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Contaminated Land Management in Hong Kong

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Outline

- Background
- Types of Contamination
- Statutory Requirements
- Assessment & Sampling
- Remediation
- Special Cases
- Conclusion

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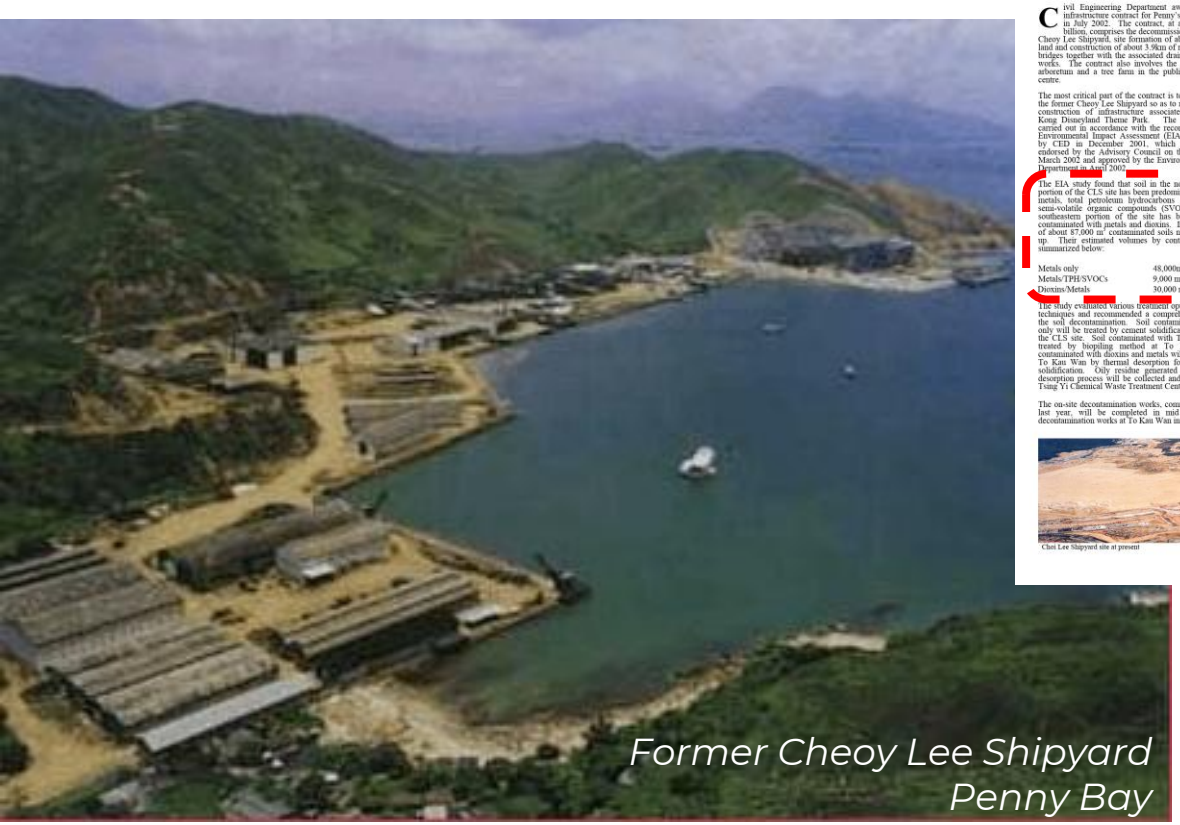
Background

Contaminated Lands in Hong Kong



Former Cheoy Lee Shipyard
Penny Bay

DECOMMISSIONING OF FORMER CHEOY LEE SHIPYARD

Civil Engineering Department awarded the second infrastructure contract for Penny's Bay Development in July 2002. The contract, at a cost of HK$1.38 billion, comprises the decommissioning of the former Cheoy Lee Shipyard, site formation of about 20 hectares of land and construction of about 3.9km of roads and vehicular bridges together with the associated drainage and sewerage works. The contract also involves the construction of an arboretum and a tree farm in the public water recreation centre.

The most critical part of the contract is to decommissioning the former Cheoy Lee Shipyard so as to release land for the construction of infrastructure associated with the Hong Kong Disneyland Theme Park. The works have to be carried out in accordance with the recommendation of the Environmental Impact Assessment (EIA) study completed by CED in December 2001, which was subsequently endorsed by the Advisory Council on the Environment in March 2002 and approved by the Environmental Protection Department in April 2002.

The EIA study found that soil in the northern and central portion of the CLS site has been predominantly impacted by metals, total petroleum hydrocarbons (TPH), and some semi-volatile organic compounds (SVOCs). Soil in the southeastern portion of the site has been found mainly contaminated with metals and dioxins. In summary, a total of about 87,000 m^3 contaminated soils needs to be cleaned up. Their estimated volumes by contaminant types are summarized below:

Metals only	48,000m^3
Metals/TPH/SVOCs	9,000 m^3
Dioxins/Metals	30,000 m^3

The study evaluated various treatment options and treatment techniques and recommended a comprehensive solution to the soil decontamination. Soil contaminated with metals only will be treated by cement solidification on site within the CLS site. Soil contaminated with TPH/SVOC will be treated by biopiling method at To Kau Wan. Soil contaminated with dioxins and metals will also be treated at To Kau Wan by thermal desorption followed by cement solidification. Oily residue generated from the thermal desorption process will be collected and incinerated at the Tsing Yi Chemical Waste Treatment Centre.

The on-site decontamination works, commenced in October last year, will be completed in mid 2003, while the decontamination works at To Kau Wan in mid 2005.

Cheoy Lee Shipyard site at present

前財利船廠原址現況

The EIA study found that soil in the northern and central portion of the CLS site has been predominantly impacted by metals, total petroleum hydrocarbons (TPH), and some semi-volatile organic compounds (SVOCs). Soil in the southeastern portion of the site has been found mainly contaminated with metals and dioxins. In summary, a total of about 87,000 m^3 contaminated soils needs to be cleaned up. Their estimated volumes by contaminant types are summarized below:

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Contaminated Lands in Hong Kong

SOUTH EAST KOWLOON DEVELOPMENT AT KAI TAK AIRPORT – DECONTAMINATION AND SITE PREPARATION

In parallel with the ground decontamination works at the apron area, most of the vacant buildings within the former airport site have been demolished. Although the advance work does not cover the former Passenger Terminal Building which is still in use until the re-development takes place at a later stage, the scale of demolition works for the 33 number of buildings is extraordinary in the Territory.

The traditional method of demolition with hydraulic breakers working 'top-down' from the roof was adopted for reinforced concrete structures. However, demolition of steel structures, such as the aircraft hangars, required tailor-made plans.

The construction and demolition (C&D) materials generated from building demolition and site preparation works are largely broken concrete and bricks. The total quantity of C&D materials is close to one million cu.m. After processing, these materials are perfect for use in future infrastructure development at Kai Tak. As such, a dedicated site near the end of the old runway has been used for crushing and stockpiling the C&D materials.

Other materials such as metals and steel reinforcement were thoroughly sorted on-site for recycling. Asbestos-containing material, timber and plastic constituted a small amount of waste and were disposed of at the landfill after appropriate treatment.

While safety is always a prime concern in building demolition, the works have been closely supervised and a comprehensive safety plan was also in place to ensure its proper execution. The air quality and construction noise were regularly monitored to make sure that the tolerable limits in these aspects would not be exceeded.

在啓德機場原址進行的九龍東南發展計劃 – 清理油污和地盤平整

在進行清理油污的同時，舊啓德機場內大部份空置的建築物都已消失了。由於舊機場客運大樓仍在使用中，以及未有即時發展計畫，所以這幢大樓的拆卸並未有包括在這項前期工程內。但是地盤平整範圍所涉及的三十三幢建築物拆卸規模已是本港罕有。

拆卸鋼筋混凝土建築物採用的傳統方法是利用液壓軋碎機由天台逐層向下推進，但對於鋼結構類建築物如飛機庫，拆卸方案有必要特別詳細設計。

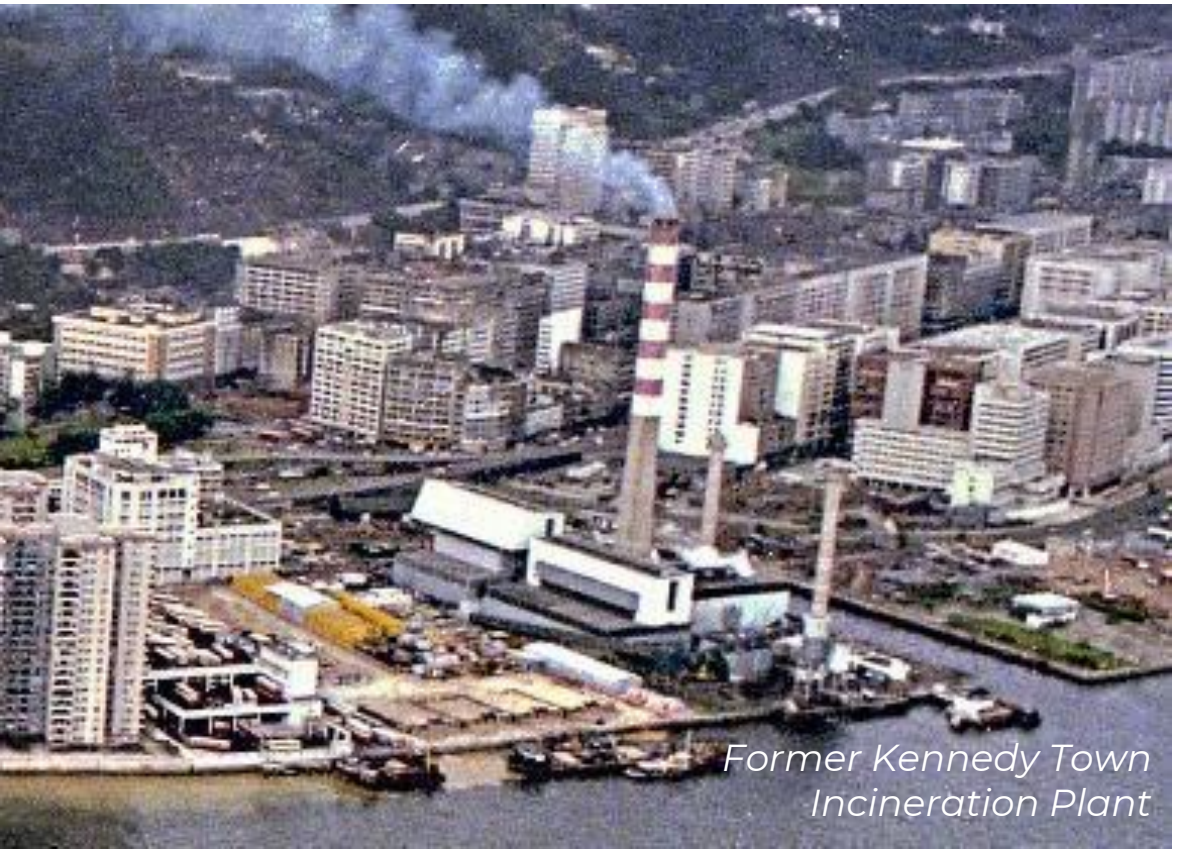
在拆卸樓宇和地盤平整過程中產生的拆建物料主要爲混凝土碎塊和磚塊，其數量約一百萬立方米。由於拆建物料經適當處理後，可適用於將來在舊機場內的基建項目，所以在跑道尾已特別留地作壓碎和貯存之用。

其他物料例如金屬和鋼筋已徹底分類，然後回收作循環使用。石棉類物料、木材和塑膠廢料，由於數量較少，處理妥當後已被送往堆填區。

拆卸過程中，工業安全一直備受重視。因此除嚴密監控拆卸工程外，在施工期間亦實施了一套全面的安全計劃，以確定工序正確地實行。而工地內亦定時進行監測，以確保拆卸工程期間，空氣質素及施工時的噪音不會超出限制。

Hong Kong's Kai Tak Airport was once the world's busiest airport and eventually became the world's largest remediation site once it was closed. When the airport was decommissioned, the government planned to rapidly clean up the site for commercial and residential development. After many years of soil penetration by various fuels and chemicals, the site required an extensive and sophisticated groundwater cleanup. The project consultant needed a treatment system that could destroy at least 95% of the volatile organic compounds (VOCs) and minimize operating cost. The project was highly publicized and generated intense government and public interest therefore the chosen treatment system had to be proven and reliable.

Contaminated Lands in Hong Kong



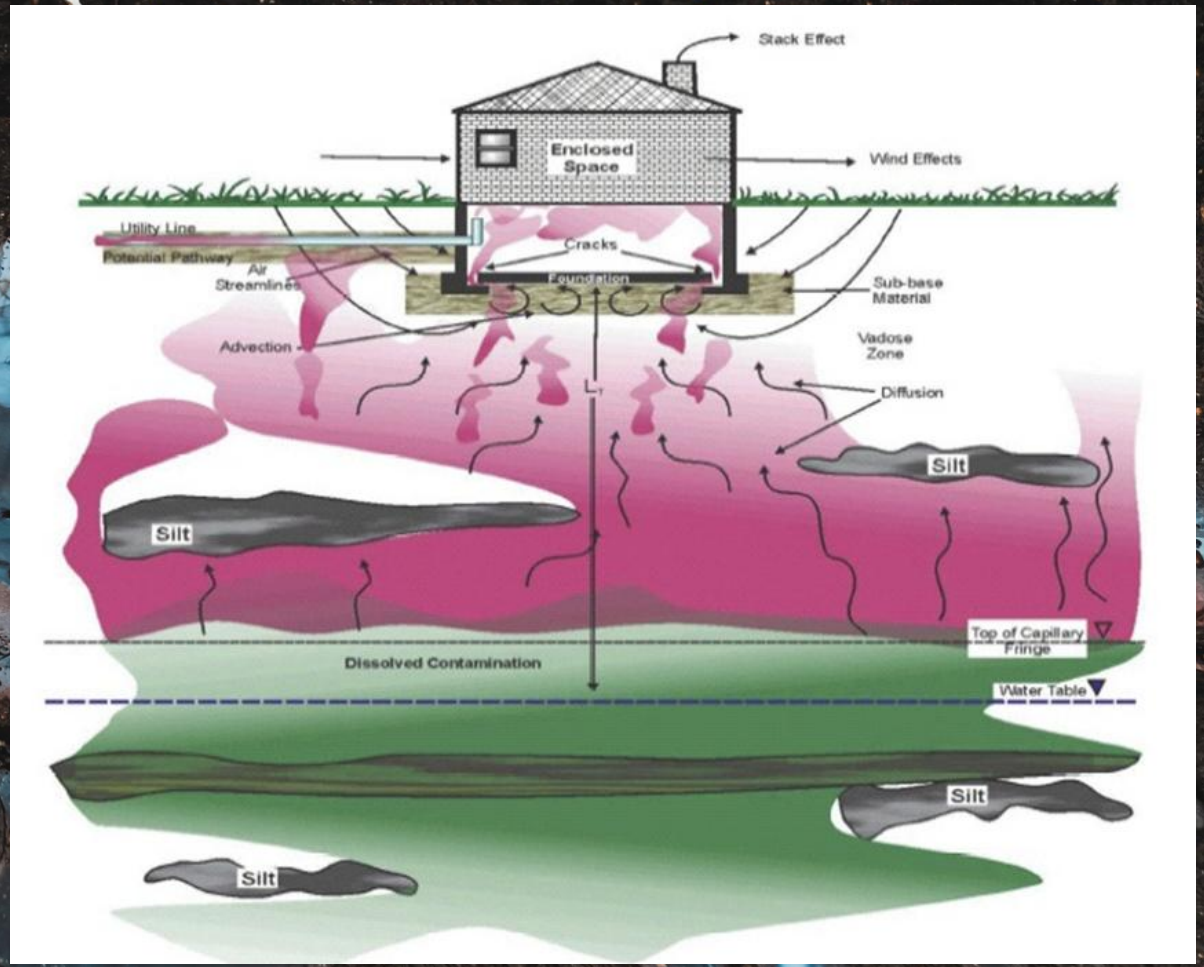
Former Kennedy Town Incineration Plant

3rd Runway Reclamation near Contaminated Mud Pits

Contaminated Sites in Hong Kong

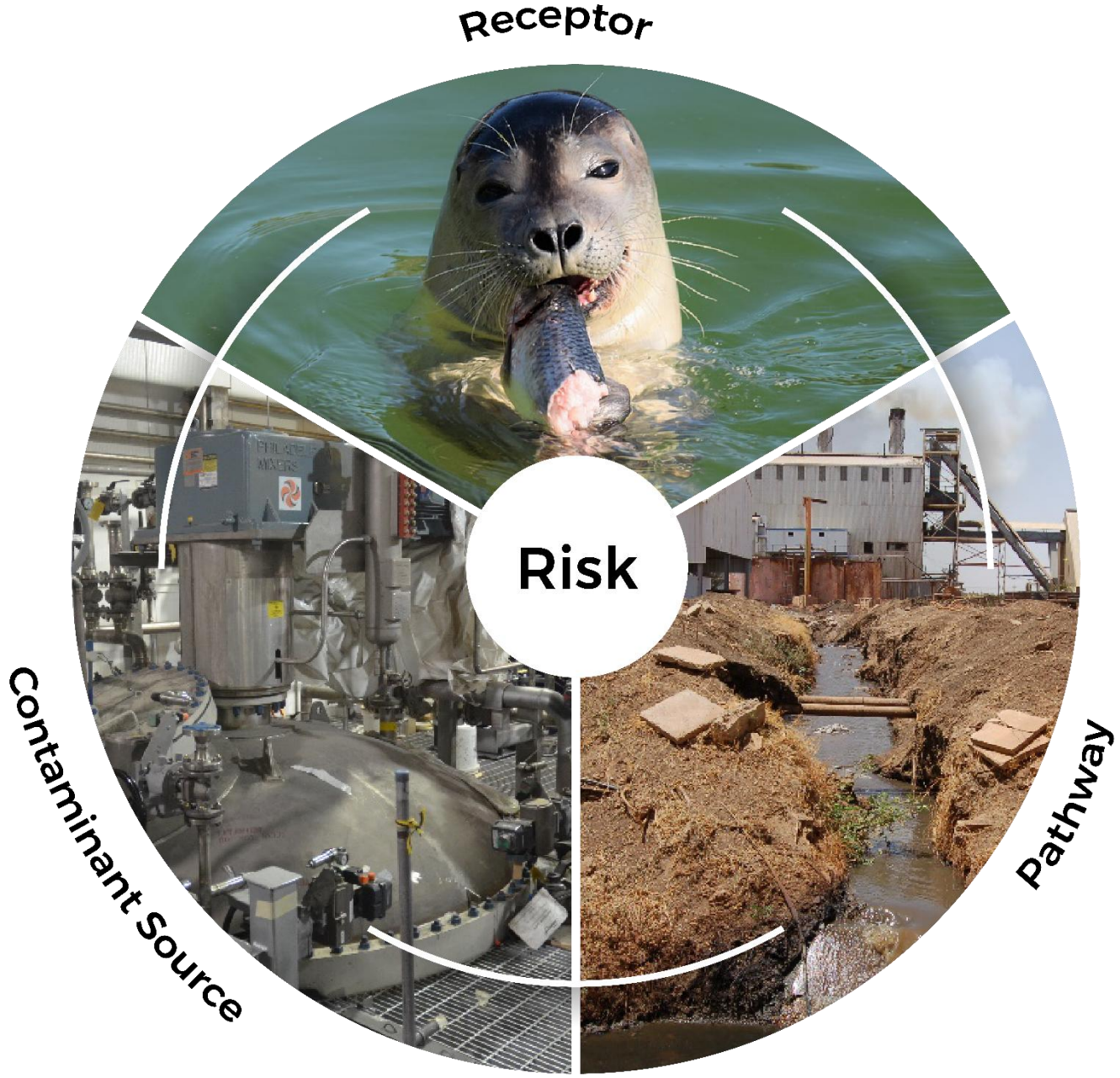
Why is it a Concern?

- Contaminated land may involve surficial and/or subsurface soils that, through leaching and transport, may impact groundwater, surface water and adjacent properties.
- Where contaminant sources include volatile substances, soil vapor may also become a transport and exposure medium.



Where is the Risk?

Should all contaminated land be fully cleaned?



Contamination Types

Typical 3 main types in Hong Kong

- Soil and groundwater contamination due to land uses
- Natural occurrence – Arsenic
- Sediment
  - Natural occurrence Marine Deposit
  - Pond

Soil and Groundwater Contamination

Table 2.3 : *Contaminated Land Types and Key Chemicals of Concern (COCs)*

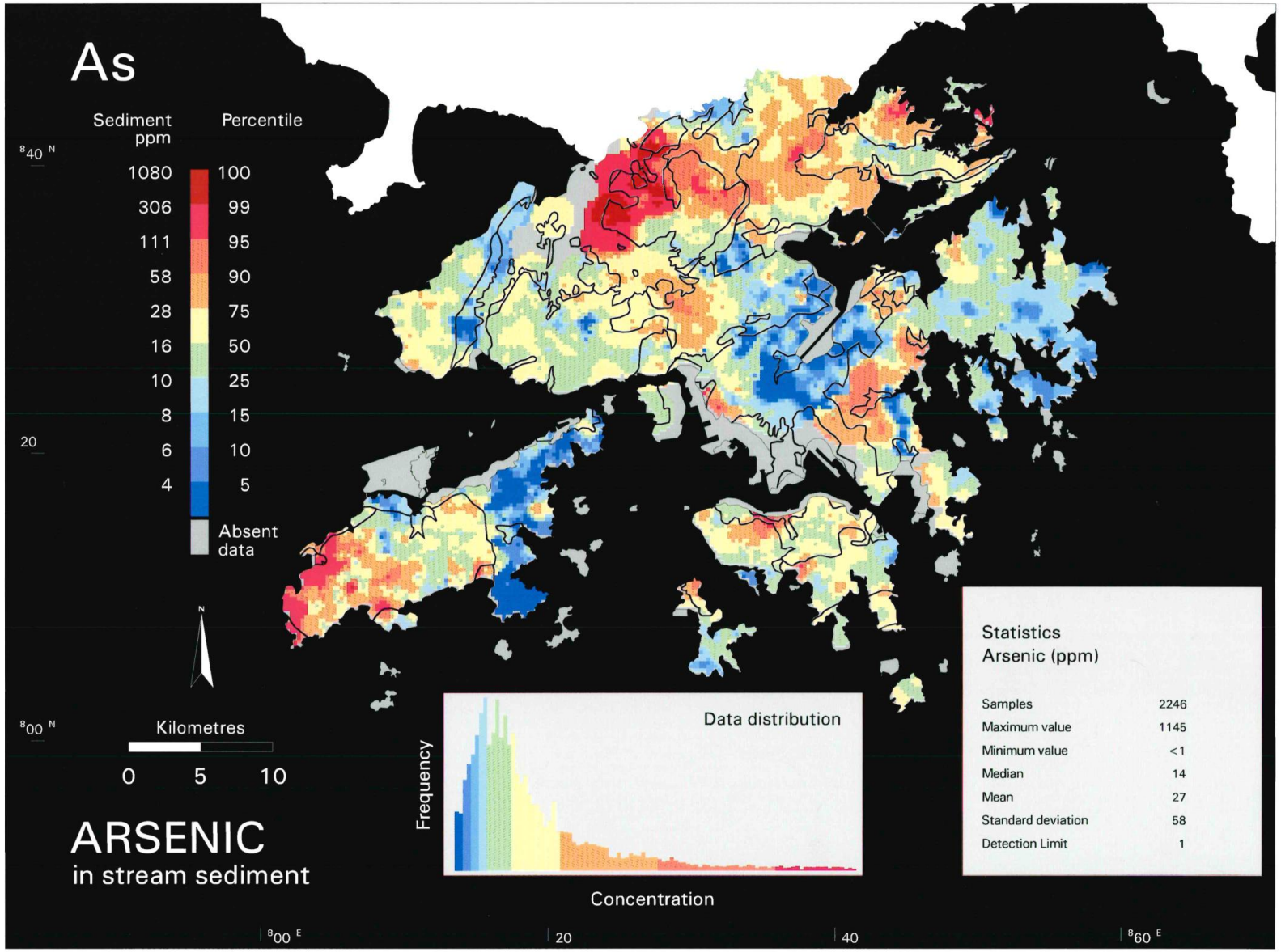
Land Use Types[x]	Potentially Polluting Activities	Key COCs[+]
• Boat / ship building or repairing	Storage, handling and use of fuels and solvents (e.g. for thinning paints, cleaning and degreasing metal parts of equipment) for ship building, repair and maintenance activities. Transfer and disposal of scrap metal, metal shaving dust and paint chips.	Metals^ (e.g. arsenic, chromium, copper, lead, nickel and zinc), free cyanide, VOCs (e.g. BTEX, 2-butanone), SVOCs, PCRs, TBTO, dioxins and furans.
• Chemical manufacturing / processing plants, dangerous goods stores	Spillages and accidents related to storage of chemicals, manufacturing process, equipment maintenance and cleaning, storage, treatment and disposal of wastes.	[#] Dependent on the materials handled, stored, used and produced on site.
• Concrete and asphalt production	Storage and transfer of residues from physical conversion of earthen materials by sorting, mixing, and grinding.	VOCs (e.g. BTEX), SVOCs and PCRs.
• Golf courses	Application of chemicals (pesticides and herbicides) for maintaining the golf courses, on-site power generation, vehicle, machinery and equipment fuelling and maintenance.	Metals (e.g. arsenic), PCRs, PCBs. pesticides[a] and herbicides[a].
• Motor vehicle / equipment depot, repairing, service centres	Release of oils and fuels and lubricants from vehicles, vehicle and equipment maintenance and refuelling. Use of chemicals and solvents in maintenance activities. Motor vehicle painting and storage and disposal of wastes.	Metals^ (e.g. chromium, copper, lead, manganese, nickel, zinc), PCRs, VOCs (e.g. acetone, BTEX, MTBE, and trichloroethene) and PAHs^^^.
• Open area storage	Loading, unloading and storage of goods, fuel storage and transfer, maintenance of equipment and vehicles.	Metals^^, PCRs, VOCs and SVOCs.
• Petrol filling stations	Leaks from pipework, tanks and offset fill pipes. Spills during customer refuelling, filling underground storage tanks and over filling of portable containers.	Metals^ (e.g. lead), PCRs, VOCs (e.g. BTEX and MTBE), and PAHs^^^.
• Petroleum Products and coal industrial operations (including oil depots and gas works)	Storage and handling of hydrocarbons and/or coal, manufacture, storage and transfer of refined hydrocarbon products.	Metals^ (e.g. arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel and zinc), free cyanide, VOCs (e.g. BTEX and MTBE), SVOCs (e.g. PAHs^^^ and phenol) and PCRs.
• Power plants, individual power generation units	Storage, transfer and use of fuels, oils and chemicals, equipment and vehicle maintenance activities, storage, treatment and disposal of combustion residues, dielectric fluid spillage/leakage from transformers and other equipment and waste disposal.	Metals^ (e.g. arsenic, cadmium, chromium, mercury, nickel related to coal/ash metal composition and lead related to petroleum products, other trace metals may also be present), PCRs, VOCs (e.g. BTEX), SVOCs (e.g. phenol, naphthalene) and PCBs.
• Scrap yards	Waste oils and fuels and lubricants from scrap vehicles, transformers, scrap metals, vehicle and equipment maintenance and refuelling. Storage and disposal of wastes.	Metals^^, VOCs (e.g. acetone, BTEX, MTBE and trichloroethene), SVOCs (e.g. PAHs ^^^), PCBs and PCRs.
• Steel mills / metal workshops	Use of metals and chemicals for manufacturing, equipment maintenance and cleaning, storage, treatment and disposal of wastes.	Metals^^, PCRs, VOCs (e.g. BTEX), SVOCs (e.g. phenol, and PAHs^^^).
• Waste recycling workshops	Storage and processing of waste materials, storage and transfer of chemicals and fuels. Storage and disposal of wastes.	Metals^^, VOCs, SVOCs and PCRs. Depending on the waste types and operations on site, PCB and dioxins may be present.

Notes:

1. The key COCs listed in this table may not reflect all those that may be present at a specific site and consideration should be given to particular process, materials used at an individual site when identifying potential COCs and planning the site investigation. This table is not intended to be exhaustive. Other polluting activities may be present in Hong Kong but not listed here. Users would need to exercise judgment to determine the COCs to be analysed on the subject site.
2. [x] **Reference:** Lands Administration Office's Technical Circular No. 735A and Environmental Protection Department's Guidance Note for Contaminated Land Assessment and Remediation.
3. [#] Sources of contaminants could be present depending onsite activities, but could include RBRGs metals, petroleum carbon ranges (PCRs) - in the RBRGs the PCRs include C_6-C_8, C_9-C_{16} and C_{17}-C_{35}, volatile organic chemicals (VOCs), semi-volatile organic chemicals (SVOCs). The desktop study will need to carefully record such items and justify the COCs to be tested for.
4. [+] The key COCs listed against each of the contaminated land types do not take into account the potential for the use of emergency power generators (such as fuel storage and transfer facilities and transformers) and associated contaminants.
5. [^] The metals listed in brackets are those that are typically present; however, the Project Proponent shall use professional judgment and historical information to determine potential COCs for an individual site.
6. [^^] It is recommended that a full suite of metals are analysed for these industries unless a specific list of metals could be confirmed based on historical information or previous investigations.
7. [^^^] Polyaromatic hydrocarbons (PAHs) in the RBRGs include, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene.
8. [a] These chemicals are not included in the RBRGs lists. The UK standard for pesticides and herbicides is very stringent at 0.1 micrograms per litre (0.1 parts per billion) for individual pesticides or 0.5 micrograms per litre for total pesticides.
9. **Reference:** US EPA Compliance Assistance http://www.epa.gov/Compliance/resources/publications/assistance/sectors/notebooks/index.html

Natural Occurrence - Arsenic

- Northern New Territories
  - Kwu Tung North



Sediment

- Natural Marine Deposit
  - Dredging
  - Reclamation Areas
  - Heavy Metals & Organics
- Pond Sediment
  - Fish Ponds
  - Northern New Territories
  - Heavy Metals
  - Nutrients

Statutory Requirements

- Lands Department - Decontamination Policy
- EPD – Land Contamination Assessment
- Buildings Department- Decommissioning and Demolition of underground oil tanks

Land Contamination Policy

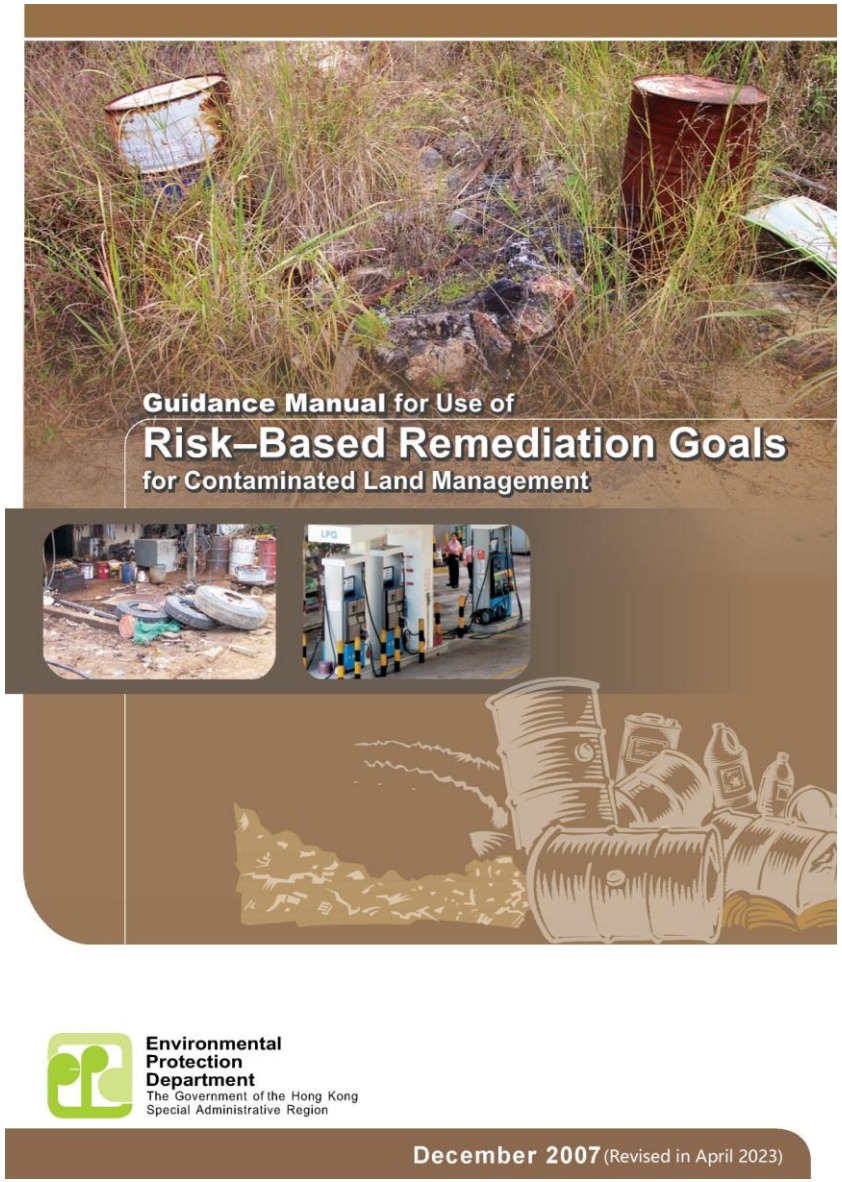
10. Land lease conditions and planning permissions are management tools used to require the lessees to conduct assessments and to remedy land contamination arising from activities that are potentially contaminating. A decontamination clause has been included in all new leases for industrial/godown and petrol filling station purposes since 2003. The decontamination clause was drawn up by Lands Department in consultation with the Environmental Protection Department (EPD). This clause is imposed as a land lease condition requiring the lessee of a site to prevent land contamination, to conduct contamination assessment and, if necessary, to clean up the site at his own expense before the site is returned to the Government. It also specifies that if the lessee fails to take up his responsibilities, the Government may carry out the works and demand the lessee to pay the full cost of the works.

11. Project proponents of "Designated Projects" as defined under the EIAO will need to go through the EIA process and obtain an EP from EPD before the relevant works can commence. If there is information to indicate that a "Designated Project" is to be carried out on land which is potentially contaminated due to previous polluting uses such as shipyard or underground oil tanks, the project proponent will need to prepare and submit a Contamination Assessment Plan (CAP) to EPD for endorsement prior to the commencement of the site investigation work. Based on the CAP, the project proponent shall conduct a contamination assessment and compile a Contamination Assessment Report (CAR) to document the findings for approval by EPD. If the findings confirm that the site is contaminated, a Remediation Action Plan (RAP) will be required. These actions have to be completed before any development can take place.

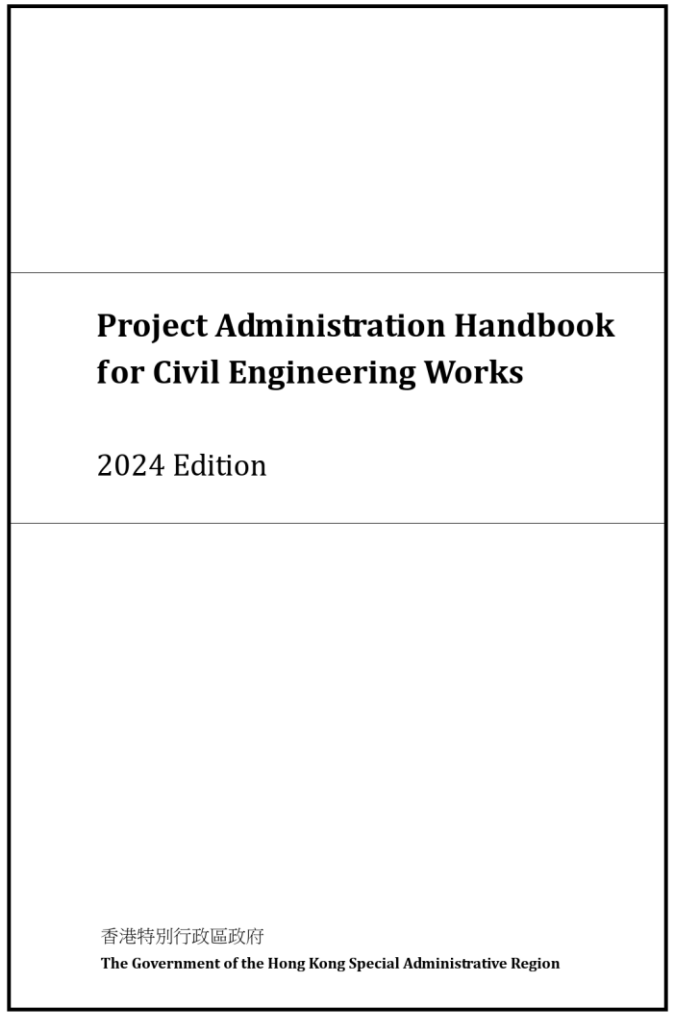
12. It is considered that the above control measures are adequate to prevent or to rectify land contamination. The Government is also reviewing international trends and control mechanisms adopted by overseas jurisdictions to enhance our knowledge and improve control over contamination issues in Hong Kong.

Environment, Transport and Works Bureau
May 2004

EPD – Land Contamination Assessment



Sediment Management Framework – Public Projects



4.2 MARINE WORKS

Guidelines on the design of marine works are contained in the Port Works Design Manual. For proposals on dredged/excavated sediment, the rationale for sediment removal and applications for approval of dredging/ excavation proposals and allocation of marine disposal space should be submitted to the Marine Fill Committee (MFC) in accordance with Section 4.2.1 of this Chapter and WBTC No. 12/2000. In addition to the requirements in Section 4.2.1 of this Chapter, additional control measures given in Appendix 4.21 should be taken for the management of dredged/excavated contaminated sediment.

4.2.1 Management of Dredged/Excavated Sediment (Subsumed from ETWB TCW No. 34/2002)

The requirements stipulated in WBTC No. 12/2000 "Fill Management" are relevant.

Effective Date

All projects or portions of projects which involve the marine disposal of dredged/excavated sediment and the Sediment Sampling and Testing Plan (SSTP) has not been approved by the Director of Environmental Protection (DEP) shall follow Section 4.2.1 of this Chapter.

Sediment Management Framework – Private Projects

Administrative Guidance – Management Framework for Disposal of Dredged/Excavated Sediment

(The requirements stipulated in WBTC No. 12/2000 "Fill Management" are relevant)

This Guidance is issued to provide information on the management framework for dredged/excavated sediment disposal under the Dumping at Sea Ordinance, Cap. 466 (DASO). It states the requirements for justifying the need for dredging and provides guidance for the authorized persons/ registered structural engineers/ registered geotechnical engineers (AP/ RSE/RGE) on how to obtain information on the sediment, which can then be used for supporting the permit application by the contractors and/or other parties responsible for the disposal. It also describes the classification of sediment into three categories based on their contaminant levels, outlines the procedures for assessing sediment quality and explains the marine disposal arrangements for the different sediment categories.

Effective Date

2. All private projects which involve the marine disposal of dredged/excavated sediment and the Sediment Sampling and Testing Plan (SSTP) has not been approved by the Director of Environmental Protection (DEP) shall follow this Guidance.

Rationale for Dredging

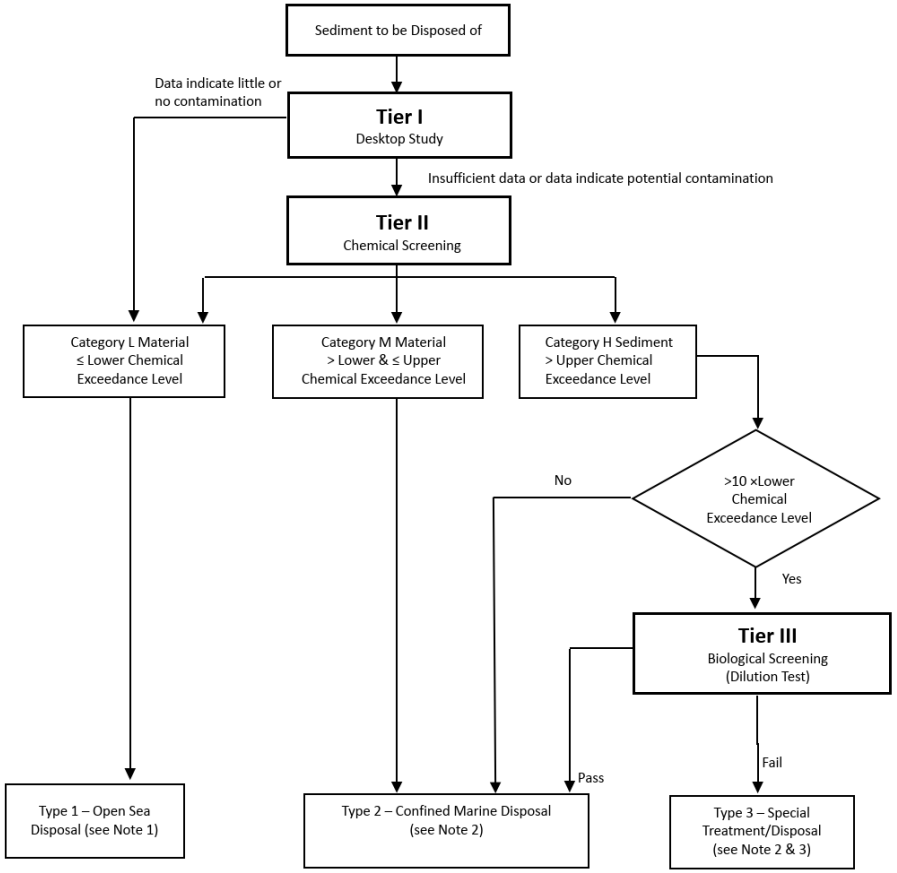
3. The allocation of sediment disposal space at sea will not be considered until the need for removal of the sediment has first been satisfactorily demonstrated. The rationale for sediment removal must therefore be provided to the Secretary of MFC for agreement, as early as possible, preferably at the Environmental Impact Assessment Stage, if one is conducted. Volumes of Category L sediment (see **Appendix A**) below 50,000 m^3 are exempted from this requirement.

4. Dredging of sediment will be allowed without justification in the following cases:

(a) emergency dredging for safety reasons or averting environmental hazards;
(b) maintenance/deepening of the harbour fairways, berths, anchorages, navigation channels or approaches; and
(c) maintenance (but not construction) of watercourses, rivers, stream courses, drainage channels or outfalls.

5. In all other cases, project proponents shall plan their projects on the assumption of keeping the mud in place. Time for consolidation of mud, with treatment if necessary, and consequential programme constraints shall be allowed for in programming. Additional time required for consolidation of mud left in place will not be accepted as justification for mud dredging. MFC will scrutinise applications for exemption taking into account factors including the practicality of performance specifications, completeness of risk management strategies, and comprehensiveness of option assessments including consideration of new technology. Where cost is considered, the estimation must include a fair and complete estimate of all cost components, including the actual cost of mud disposal (obtainable from MFC Secretariat) and necessary dredging and transportation, disposal management, monitoring and other associated activities.

APPENDIX C Management Framework for Dredged/Excavated Sediment



Notes

(1) Most open sea disposal sites are multi-user facilities and as a consequence their management involves a flexibility to accommodate varying and unpredictable circumstances. Contract documents should include provisions to allow the same degree of flexibility should it be necessary to divert from one disposal site to another during the construction period of a contract.

Pond Sediment

- Similar Testing as Marine Deposit
- Additional Test
  - Nutrients
- Case by case

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Assessment

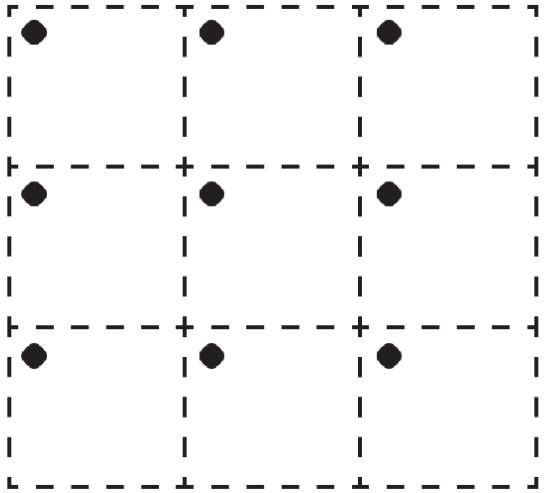
Cable Percussive Drill

Shelby Tube Sampler

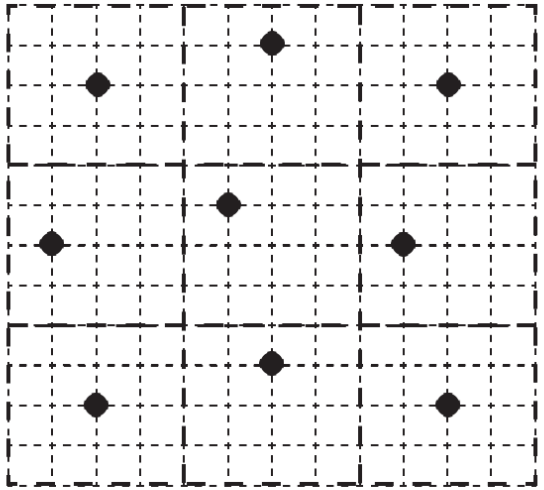
Split Barrel Sampler

Site Investigation

Figure 2.3 : *Regular Square Grid Pattern and Offset Square Grid Pattern (Herringbone Pattern) Sampling Design*



Regular Square Grid Pattern



Offset Square Grid Pattern
(note the herringbone pattern with 1/4 grid offset)

Table 2.1 : *Minimum Number of Grid Sampling Points*

Area of site (m^2)	Square grid size (m)	Minimum number of sampling points
100	6	3
500	13	3
1,000	13	6
2,000	13	12
4,000	17	14
5,000	17	17
8,000	17	28
10,000	19	29
30,000	31	32
90,000	51	35

Notes:

1. For an area of site greater than 90,000m^2, project proponent should propose the number of grid sampling points for EPD's agreement. In any case, the square grid size should not be greater than 100m.
2. Apart from grid sampling, soil samples should also be taken from any identified hot spots.

Estimated Total Volume of Dredged Materials (10,000 m^3)	Number of Sampling Station
<2.5	3
2.5 to <10	8
10 to <50	12
50 to <200	20
100k to <100k +100	(16+4k)
k is an integer which is larger than or equal to 2	

Assessment - Sampling

Soil and Ground

- Dry Borehole Drilling
- Soil samples at 0.5, 1.5 & 3.0mbgl
- Terminated at 6mbgl
- Groundwater well installation

Natural Arsenic

- Dry Borehole Drilling
- Terminated at rock level
- Sampling at every 1m

Sediment

- Dry Borehole Drilling
- 0-0.9, 1-1.9, 2-2.9m then every 3m
- Terminated at change of strata or excavation level

Assessment – Chemical & Biological Testing

Soil and Ground

- Depending on land use
- RBRGs
- Heavy Metals
- VOCs
- SVOCs
- PCBs
- PCRs
- Cyanide
- Dioxins

Natural Arsenic

- Arsenic only

Sediment

- Metals
- Metalloids
- Organic PAHs
- Organic Non-PAHs (PCBs)
- Organometallic
- Toxicity
- Nutrients (pond sediment)

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Remediation

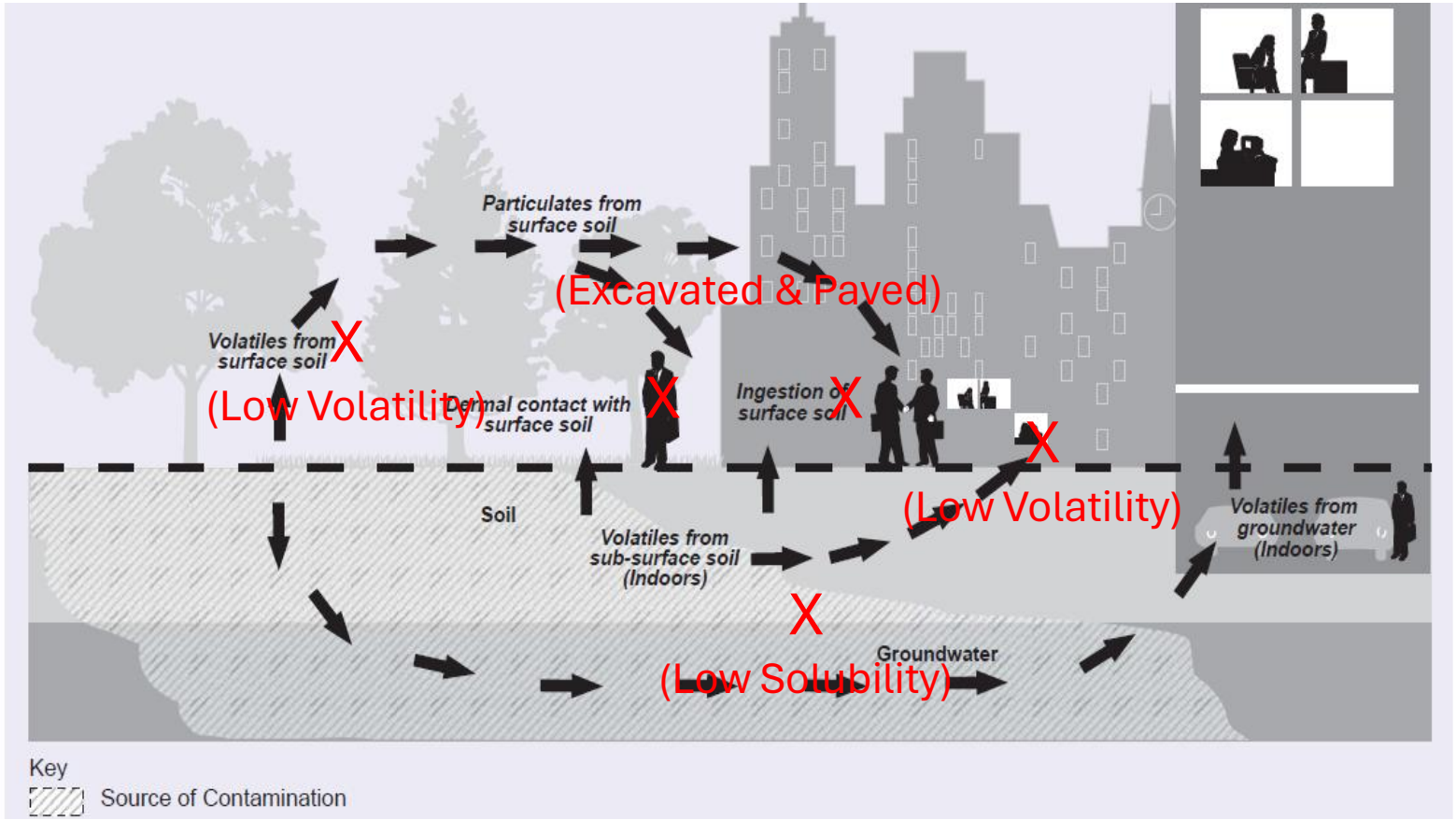
Remediation Measures

Considerations

1. Contaminant nature
2. Human exposure during construction and future occupation
3. Project constraints e.g. building retain

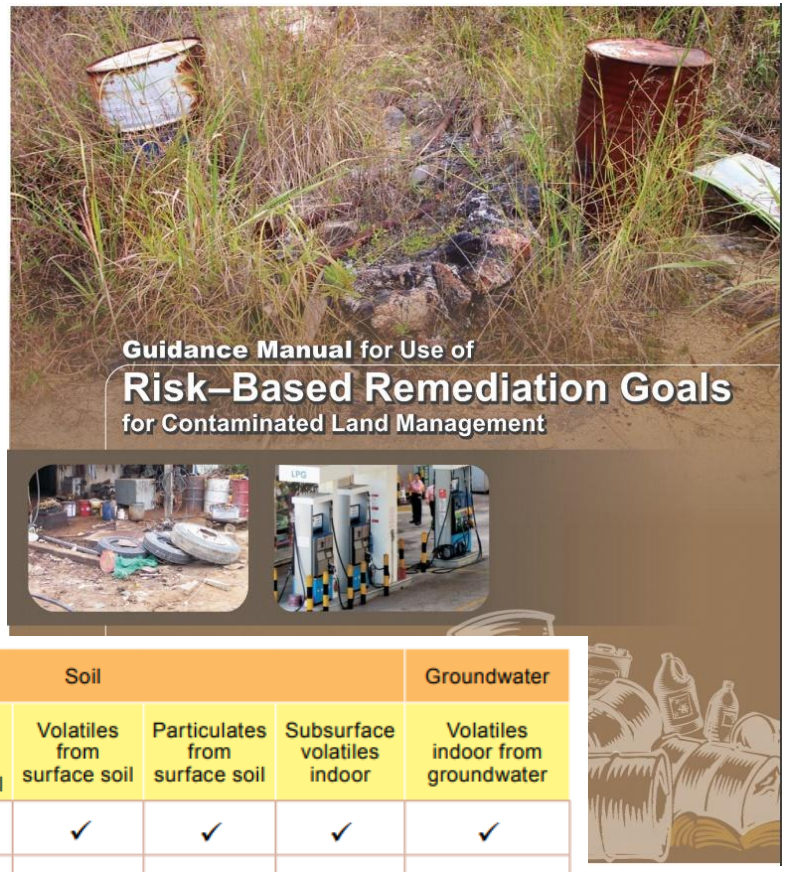
Measures:

1. Excavation and Remediation
2. Administrative Measures to avoid disturbance to sub-surface soil
3. Capping using clean fills under concrete slab



Source: Practice Guide for Investigation and Remediation of Contaminated Land

When do we need treatment?



Land Use Scenario	Type of RBRG	Soil					Groundwater
	Pathway	Ingestion of surface soil	Dermal contact with surface soil	Volatiles from surface soil	Particulates from surface soil	Subsurface volatiles indoor	Volatiles indoor from groundwater
	Urban Residential	✓	✓	✓	✓	✓	✓
	Rural Residential	✓	✓	✓	✓	✓	✓
	Industrial	✓	✓	✓	✓	✓	✓
	Public Parks	✓	✓	✓	✓		

Chemical	Risk-Based Remediation Goals for Soil				Soil Saturation Limit (C_{sat}) (mg/kg)
	Urban Residential (mg/kg)	Rural Residential (mg/kg)	Industrial (mg/kg)	Public Parks (mg/kg)	
VOCs					
Acetone	9.59E+03	4.26E+03	1.00E+04*	1.00E+04*	***
Benzene	7.04E-01	2.79E-01	9.21E+00	4.22E+01	3.36E+02
Bromodichloromethane	3.17E-01	1.29E-01	2.85E+00	1.34E+01	1.03E+03
2-Butanone	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	***
Chloroform	1.32E-01	5.29E-02	1.54E+00	2.53E+02	1.10E+03
Ethylbenzene	7.09E+02	2.98E+02	8.24E+03	1.00E+04*	1.38E+02
Methyl tert-Butyl Ether	6.88E+00	2.80E+00	7.01E+01	5.05E+02	2.38E+03
Methylene Chloride	1.30E+00	5.29E-01	1.39E+01	1.28E+02	9.21E+02
Styrene	3.22E+03	1.54E+03	1.00E+04*	1.00E+04*	4.97E+02
Tetrachloroethene	1.01E-01	4.44E-02	7.77E-01	1.84E+00	9.71E+01
Toluene	1.44E+03	7.05E+02	1.00E+04*	1.00E+04*	2.35E+02
Trichloroethene	5.23E-01	2.11E-01	5.68E+00	6.94E+01	4.88E+02
Xylenes (Total)	9.50E+01	3.68E+01	1.23E+03	1.00E+04*	1.50E+02
SVOCs					
Acenaphthene	3.51E+03	3.28E+03	1.00E+04*	1.00E+04*	6.02E+01
Acenaphthylene	2.34E+03	1.51E+03	1.00E+04*	1.00E+04*	1.98E+01
Anthracene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	2.56E+00
Benzo(a)anthracene	1.20E+01	1.14E+01	9.18E+01	3.83E+01	
Benzo(a)pyrene	1.20E+00	1.14E+00	9.18E+00	3.83E+00	
Benzo(b)fluoranthene	9.88E+00	1.01E+01	1.78E+01	2.04E+01	
Benzo(g,h,i)perylene	1.80E+03	1.71E+03	1.00E+04*	5.74E+03	
Benzo(k)fluoranthene	1.20E+02	1.14E+02	9.18E+02	3.83E+02	
bis-(2-Ethylhexyl)phthalate	3.00E+01	2.80E+01	9.18E+01	9.42E+01	
Chrysene	8.71E+02	9.19E+02	1.14E+03	1.54E+03	
Dibenzo(a,h)anthracene	1.20E+00	1.14E+00	9.18E+00	3.83E+00	
Fluoranthene	2.40E+03	2.27E+03	1.00E+04*	7.62E+03	
Fluorene	2.38E+03	2.25E+03	1.00E+04*	7.45E+03	5.47E+01
Hexachlorobenzene	2.43E-01	2.20E-01	5.82E-01	7.13E-01	
Indeno(1,2,3-cd)pyrene	1.20E+01	1.14E+01	9.18E+01	3.83E+01	
Naphthalene	1.82E+02	8.56E+01	4.53E+02	9.14E+02	1.25E+02
Phenanthrene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	2.80E+01
Phenol	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	7.26E+03
Pyrene	1.80E+03	1.71E+03	1.00E+04*	5.72E+03	
Metals					
Antimony	2.95E+01	2.91E+01	2.61E+02	9.79E+01	
Arsenic	2.21E+01	2.18E+01	1.96E+02	7.35E+01	
Barium	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Cadmium	7.38E+01	7.28E+01	6.53E+02	2.45E+02	
Chromium III	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Chromium VI	2.21E+02	2.18E+02	1.96E+03	7.35E+02	
Cobalt	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Copper	2.95E+03	2.91E+03	1.00E+04*	9.79E+03	
Lead	2.58E+02	2.55E+02	2.29E+03	8.57E+02	
Manganese	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Mercury	1.10E+01	6.52E+00	3.84E+01	4.56E+01	
Molybdenum	3.69E+02	3.64E+02	3.26E+03	1.22E+03	
Nickel	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Tin	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Zinc	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Dioxins / PCBs					
Dioxins (I-TEQ)	1.00E-03	1.00E-03	5.00E-03	1.00E-03	
PCBs	2.36E-01	2.26E-01	7.48E-01	7.56E-01	
Petroleum Carbon Ranges					
C6 - C8	1.41E+03	5.45E+02	1.00E+04*	1.00E+04*	1.00E+03
C9 - C16	2.24E+03	1.33E+03	1.00E+04*	1.00E+04*	3.00E+03
C17 - C35	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	5.00E+03
Other Inorganic Compounds					
Cyanide, free	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	

Remediation

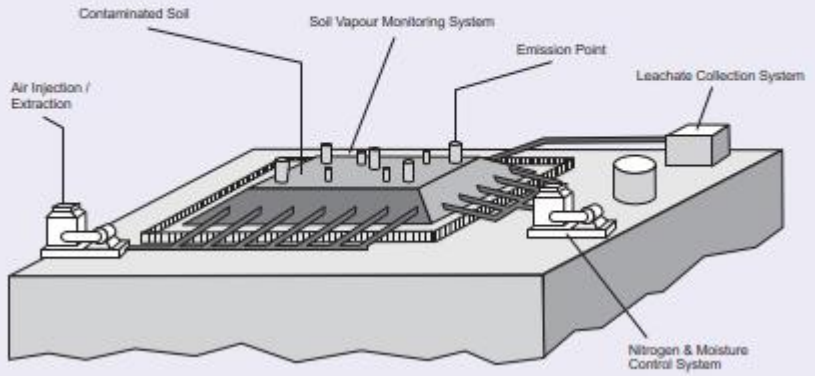
For Hong Kong

- Soil
  - Heavy Metals – Cement Solidification / Stabilisation (C S/S)
  - Organics - Biopiling

Ex situ Solidification/ Stabilisation solutions

Biopile

Engineered soil pile designed to enhance biodegradation. It allows natural processes to breakdown harmful chemicals. The microorganisms that live in soil can transform certain harmful chemicals, such as those found in gasoline and oil spills, eventually into water and carbon dioxide.



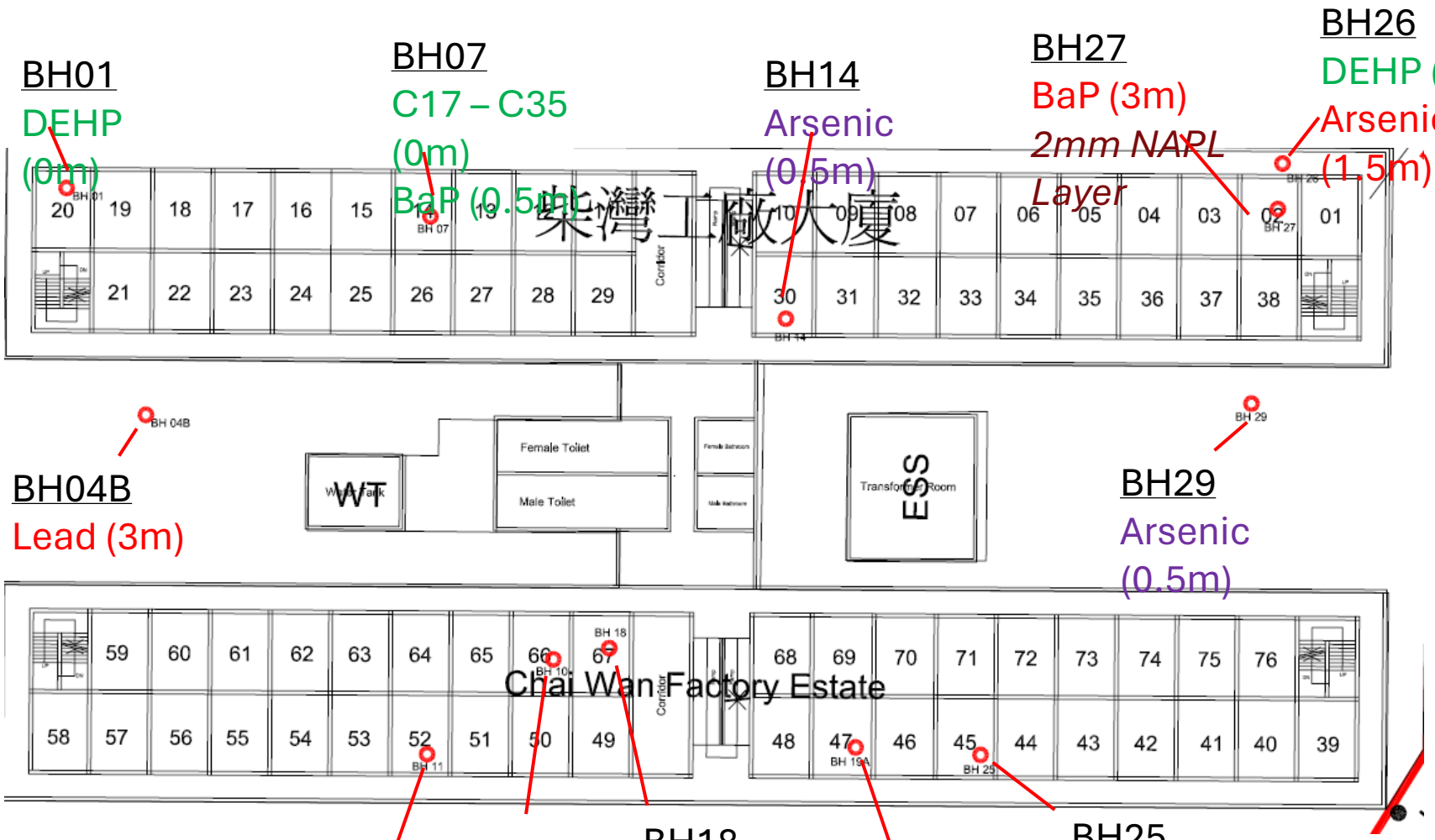
Remediation

- Groundwater
  - Contaminants
  - Cost
  - Operations

Special Cases

Chai Wan Factory Estate

Summary of Preferred Remediation



Legends

Excavation and Cement Solidification

Excavation and Disposal

In-situ Capping

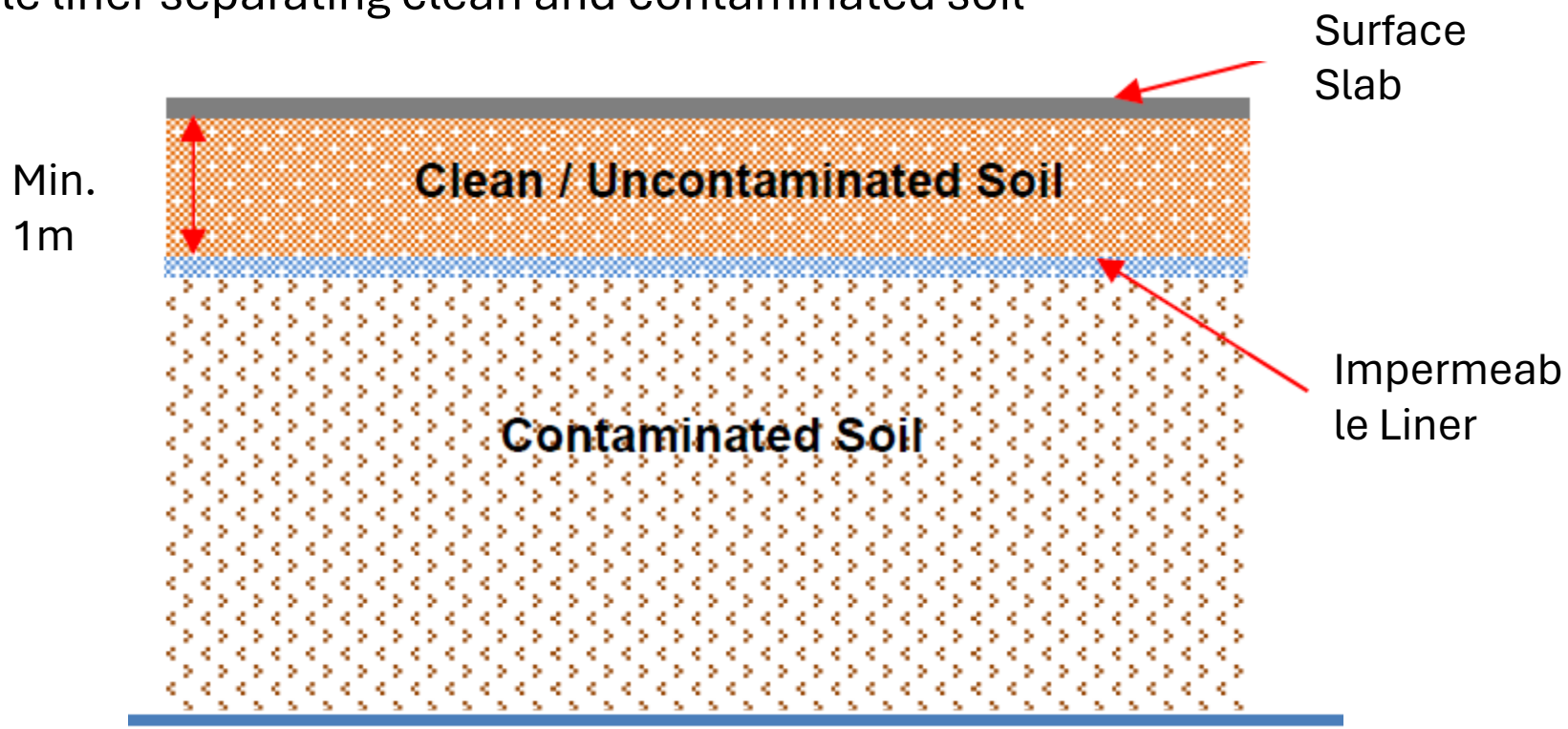
Groundwater Remediation

Excavation and Remediation (Soil above 1.47m)

- Confirmation Sampling to confirm excavation extents
- Remediation
  - Cement Solidification
    - Metal-contaminated soil (Arsenic, Lead)
    - Mix soil with cement and water in a pre-determined ratio (from pilot study) to stabilise the contaminant
    - Universal Treatment Standards for On-site Reuse of Cement Stabilisation/ Solidification Treated Soil (TCLP Test) and Unconfined Compressive Strength (UCS Test)
    - On-site reuse or CEDD Public Fill Bank after TCLP Confirmation or direct disposal to Landfill
  - Direct Disposal
    - Organic-contaminated soil (BaP, DEHP)
    - Disposal as Chemical Wastes to SENT Landfill
    - Application to WFG/EPD with approved CAR/RAP 3 months before disposal

In-situ Capping

- Confirmation Sampling to confirm capping extents
- Structural design using concrete slab on the surface with at least 1m clean soil under the ground floor slab
- Impermeable liner separating clean and contaminated soil



Lok Ma Chau Loop – Pond Sediment

Pond Sediment Disposal

- C S/S Treatment and backfill (planned)
- Marine Disposal
  - EPD and MFC of CEDD arrangement
  - Additional Testing - nutrients
  - Trial dumping and monitoring
    - Water Quality Monitoring during Trial Dumping (background and post dumping)
    - Regular water quality monitoring

Conclusion

- Three main types of land contamination
  - Soil and groundwater due to land use
  - Natural Arsenic
  - Sediment
- EPD standard sampling and testing
- Case by case for remediation


SJ
Real impact,
made together.
Thank You