheless, detailed environmental implications of the proposed cavern developments will be further investigated in a separate EIA under the EIAO.

1.1.4 Subsequently, in accordance with the requirements of Section 5(1) of the EIAO, a project profile (No. PP-501/2014) for the "Development of Anderson Road Quarry Site – Rock Cavern Developments" (the Project) was submitted to the Director of Environmental Protection (the "DEP") for application for an EIA Study Brief on 27 January 2014. Pursuant to Section 5(7)(a) of the EIAO, the DEP has issued a Study Brief (No.: ESB-269/2014) dated 10 March 2014 for the EIA study.

1.1.5 The purpose of the EIA study is to provide information on the nature and extent of environmental impacts arising from the construction and operation of the Project and associated works that will take place concurrently. This information will contribute to decisions by the Director on:

- the overall acceptability of any adverse environmental consequences that are likely to arise as a result of the Project;
- the conditions and requirements for the detailed design, construction and operation of the Project to mitigate against adverse environmental consequences wherever practicable; and
- the acceptability of residual impacts after the proposed mitigation measures are implemented.

1.1.6 This Project comprises the construction of a cavern located on the rock slopes in the north side of the ARQ Development.

1.2 Purpose of this Executive Summary

1.2.1 The principal purpose of this EIA Executive Summary (ES) is to present the summary of the findings, conclusions and recommendations in the EIA report. This ES contains the following information:

- Section 2 presents purpose and nature of the Project.
- Section 3 outlines information over consideration of alternatives.
- Section 4 presents the key findings of environmental impacts.
- Section 5 describes environmental monitoring and audit.
- Section 6 presents the conclusions.

2 PROJECT DESCRIPTION

2.1 Brief Description of the Project

2.1.1 With reference to the EIA SB, the original scope of the proposed cavern developments under the Project comprises a cavern for quarry exhibition and caverns for commercial use as shown in **Figure 2.1** with the following details:

- One cavern at +200mPD for quarry exhibition area/resource centre. Its dimensions are about 25m(W) x 11m(H) and 35m(D);
- One cavern at +310mPD for commercial use (e.g. food and beverage). Its dimensions are about 25m(W) x 5m(H) and 10m (D);
- Three caverns at +310mPD for commercial use (e.g. food and beverage). Their dimensions are about 16m(W) x 4m(H) x 10m(D); and
- Three caverns at +190mPD for commercial use (e.g. food and beverage). Their dimensions varies between 22-25m(W) x 11m(H) x 25-35m(D).

2.1.2 The Project Proponent has conducted a "*Market Study and Financial Analysis for Proposed Commercial Portion of ARQ Site Development*" including the proposed caverns for commercial development, which is still undergoing at the time when this EIA Report is prepared. Because decisive information on the commercial caverns is not yet available, the 7 nos. of proposed caverns for commercial use will not be constructed and developed under the ARQ project or in the foreseeable future, Hence, the proposed caverns for commercial use is not covered in this EIA.

2.1.3 The scope of the Project has now been revised and includes only the construction of the cavern for the quarry exhibition centre. The proposed cavern for quarry exhibition area/resource centre located at the northern rock slope of the ARQ development, which is shown in **Figure 2.2**.

2.1.4 The scope of the works of the proposed cavern for quarry exhibition will comprise the following activities:

- Mobilization of construction plant and site clearance at portal area of the cavern;
- Removal of existing vegetation at portal area of the cavern;
- Slope excavation and stabilization works, e.g. rock dowel installation at cavern portal;
- Rock excavation by drill and break method (estimated volume of excavation is 14,820 m^3 approximately) and temporary installation for cavern;
- Permanent lining of approximate 0.9m thick and portal structure construction for cavern; and
- Landscaping works.

2.2 The Need of the Project

2.2.1 The quarry operation of the Anderson Road Quarry (ARQ) Site, currently under a *Quarry Rehabilitation Contract*, will be terminated in mid-2016. The rehabilitation of the ARQ Site will provide a new landform consisting of benches and slopes on rock face, and a platform of approximate 40 ha for development.

2.2.2 Planning Department (PlanD) of the HKSAR Government conducted the *Planning Study on Future Land Use at Anderson Road Quarry – Feasibility Study* (the Planning Study) which was commenced and completed in 2011 and 2013 respectively. The overall objective of this Planning Study is to examine the future land use of the ARQ Site and to explore the development potential for residential and other uses.

2.2.3 According to the findings and recommendations of the Planning Study, apart from housing development, the ARQ Site also provides a solution space for accommodating district-wide G/IC provision and the potential use of the man-made slopes at the backdrop amounting over 45 ha of area should also be explored, which may include using rock cavern to accommodate suitable land uses to serve this area or to release land resources in other areas, and using the rock face for recreational purposes.

2.2.4 After reviewing the current available geotechnical data and site situation, it is feasible to construct some rock caverns at ARQ Site for future development. In view of the shortage of land supply for housing development in the Territory, placing of some suitable land uses e.g. G/IC facilities and/or commercial development into rock caverns to serve the ARQ area could release some of the precious land resources in other areas for residential development.

2.2.5 In addition, the ARQ has been in operation for more than 50 years, cavern could be used for retaining some of the features of the past quarry operation to reflect the history and for educational or tourism functions.

2.3 Project Programme

2.3.1 The works of rock cavern development will be included in Phase 2 of the main contract of site formation and infrastructures (SF&I Contract) of the ARQ Site Development. The anticipated commencement date of the SF&I Contract will be in 2016 Q3 while its Phase 2 construction works is expected to be carried out in early 2018. The anticipated construction time for the quarry exhibition cavern will be around 24 months and the anticipated completion date will be 2020.

2.4 Concurrent Projects

2.4.1 During the period of construction for the rock cavern development, the concurrent projects with construction works in the vicinity (500m from the site of cavern construction) will include the followings:

Project Item	Works Components	Time Line
1	Site formation and infrastructure within ARQ Site	End 2016 – end 2020
2	Flood attenuation facilities (drainage retention tank and artificial lake, etc.) within Quarry Park area	Early 2018 – end 2020
3	Salt and fresh water pumping stations at northern portion of ARQ Site	Mid 2018 – end 2020
4	Service reservoirs at +250mPD platform of rock slopes at the northern portion of ARQ Site	Mid 2018 – end 2020
5	Road improvement works at junction of Clear Water Bay Road and On Sau Road	End 2016 - mid 2020

2.4.2 The cumulative impacts for construction phase and operation phase have been assessed respectively in the EIA.

3 CONSIDERATION OF ALTERNATIVES

3.1 Scenario with and without the Project

3.1.1 Under the *Planning Study on Future Land Use at Anderson Road Quarry – Feasibility Study* conducted by Planning Department, extensive community engagement exercise on the suggested land use options was conducted. Rock cavern on existing rock slopes was recommended for options of land supply.

3.1.2 The proposed rock cavern development is located at the north side of the ARQ Development. Due to its use as a quarry site, ARQ is a highly disturbed environment where ecological value is considered to be minimal. Under the rehabilitation contract (No. GE/96/10), the landscape of the quarry will be rehabilitated through extensive tree and shrub planting on exposed rock face.

3.1.3 Without the proposed rock cavern development, the planting established under the rehabilitation contract will, though gradually, begin to mature. Some habitats may be expected to increase in ecological value in future as a result of ecological succession, such as the maturation of shrubland into woodland.

3.1.4 However, without the proposed rock cavern development, the area will be left as a vacant rock face. The opportunity to fulfil the social needs of using the rock cavern as the alternative land supply will be lost. It will also be difficult to find space within ARQ development unless other land areas e.g. with residential/recreation uses are consumed.

3.2 Consideration of Alternative Development Options

3.2.1 The prime objectives of proposing cavern development are to fully utilize the available rock feature available and to explore the alternative way for land supply.

3.2.2 Since the ARQ has been in operation for more than 50 years in the Territory, it is considered worth to make efforts for retaining some of the features of quarry operation to reflect the history. An exhibition centre or a resource centre is reckoned to be a suitable way of showing the history of past quarry operation to the public.

Size of the exhibition centre

3.2.3 The proposed cavern for exhibition centre with an exhibition area of 1,000 m^2, based on a usable floor area of 2.6 m^2 per visitor and a staff/visitor ratio of 1:13, is considered appropriate and sufficient for exhibition centre of similar nature.

3.2.4 Alternative footprint area of the proposed quarry exhibition cavern has been considered for accommodating larger scale of exhibition centre. After coordination with relevant government departments and with consideration of the geography of the ARQ Development and the nature / content of possible exhibition, the proposed quarry exhibition centre is considered sufficient with reference to some of the existing museums with similar nature and scale such as Police Museum (570m^2) and Dr Sun Yat-sen Museum (2,560 m^2) in Hong Kong. The sizes of the proposed quarry exhibition centre is approx. 1,000m^2, which is in between the Police Museum and Dr Sun Yat-sen Museum. Furthermore, the added environmental benefit of the compact design is the reduction of construction and demolition materials/wastes quantity arising from the construction stage. Thus, the recommended exhibition area of approximate 1,000m^2 is considered appropriate.

Location of the exhibition centre

3.2.5 The location of the proposed quarry exhibition centre cavern is currently at the northern rock slope of the ARQ Site Development as shown in **Figure 3.1**, it is adjacent to the proposed public transport terminus and within the future Quarry Park area. Other possible locations as

indicated in **Figure 3.1** at the existing rock slopes and within the boundary of the ARQ Site Development for situating the proposed cavern for quarry exhibition centre have been examined. These locations include

- Alternative 1 - Rock slopes at platform of +200mPD along and adjacent to the proposed carriageway of Road L1 (middle portion of existing rock slopes);
- Alternative 2 - Rock slopes at platform of +200mPD adjacent to future development sites (south-eastern portion of existing rock slopes); and
- Alternative 3 - Rock slopes at platforms of other level higher than +200mPD.

3.2.6 These other possible locations were considered not as suitable as the current location. Since the existing rock slopes of Alternative 1 and Alternative 2 are mainly contiguous to proposed public carriageway and residential developments, size of the cavern should be further enlarged (i.e. the environmental dis-benefit would be increasing the quantities of construction and demolition materials/wastes in the construction stage as well as the construction air quality and noise impacts) to allow assembly area for visitors and vehicular loading and unloading area for the museum cavern development if the cavern is adjacent to carriageways. In addition, there is no public access, both pedestrian and vehicular accesses to the proposed cavern under Alternative 2 if it is located adjacent to future residential developments. Nuisance will be created to the nearby future residential areas and school sites by the visitors of the quarry exhibition / museum cavern in case it is situated in the close proximity to the nearby development sites.

3.2.7 For Alternative 3, if the proposed quarry exhibition cavern is situated at platforms of level above +200mPD, there will be no direct connection, either pedestrian or vehicular access, from the platform of the main ARQ Site Development, which is at approximately +200mPD. Additional vehicular access and pedestrian facilities, e.g. vertical transfer system will be required for connection between the cavern and the ARQ Site Development. This will not only involve additional and substantial rock excavation and tree removal for the formation of pedestrian and vehicular accesses to the cavern (substantial construction waste and material generated as well as the associated construction air quality and noise impacts), but it will also involve extra energy consumption for the operation of the pedestrian connection (vertical transfer system) and the vehicular access road (street lighting). Furthermore, the landscape and visual impacts of Alternative 3 will be more significant and substantial comparing with the recommended location, locations of Alternative 1 and Alternative 2 since it will involve large scale site formation works for access roads and facilities.

3.2.8 The recommended location of the proposed cavern is within the boundary of and at the same level as the future Quarry Park such that some common facilities, e.g. visitor reception counter, loading and unloading facilities, car parking spaces, etc. could be shared between the Quarry Park and the exhibition centre cavern. This could reduce the amount of land required and better utilization of facilities.

3.2.9 Moreover, the proposed cavern for quarry exhibition centre will be situated adjacent to the proposed public transport terminus. This can encourage and facilitate the public visiting the exhibition centre by means of public transport.

3.2.10 The proposed location of the cavern is considered to be most suitable location within the Quarry Park as the rock slope at this location will provide the largest rock cover for the cavern, as the bedrock level will be dipping toward the northern end of the rock slope. The rock quality is better and the required temporary support for the cavern is envisaged to be less substantial.

3.2.11 The recommended location has the advantages of sharing the planned public transport and access of the Quarry Park and only requiring an emergency vehicular access for connection. Since no additional rock excavation and tree removal is required for the formation of vehicular and pedestrian accesses to the proposed quarry exhibition cavern under the recommended location, the adverse environmental impacts including construction waste / material generation, noise and air quality impacts and landscape and visual impacts of the

recommended location are comparatively less than the alternative locations. Summary of the environmental benefits and dis-benefits of alternative options are shown below:

Environmental Consideration	Alternative 1	Alternative 2	Alternative 3	Recommended
Rock Excavation Quantities	Extra rock excavation required for formation of loading & unloading facilities and assembly area	Extra rock excavation required for formation of loading & unloading facilities and assembly area	Substantial rock excavation required for formation of loading & unloading facilities, assembly area, vehicular access road and pedestrian connection facilities	No extra rock excavation required as visitor facilities including assembly area, loading and unloading facilities can be shared with the future Quarry Park.
Impacts to Existing Trees	Removal of additional trees on rock slopes required due to the site formation works of loading & unloading and assembly area facilities	Removal of additional trees on rock slopes required due to the site formation works of loading & unloading and assembly area facilities	Removal of additional trees on rock slopes required due to the site formation works of loading & unloading, assembly area facilities, vehicular access road and pedestrian connection facilities	No additional tree removal is required.
Nuisance of Operation to Nearby Development Sites	Close to the residential area and level of nuisance is slightly to moderate	No direct vehicular & pedestrian access from public road to quarry exhibition cavern. Access will be in close proximity to development sites. Nuisance to nearby development sites is substantial.	Quarry exhibition cavern will be at higher level platform of existing rock slopes and will be away from development site. Nuisance is minor comparatively.	Quarry exhibition cavern will be within future Quarry Park and away from the development sites. Nuisance is minimal.
Construction Noise & Air Quality Impacts	Larger extent of rock excavation due to site formation works for loading & unloading area for quarry exhibition cavern comparing with the recommended location. Hence, the construction noise and air quality impacts are higher as well.	Larger extent of rock excavation due to site formation works for loading & unloading area for quarry exhibition cavern comparing with the recommended location. Hence, the construction noise and air quality impacts are higher as well.	Extent of site formation works and rock excavation works will be the greatest amongst all 4 location options due to the provision of vehicular and pedestrian accesses. Hence, the construction noise and air quality impacts are the most significant.	No additional rock excavation will be required for the provision of access road and loading & unloading facilities of the quarry exhibition cavern as they are all within the future Quarry Park area. Hence, the construction noise & air quality impacts are the least amongst the

Environmental Consideration	Alternative 1	Alternative 2	Alternative 3	Recommended
				4 options.
Visual Impacts	Insignificant	Insignificant	Critical as the provision of vehicular access road and pedestrian connection facilities will involve substantial rock excavation and tree removal at existing rock slopes	Insignificant

Alternative use of cavern apart from exhibition centre

3.2.12 Apart from the use of quarry exhibition centre, the proposed cavern has been considered for other alternative functional or operational uses, e.g. public utilities facilities like the proposed fresh and salt water pumping stations of the ARQ Development.

3.2.13 Placing public utilities facilities like the proposed fresh and salt water pumping stations into the proposed cavern is technically feasible in general. However, the proposed fresh and salt water pumping station of the ARQ Site Development will be fed from the existing Anderson Road No. 3 Freshwater Service Reservoir (AR3-FWSR) and Anderson Road Saltwater Service Reservoir (ARSWSR) respectively. These two service reservoirs are currently situated level of +190mPD to +200mPD approximately which is the slightly below the level of the proposed cavern for the quarry exhibition centre. In case the proposed cavern is changed for pumping station use, the pressure head difference between the service reservoirs and the pumping stations is inadequate to drive the water pumps and hence the cavern for accommodating the pumping stations should be excavated deeper in order to achieve the functional requirement of pumping stations and hence increasing the construction difficulties and volume of rock excavation for cavern (i.e. the environmental dis-benefit would be increasing the quantity of construction and demolition materials/waste in construction stage) and associated pipe works.

3.2.14 Furthermore, the vehicular maintenance access for the pumping stations would pass through the future Quarry Park and impose significant disturbance and constraints to the operation and design of the Quarry Park. In view of the above concerns, the proposed cavern is not recommended to be used for other public facilities.

3.2.15 In consideration of the regional significance of the future Quarry Park, a cavern for museum or exhibition centre is important and appropriate use for showcasing the quarrying history of the ARQ over other possible uses of the cavern.

3.3 Alternative Construction Methods and Sequences of Works

3.3.1 There are a number of rock excavation methods to be used such as mechanical means by drill and split (or drill and break), use of chemical expansion agent, Cardox method and drill-and-blast technique.

Mechanical excavation method

3.3.2 The excavation method is by means of hydraulic excavator, hammer and hydraulic splitter. The hydraulic splitter acts by increasing the tensile strength beyond that of the material and a split will occur. This method is suitable for small portion excavation, and an excavation conducts very close to sensitive receiver from vibration, i.e. gas & water mains, railway track,

information transmission system / communication cables, etc. Disadvantage – Slow production rate for high strength rock mass (less than 40 m³ per 8-hrs per one-work-site, including rock removal). For worst scenario of MTR West Kowloon Terminal experience, only 30m^3 per day, with 4 drill rigs and 3 breakers.

Use of chemical expansion agent

3.3.3 This method makes use of the expansion force of the injected very high expansive capability chemical slurry. After self-expansive chemical slurry is poured into holes drilled in rocks, the expansive stress gradually increases with time, and generates the expansive stress. The material will then be cracked down. Therefore, this fracture mechanism is distinguished from a breakage by blasting. This method is suitable for small portion excavation, and an excavation conducts very close to sensitive receiver from vibration, i.e. gas & water mains, railway track, information transmission system/communication, etc. Disadvantage of this method is slow production rate (< 40 m³ per 8-hr shift), long standing time (up to 24 hours), and not suitable for fractured & weak rock mass.

Cardox method

3.3.4 The Cardox system is based on liquid carbon dioxide being converted to high pressure carbon dioxide gas with ignition. Tubes are filled with liquid carbon dioxide. When energized by the application of a small electrical charge, the chemical heater instantly converts the liquid carbon dioxide to a gas. This conversion expands the CO_2 volume and builds up pressure inside the tube. This instantaneous build-up in pressure reaches the yielding pressure of the rupture (shear) disc which bursts releasing a heaving mass of carbon dioxide which breaks the surrounding material. The advantages are low vibration effects to surroundings, environmental friendly, highly safe of rock breaking method and have similar production to drill-and-split. However, the disadvantages of the Cardox method are relative high operation cost and not suitable for very high strength rock such as Tuff and Granite.

Conventional drill and blast method

3.3.5 This method is suitable for bulk excavation in non-sensitive area (i.e. remote area). Approx. production rate: > 100 m³ per 8-hrs per one-work-face. Disadvantage – explosive handling including supply, transportation and storage is an issue on hazards for this project. It also requires longer process time (normally longer than 9 months) applying blast permit. Geotechnical features surrounded the caverns will be key sensitive receivers to control the blasting works. Hence, 2m round per blast for excavation and 2 days per blast (which considers drill, blast, muck out and installation of temporary support) may be expected.

3.3.6 Having reviewed the general layout of the museum cavern, the anticipated excavation sequence of the entrance and exit adits of the cavern, where the section locates below the berm +210 mPD, cut-and-cover method will be adopted due to the rock cover is very shallow of 2 m. The remaining section of adits will be full face excavation. The main cavern will be excavated by using top head and bench method.

Environmental benefits and dis-benefits for construction methods

3.3.7 Common to the mechanical excavation method, use of chemical expansion agent and Cardox method, they are purposed to control the rock breaking process and the environmental impacts particularly noise and dust are minimized. As the works will be carried out inside the caverns, the environmental impacts to the surroundings are controlled and minimized. The dis-benefits would be the long construction time. For the drill and blast method, the environmental benefit is the faster construction time, while the environmental dis-benefit is the hazards to the surroundings arising from the handling, transportation and storage of explosive. Balancing the benefits and disbenefits, use of chemical expansion agent and Cardox is not suitable for hard rock found in the site and the production rate would be low with long construction period (which means longer duration of environmental impacts e.g. noise and

dust emission). Therefore, the method is considered not suitable for meeting the programme of this Project.

3.4 Selection of Preferred Scenario

3.4.1 Based on the general layout of the quarry museum cavern, the calculated total excavation volume is about 14,820 m³.

3.4.2 The most likely excavation method would be mechanical or drill-and-blast methods. Further comparison with mechanical and drill-and-blast methods (only for museum cavern excavation) is summarized in the table below:

	Mechanical	Drill-and-Blast
Production rate (per 8hr shift)	30 m³ (nominal) per 1-work site-machine [60 m³ (nominal) per 2-work site-machines, and so on]	> 100 m³
Environmental Benefits	Controllable production rate and minimize the adverse impact Impacts controlled inside the caverns	Shorter construction time
Environmental Disbenefits	Slower production and longer construction time	Handling, transportation and storage of explosives having hazards to surroundings Additional control/restrictions during blasting
Permit application duration	Not applicable	At least 9 months
Excavation duration	If 2-work site-machines deployed: 14,820 / 60 = 247 days	14,820 / 100 = 149 days
Total duration	247 days	9 months + 149 days = 419 days

3.4.3 The above calculation shows that mechanical excavation method (i.e. by means of drill-and-split) will be the most preferable excavation method from a construction progress view point. The method has less environmental impacts in terms of construction noise and dust emission, as the excavation works for the cavern space will be conducted within the cavern space. It does not involve delivery storage and handling of explosive and hence minimises the hazard to the public.

4 KEY FINDINGS OF THE ENVIRONMENTAL IMPACTS

4.1 Air Quality

Construction Phase

4.1.1 Fugitive dust impact assessment taking into cumulative impact from concurrent projects within the study area has been conducted. With the provision of suitable dust mitigation measures, results indicate that all air sensitive receivers (ASRs) would comply with the 1-hour TSP EIAO-TM, 24-hour average Respirable Suspended Particles (RSP) / Fine Suspended Particles (FSP) and annual average RSP/FSP criteria under AQOs.

Operational Phase

4.1.2 Based on the preliminary traffic forecast, the induced daily traffic (2-way) would be in the order of 50 vehicles/day induced on the local distributor road and the traffic is mainly attributed to the maintenance activities (wastes collection and daily necessities delivery) and work-related transport (e.g. exhibition materials transport). Comparing to the traffic flows of nearby local distributors (i.e. Road L1 & L2) which have around 4000 vehicles /day, the induced traffic volume is small and hence it would not cause adverse air quality to the surroundings.

4.1.3 Reference has been made to the approved Schedule 3 EIA Report for Anderson Road Quarry Development (Register No.: AEIAR-183/2014) for the predicted air quality condition in the vicinity of the cavern development during the operational phase of ARQ Site. The predicted representative air pollutants concentration including NO_2, RSP and FSP at the worst-case year (i.e. Year 2026) on areas nearby the cavern development are well complied to the AQOs with taken the nearby emission sources into account. Provided that the location of fresh air intake for the cavern will be properly located with sufficient buffer distance to emission sources, adverse air quality impact is not anticipated to the proposed exhibition area/resource centre in cavern.

4.2 Noise

Construction Phase

4.2.1 Noise impacts arising from the construction activities of the project are assessed for noise sensitive receivers (NSRs) located in proximity of the works areas. Cumulative unmitigated construction noise levels at the representative NSRs are predicted to be in the range of 61 to 72 dB(A), complying with the construction noise criterion of 75 dB(A). No adverse construction noise impact is therefore anticipated.

4.2.2 With respect to the Project's contribution alone, it is recommended that the future contractors should follow the requirements set out in the "Recommended Environmental Pollution Control Clauses" published by EPD and adopt good site practice to minimise construction noise impacts on the surrounding environment.

Operational Phase

4.2.3 The maximum permissible sound power levels at daytime/evening time and night-time of the ventilation shaft of the cavern are determined. With the proper selection of plant and adoption of acoustic treatment, the NSRs would not be adversely affected.

4.3 Water Quality

Construction Phase

4.3.1 Water Sensitive Receivers (WSRs) were identified for the water quality impact assessment. The key issue from the land-based construction activities would be the potential release of wastewater from surface works areas, open cut excavation and groundwater infiltration during the formation of rock cavern. Minimization of water quality deterioration could be achieved through implementing adequate mitigation measures, such as control of construction site run-off and effluent. A water quality monitoring and audit programme will be implemented to ensure the effectiveness of the proposed water quality mitigation measures.

Operational Phase

4.3.2 The key source of potential impact on water quality during the operational phase would be the sewage and wastewater generated from the rock cavern development. However, no adverse water quality impact associated with the operational phase would be anticipated, provided that adequate sewerage and sewage treatment facilities are properly implemented to accommodate all the sewage effluents.

4.4 Sewerage and Sewage Treatment

4.4.1 The proposed sewer network in the ARQ development will be designed to cater for future residential development, commercial activities and sewage flow arising from the cavern development.

4.4.2 The sewage flow from the cavern development is estimated to be about 8.4m^3/day, which is around 0.1% of the total sewage flow of ARQ (i.e. 8,863m^3/day), and has been taken in account in the design of ARQ sewerage system. Therefore, sewerage and sewage implications arising from cavern development are not anticipated.

4.5 Waste Management

Construction Phase

4.5.1 Construction and demolition (C&D) materials would be generated from excavation works for museum cavern which include: Main Museum, Entrance/Exit Adits and M&E Niches. The C&D materials would comprise both inert and non-inert components, such as soil, artificial hard materials (AHM) (i.e. broken concrete, etc.), rocks, wood and metals. The Engineer has estimated the volume of surplus C&D materials to be approximately 18,175m^3 of inert materials and approximately 310m^3 of non-inert materials. There is no sediment present requiring marine disposal.

4.5.2 The C&D materials would be sorted on-site and the inert portion would be stored in different containers, skips or stockpiles to re-use on-site as far as possible to minimise the net amount of C&D materials generated from this Project. Surplus excavated materials, mainly the excavated rock material of size over 200mm, would be recycled and crushed into aggregates for reuse either at the main site of the ARQ project or other construction projects. The potential environmental impacts arising from the handling and disposal of the inert C&D materials, such as air and odour emissions, noise and potential hazard, would be negligible. Appropriate measures should be taken to minimise potential adverse impacts from dust during the transportation of C&D materials. Non-inert C&D materials generated would be reused and recycled as much as possible before disposing to landfills.

4.5.3 Other waste materials, including general refuse and chemical waste would also be generated throughout construction. Provided that these identified wastes would be handled, transported and disposed of using the recommended methods and that good site practices would be strictly followed, adverse environmental impacts are not expected.

Operational Phase

4.5.4 It is expected that general refuse will be generated during the operational phase of the Project. As advised by Leisure and Cultural Services Department, the area of the quarry exhibition and supporting facilities will be 1,000m^2 and 800m^2 respectively. It is assumed that (1) each customer occupy 2.6 m^2, (2) 1 retail staff serves 13 visitors, (3) waste generation rate = 2.69 kg/person/day. By using the above assumptions, it is expected during the operation of the Project there will be 385 customers and 30 retail staff per day. As such, the general refuse generated will be about 1,116 kg/day.

4.5.5 Sufficient recycling containers are recommended to be provided at suitable locations to encourage recycling of such waste as aluminium cans, plastics and waste paper. The refuse must be disposed at approved waste transfer or disposal facilities by refuse collection vehicle. As such it is considered to have no adverse or minimal environmental impacts.

4.6 Landscape and Visual

4.6.1 The scale of the Rock Cavern Development (RCD) is small and is located in the rock slope adjacent to the proposed Open Space, which is currently semi-barren with some vegetation on slope platforms. Landscape impact is, therefore, minimal and is limited only to the works area, whilst visual impact is slight to Insubstantial due to its small scale and great distance from potential visually sensitive receivers. Landscape and visual impacts are minimized through revegetation proposals and proposed hardscape/façade treatment to the future Quarry Museum of the RCD. It is considered that the RCD scheme will complement the proposed Open Space stipulated in Kwun Tong (North) Outline Zoning Plan (OZP) No. S/K14N/14 gazetted on 26 June 2015 and will have enhancement to both landscape and visual perspective.

4.6.2 Based on the tree survey, 30 existing trees which located in front of and above the proposed RCD would be impacted by the RCD. These trees are common species including Acacia confusa and Casuarina equisetifolia. Most trees are generally in poor form, poor structural condition and fair health condition. Aesthetic value is moderate. All of the 30 existing trees are in conflict with the development works area and are proposed to be felled. 30 compensatory trees are proposed near the entrance to cavern and on the platform to maximize greening opportunity and minimize visual impacts.

4.6.3 Only quarry site and trees in front of and above the proposed RCD are impacted by the proposed RCD due to site formation works, stockpiling of construction and demolition materials and construction of Portal within the works area. Sensitivity of change of trees in front of and above the proposed RCD is medium. Magnitude of Change to those trees is expected to be large. Impact Significance Threshold of trees in front of and above the proposed RCD is substantial before mitigation but is reduced to moderate after mitigation. Impact Significance Threshold of quarry site is slight before mitigation and is reduced to insubstantial after mitigation. Landscape treatment to slope, compensatory tree planting and shrub planting are proposed as mitigation measures to landscape impact to trees in front of and above the proposed RCD.

4.6.4 The scale and the extent of RCD are small. The proposed RCD is visible mainly at the quarry within the proposed Open Space and the residential areas immediately adjacent to the Open Space. Since the RCD is located at 200mPD and other existing residential areas to the west to the development are located around 50mPD – 100mPD, the RCD is non-visual from these areas due to the topography of the site. Impacts to visually sensitivity receivers from within the site and from the planned Development at Anderson Road (DAR) have been assessed. Impact Significance Threshold for all visually sensitivity receivers is slight before mitigation and is further reduced to insubstantial after mitigation. Decorative screen hoarding, sensitive and aesthetically pleasing cavern portal design, landscape treatment to slope, and compensatory tree planting and shrub planting are proposed as mitigation measures to visual impacts to visually sensitivity receivers.

4.6.5 The project will help enhance the landscape and visual quality of the existing barren rocky slope. While the overall planning of the ARQ development will provide large area of greening, mitigation measures for RCD will be applied to improve landscape area adjacent to the Rock Cavern and will benefit the whole development in the long term.

4.6.6 Overall, the landscape and visual impacts due to the RCD are considered to be acceptable. With the implementation of the appropriate mitigation measures, both landscape and visual impacts will be insubstantial.

4.7 Summary

4.7.1 The EIA report has provided information on the nature and extent of environmental impacts arising from the construction and operation of the Project, and the nearby project operating concurrently which they are summarized in **Appendix A**.

5 ENVIRONMENTAL MONITORING AND AUDIT

5.1.1 An environmental monitoring and audit (EM&A) programme was recommended for air quality, noise, water quality, waste management, and landscape and visual during construction phase. Site inspection/audit was also recommended to check the implementation of the air quality, noise, water quality, waste management, and landscape and visual mitigation measures during the construction phase. A summary of the EM&A requirements by each of the environmental parameters is presented in **Table 5.1** below.

Table 5.1 Summary of EM&A Requirements

	Prior to Construction	Construction Phase	Operational Phase
Air Quality	×	✓	×
Noise	×	✓	×
Water Quality	✓	✓	×
Sewerage and Sewage Treatment	×	×	×
Waste Management	×	✓	×
Landscape and Visual	✓	✓	✓

Air Quality

5.1.2 Given the mitigated Total Suspended Particles, RSP and FSP levels (with implementation of recommended mitigation measures) would comply with the relevant air quality criteria/AQOs and minimal dust impact will be anticipated from the Project works itself, environmental monitoring for the Project is considered unnecessary. Nevertheless, regular audit during construction phase is recommended to ensure the effectiveness of implementation of recommended mitigation measures.

5.1.3 No adverse impact would be generated during the operational phase of this Project. Therefore, the EM&A works related to air quality for the operational phase is considered unnecessary.

Noise

5.1.4 No adverse construction noise impacts were predicted and construction phase noise monitoring is not necessary under the EM&A programme. Nevertheless, regular audit during construction phase is recommended to ensure the effectiveness of implementation of recommended mitigation measures.

5.1.5 Prior to the operational phase of the Project, a commissioning test for the fixed plant of the ventilation shaft should be conducted to ensure compliance with the relevant noise criteria.

Water Quality

5.1.6 Water quality monitoring is recommended to be carried out at the Tseng Lan Shue Stream before the construction commences as well as during the site clearance and slope excavation works.

5.1.7 It is recommended that regular site inspections during the construction phase should be undertaken to inspect the construction activities and works areas in order to ensure the recommended mitigation measures are properly implemented.

Sewerage and Sewage Treatment

5.1.8 Since the sewage flow from the cavern has been taken in account in the design of ARQ sewerage system, sewerage and sewage implications arising from cavern development are not anticipated. Thus, EM&A works is considered unnecessary.

Waste Management

5.1.9 It will be the contractor's responsibility to ensure that any wastes produced during the construction of the Project are handled, stored and disposed of in accordance with good waste management practices and relevant regulations and other legislative requirements. Regular audit during construction phase is recommended to ensure the effectiveness of implementation of recommended mitigation measures.

Landscape and Visual

5.1.10 Landscape and visual mitigation measures is recommended at construction and operational phase to ensure the landscape resources or character can be reinstated or enhanced to compatible with surrounding context in accordance with relevant regulations. The construction phase mitigation measures should be adopted from the commencement of construction and should be in place throughout the entire construction period. The operational phase mitigation measures should be adopted during the detailed design, and be built as part of the construction works so that they are in place at the date of commissioning of the Project.

5.1.11 Regular audit during construction phase and operational phase are recommended to ensure the effectiveness of implementation of recommended mitigation measures in order to reduce the visual impact during construction and operation. Also, mitigation measures to reinstate or enhance the landscape by proper landscape treatment at operational phase are applied. EM&A works is considered necessary.

6 CONCLUSION

6.1.1 The findings of the EIA provided information on the nature and extent of the environmental impacts likely arise from the construction and operation of the Rock Cavern Development. The EIA has, where appropriate, identified mitigation measures to ensure compliance with environmental legislation and standards.

6.1.2 Overall, the EIA concluded that the Rock Cavern Development would comply with the requirements of the EIA Study Brief (ESB-269/2014) and EIAO-TM with the implementation of the recommended mitigation measures during the construction and operational phases. The schedule of implementation of the recommended mitigation measures has been provided in the EIA report. An EM&A programme has also been recommended to check the effectiveness of the proposed mitigation measures.