8 Land Contamination Impacts

8.1 Overview

This section presents the assessment of land contamination impacts which may arise during the construction and operation phases. The assessment has covered the areas within the boundaries of KTN and FLN NDAs. Details of the assessment can be referred to the Contamination Assessment Plans (CAPs) given in **Appendices 8.1** and **8.2**.

Environmental Site Investigation (SI) has been conducted in 4 government sites (3 in KTN and 1 in FLN). The concentration of the metal "Arsenic (As)" (i.e. ranged from 24 mg/kg to 430 mg/kg) from 35 soil samples collected from 10 inspection pits and 2 boreholes at 3 government sites in KTN exceeded various Risk-Based Remediation Goals (RBRGs) from Rural Residential (i.e. the stringent set of RBRG) to Industrial (i.e. the most relax set of RBRG) land uses while that (ranged from 1.4 mg/kg to 8.9 mg/kg)from 11 soil samples collected from 2 inspection pits and 1 boreholes at 1 government site in FLN was well below the stringent set of the RBRG. A supplementary environmental SI (i.e. 1 inspection pit at each of 3 sites in KTN) with comprehensive "Arsenic Specimen" testing was subsequently conducted at the 3 government sites in KTN to investigate the toxicity of high Arsenic levels detected in KTN. An "Off-site" location in KTN (i.e. a location without significant human and industrial activities base on the review of historical aerial photos) was also selected for borehole drilling to provide further "background" information of Arsenic level in KTN. Details of the SI results could be referred to the Contamination Assessment Report (CAR) given in **Appendix 8.3**.

Anomalistic high arsenic detected in KTN was investigated. The investigation results indicated that the high arsenic in KTN is likely to be naturally occurred. A Health Risk Assessment (HRA) has been conducted for assessing the health risk levels due to the inhalation of arsenic-containing dust during construction stage and incidental ingestion of arsenic-containing soil during operational stage. A HRA Report has been prepared to summarize the extent mapping of arsenic level, the health risk assessment findings, and the proposed treatment method for high background arsenic (**Appendix 8.4**).

All other potentially contaminated sites identified in 2 NDAs (include Fanling Bypass) were inaccessible and hence, no soil and groundwater sample has been collected during the course of this land contamination assessment study. Nevertheless, detailed SI for these sites should be conducted when they are resumed and handed over to the Project Proponent (PP).

On the other hand, although many of the sites were not identified as potentially contaminated or could not be accessed for visual inspection during the site survey, these sites would still in operation until

commencement of construction. Any potential change of land uses (e.g. change of uses to say chemical storage area, dismantling workshop, etc) may result in potential land contamination. Re-appraisal of these sites is therefore required if they become part of the land requirement for NDA development.

The PP would prepare and submit the Supplementary CAP to EPD prior to the commencement of SI works. Following on from the submission of CAP and completion of SI, the PP would prepare CAR, RAP and RR and submit to EPD for contaminants other than As (which will follow the recommendations of the HRA) for agreement prior to commencement of the development works on these sites.

The land contamination assessment has been conducted in accordance with the requirements of Annexes 19 of the TM-EIAO as well as the requirements set out under Clause 3.4.9 of the EIA Study Brief.

8.2 Environmental Legislation, Standards and Guidelines

The relevant legislations, standards and guidelines applicable to the present study for the assessment of land contamination include:

- Annex 19 of the TM-EIAO, Guidelines for Assessment of Impact On Sites of Cultural Heritage and Other Impacts (Section 3 : Potential Contaminated Land Issues), EPD, 1997;
- Guidance Manual for Use of Risk-Based Remediation Goals (RBRGs) for Contaminated Land Management, EPD, 2007.
- Guidance Notes for Contaminated Land Assessment and Remediation EPD, 2007 ; and
- Practice Guide for Investigation and Remediation of Contaminated Land, EPD, 2011

8.2.1 Environmental Impact Assessment Ordinance (EIAO) (Cap. 499), Technical Memorandum on Environmental Impact Assessment Process (TM-EIAO)

Under Annex 19 of the TM-EIAO, a number of potentially contaminating historical land uses should be considered, including oil installations, gas works, metal workshops, car repair and dismantling workshops, which have the potential to cause or have caused land contamination.

8.2.2 Guidance Manual for Use of Risk-Based Remediation Goals (RBRGs) for Contaminated Land Management

The Guidance Manual introduces the risk based approach in land contamination assessment and present instructions for comparison of soil and groundwater data to the Risk-based Remediation Goals (RBRGs) for 54 chemicals of concern commonly found in Hong Kong. The RBRGs were derived to suit Hong Kong conditions by following the international

practice of adopting a risk-based methodology for contaminated land assessment and remediation and were designed to protect the health of people who could potentially be exposed to land impacted by chemicals under four broad post restoration land use categories. The RBRGs also serve as the remediation targets if remediation is necessary. The RBRGs for soil and groundwater are given in **Table 8.1** and **Table 8.2** respectively.

Table 8.1 - Risk-Based Remediation Goals (RBRGs) for Soil & Soil Saturation Limit

Chemical	Risk-Based Remediation Goals (RBRGs) for Soil				Soil Saturation Limit (C_{sat})
	Urban Residential (mg/kg)	Rural Residential (mg/kg)	Industrial (mg/kg)	Public Park (mg/kg)	(mg/kg)
VOCs					
Acetone	9,590	4,260	10,000*	10,000*	***
Benzene	0.704	0.279	9.21	42.2	336
Bromodichloromethane	0.317	0.129	2.85	13.4	1,030
2-Butanone	10,000*	10,000*	10,000*	10,000*	***
Chloroform	0.132	0.0529	1.54	253	1,100
Ethylbenzene	709	298	8,240	10,000*	138
Methyl tert-Butyl Ether	6.88	2.80	70.1	505	2,380
Methylene Chloride	1.30	0.529	13.9	128	921
Styrene	3,220	1,540	10,000*	10,000*	497
Tetrachloroethene	0.101	0.0444	0.777	1.84	97.1
Toluene	1,440	705	10,000*	10,000*	235
Trichloroethene	0.523	0.211	5.68	69.4	488
Xylenes (Total)	95.0	36.8	1,230	10,000*	150
SVOCs					
Acenaphthene	3,510	3,280	10,000*	10,000*	60.2
Acenaphthylene	2,340	1,510	10,000*	10,000*	19.8
Anthracene	10,000*	10,000*	10,000*	10,000*	2.56
Benzo(a)anthracene	12.0	11.4	91.8	38.3	
Benzo(a)pyrene	1.20	1.14	9.18	3.83	
Benzo(b)fluoranthene	9.88	10.1	17.8	20.4	
Benzo(g,h,i)perylene	1,800	1,710	10,000*	5,740	
Benzo(k)fluoranthene	120	114	918	383	
Bis-(2-Ethylhexyl)phthalate	30.0	28.0	91.8	94.2	
Chrysene	871	919	1,140	1,540	
Dibenzo(a,h)anthracene	1.20	1.14	9.18	3.83	
Fluoranthene	2,400	2,270	10,000*	7,620	
Fluorene	2,380	2,250	10,000*	7,450	54.7
Hexachlorobenzene	0.243	0.220	0.582	0.713	
Indeno(1,2,3-cd)pyrene	12.0	11.4	91.8	38.3	

Chemical	Risk-Based Remediation Goals (RBRGs) for Soil				Soil Saturation Limit (C_{sat})
	Urban Residential (mg/kg)	Rural Residential (mg/kg)	Industrial (mg/kg)	Public Park (mg/kg)	(mg/kg)
Naphthalene	182	85.6	453	914	125
Phenanthrene	10,000*	10,000*	10,000*	10,000*	28.0
Phenol	10,000*	10,000*	10,000*	10,000*	7,260
Pyrene	1,800	1,710	10,000*	5,720	
Metals					
Antimony	29.5	29.1	261	97.9	
Arsenic	22.1	21.8	196	73.5	
Barium	10,000*	10,000*	10,000*	10,000*	
Cadmium	73.8	72.8	653	245	
Chromium III	10,000*	10,000*	10,000*	10,000*	
Chromium VI	221	218	1,960	735	
Cobalt	1,480	1,460	10,000*	4,900	
Copper	2,950	2,910	10,000*	9,790	
Lead	258	255	2,290	857	
Manganese	10,000*	10,000*	10,000*	10,000*	
Mercury	11.0	6.52	38.4	45.6	
Molybdenum	369	364	3,260	1,220	
Nickel	1,480	1,460	10,000*	4,900	
Tin	10,000*	10,000*	10,000*	10,000*	
Zinc	10,000*	10,000*	10,000*	10,000*	
Dioxins / PCBs					
Dioxins (I-TEQ)	0.001	0.001	0.005	0.001	
PCBs	0.236	0.226	0.748	0.756	
Petroleum Carbon Ranges					
C6 - C8	1,410	545	10,000*	10,000*	1,000
C9 - C16	2,240	1,330	10,000*	10,000*	3,000
C17 - C35	10,000*	10,000*	10,000*	10,000*	5,000
Other Inorganic Compounds					
Cyanide, free	1,480	1,460	10,000*	4,900	
Organometallics					
TBTO	22.1	21.8	196	73.5	

Note:

(1) For Dioxins, the cleanup levels in USEPA Office of Solid Waste and Emergency Response (OSWER) Directive of 1998 have been adopted. The OSWER Directive value of 1 ppb for residential use has been applied to the scenarios of "Urban Residential", "Rural Residential", and "Public Parks", while the low end of the range of values for industrial, 5 ppb, has been applied to the scenario of "industrial".

(2) Soil saturation limits for petroleum carbon ranges taken from the Canada-Wide Standards for Petroleum Hydrocarbons in Soil, CCME 2000.

(3) * indicates a 'ceiling limit' concentration.

(4) *** indicates that the C_{sat} value exceeds the 'ceiling limit' therefore the RBRG applies.

Table 8.2 - Risk-Based Remediation Goals (RBRGs) for Groundwater and Solubility Limit

Chemical	Risk-Based Remediation Goals (RBRGs) for Groundwater			Solubility Limit (mg/L)
	Urban Residential (mg/L)	Rural Residential (mg/L)	Industrial (mg/L)	
VOCs				
Acetone	10,000*	10,000*	10,000*	***
Benzene	3.86	1.49	54.0	1,750
Bromodichloromethane	2.22	0.871	26.2	6,740
2-Butanone	10,000*	10,000*	10,000*	***
Chloroform	0.956	0.382	11.3	7,920
Ethylbenzene	1,020	391	10,000*	169
Methyl tert-Butyl Ether	153	61.1	1,810	***
Methylene Chloride	19.0	7.59	224	***
Styrene	3,020	1,160	10,000*	310
Tetrachloroethene	0.250	0.0996	2.95	200
Toluene	5,110	1,970	10,000*	526
Trichloroethene	1.21	0.481	14.2	1,100
Xylenes (Total)	112	43.3	1,570	175
SVOCs				
Acenaphthene	10,000*	7,090	10,000*	4.24
Acenaphthylene	1,410	542	10,000*	3.93
Anthracene	10,000*	10,000*	10,000*	0.0434
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene	0.539	0.203	7.53	0.0015
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Bis-(2-Ethylhexyl)phthalate				
Chrysene	58.1	21.9	812	0.0016
Dibenzo(a,h)anthracene				
Fluoranthene	10,000*	10,000*	10,000*	0.206
Fluorene	10,000*	10,000*	10,000*	1.98
Hexachlorobenzene	0.0589	0.0234	0.695	6.20
Indeno(1,2,3-cd)pyrene				
Naphthalene	61.7	23.7	862	31.0
Phenanthrene	10,000*	10,000*	10,000*	1.00
Phenol				
Pyrene	10,000*	10,000*	10,000*	0.135
Metals				
Antimony				
Arsenic				
Barium				

Chemical	Risk-Based Remediation Goals (RBRGs) for Groundwater			Solubility Limit (mg/L)
	Urban Residential (mg/L)	Rural Residential (mg/L)	Industrial (mg/L)	
Cadmium				
Chromium III				
Chromium VI				
Cobalt				
Copper				
Lead				
Manganese				
Mercury	0.486	0.184	6.79	
Molybdenum				
Nickel				
Tin				
Zinc				
PCBs				
Dioxins (I-TEQ)				
PCBs	0.433	0.171	5.11	0.031
Petroleum Carbon Ranges				
C6 - C8	82.2	31.7	1,150	5.23
C9 - C16	714	276	9,980	2.80
C17 - C35	12.8	4.93	178	2.80
Other Inorganic Compounds				
Cyanide, free				
Organometallics				
TBTO				

Note:

(1) Blank indicates that RBRG could not be calculated because the toxicity or physical/chemical values were unavailable, or the condition of Henry's Law Constant>0.00005 was not met for the inhalation pathway.

(2) Where solubilities for Petroleum Carbon Range aliphatic C9-C16 and greater than C16 generally are considered to be effectively zero and therefore the aromatic solubility for C9-C16 is used.

(3) * indicates a 'ceiling limit' concentration.

(4) *** indicates that the solubility limit exceeds the 'ceiling limit' therefore the RBRG applies.

8.2.3 Guidance Note for Contamination Land Assessment and Remediation

In accordance with EPD's Guidance Note for Contamination Land Assessment and Remediation, a contamination assessment evaluation should:

- Provide a clear and detailed account of the present land-use and the relevant past land history, in relation to possible land contamination;

- Identify areas of potential contamination and associated impacts, risks or hazards; and
- Submit a plan to evaluate the actual contamination conditions for soil and/or groundwater, if required.

8.2.4 Practice Guide for Investigation and Remediation of Contaminated Land

The EPD's *Practice Guide for Investigation and Remediation of Contaminated Land* includes a summary of the general steps of a contamination assessment study, which include site appraisal, site investigation and remediation.

8.3 Assessment Methodology

Land contamination assessment has been conducted according to the following procedures:

- Desktop review of site history;
- Site survey to identify the potentially contaminated sites;
- Prepare Contamination Assessment Plan for EPD's agreement;
- Site Investigation for soil and groundwater sampling and testing;
- Interpret the laboratory test results and evaluate the contamination level:
- Prepare Contamination Assessment Report to summarize the assessment findings for EPD's agreement;
- If contamination is confirmed, propose remediation method and prepare Remediation Action Plan for EPD's agreement.

8.3.1 Desktop Review

The following information has been collated for the desktop review of site history:

- Hong Kong Ordinance Survey Maps from various years;
- Relevant Outline Zoning Plans (OZPs) for Kwu Tung, Sheung Shui and Fanling;
- Hong Kong Geological Survey Maps (GSMs);
- Relevant aerial photos from 1963;
- Landuse information from the District Land Offices (DLO) in Yuen Long (DLO Yuen Long) and Fanling (DLO North);
- "Mapping Hong Kong, A Historical Atlas", Government Information Services, 1992;

- "Sheung Shui to Lok Ma Chau Spurline Contaminated Land Assessment, Contamination Assessment Report (CAR) and Remediation Action Plan (RAP) Final (May 2002) with Addendum (August 2002) (2141/913)", MTR, 2002; and

  "Environmental Impact Assessment Report for Planning and Development Study on North East New Territories", CEDD and PlanD", 2003.

8.3.2 Site Survey

Site surveys were conducted in May to June 2009 to ground truth findings of desktop review and to identify any other land uses within the NDA boundaries (i.e. include the associated Designated Projects and southern section of Fanling Bypass) which might have the potential for causing soil and groundwater contamination. The surveyed sites had also been re-visited from July 2012 to September 2012 to ensure the information is up-to-date, and the specific land uses which were identified as potentially contaminating sources include:

- Vehicle repair and maintenance yards / workshops;
- Car junk yards:
- Trailer /container storage yards;
- Scrap yards and metal recycling facilities;
- Petrol stations;
- Concrete batching plants;
- Metal workshops;
- Saw mills;
- Construction material and open storage areas; and
- Uncontrolled dumping; and
- Several types of manufacturing facilities (electronic, umbrella, chemical manufacturing etc)

The findings of site inspections and review of aerial photographs indicated that a number of these designated land uses do exist within the proposed NDAs. The range of business activities identified in the report for the proposed NDAs include the saw mills, metal works, food manufacturing, marble, concrete and timber workshops, construction materials, vehicle repair yards, truck/trailer parks, chemical processing and storage area, industrial estate and others.

Typical contaminants associated with industrial land use activities which are known to occur in the proposed NDAs are summarized in **Table 8.3**.

Table 8.3 - Potential contaminants associated with industrial land use in NDAs

Type of Activities Based upon Site Surveys in 2009/ 2011	Potentially Polluting Activities	Potential Source of Contamination	Possible Contaminants	Key Chemical of Concern (COCs)
Motor vehicle/ equipment depot, repairing, service centre	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.	Vehicle maintenance, scrap vehicle parts, fuels and lubricants storage	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers, paint and battery acid.	Metals (e.g. chromium, copper, lead, manganese, nickel, zinc), PCRs, VOCs (e.g. acetone, BTEX, MTBE, and trichloroethene) and SVOCs (e.g. PAHs),
Car junk yards	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.	Vehicle maintenance, scrap vehicle parts, fuels and lubricants storage	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers, paint and battery acid.	Metals (e.g. chromium, copper, lead, manganese, nickel, zinc), PCRs, VOCs (e.g. acetone, BTEX, MTBE, and trichloroethene) and SVOCs (e.g. PAHs),
Trailer /container storage yards	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.	Vehicle maintenance, scrap vehicle parts, fuels and lubricants storage	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers, paint.	Metals (e.g. chromium, copper, lead, manganese, nickel, zinc), PCRs, VOCs (e.g. acetone, BTEX, MTBE, and trichloroethene) and SVOCs (e.g. PAHs),
Scrap yards and metal recycling facilities	Waste oils and fuels and lubricants from scrap vehicles/ machinery, transformers, scrap metals, vehicle and equipment maintenance and refuelling. Storage and disposal of wastes.	Mechanical machinery, scrap metals and debris storage, maintenance activities.	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers.	Metals (full list), VOCs (e.g. acetone, BTEX, MTBE and trichloroethene), PCRs, SVOCs (e.g. PAHs), and PCBs.

Type of Activities Based upon Site Surveys in 2009/ 2011	Potentially Polluting Activities	Potential Source of Contamination	Possible Contaminants	Key Chemical of Concern (COCs)
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.	Petrol station fuel tanks / drums, possible vehicle maintenance.	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers.	Metals (e.g. lead), PCRs, VOCs (e.g. BTEX and MTBE), and SVOCs (e.g. PAHs).
Concrete and asphalt production	Storage and transfer of residues from physical conversion of earthen materials by sorting, mixing, and grinding.	Mechanical machinery, maintenance activities, fuel and lubricants storage.	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers.	VOCs (e.g. BTEX), PCRs, and SVOCs.
Steel mills/ metal workshops	Use of metals and chemicals for manufacturing, equipment maintenance and cleaning, storage, treatment and disposal of wastes.	Mechanical machinery, foundry metal works, scrap metals and debris storage, fuel and lubricants storage.	Heavy metals, hydrocarbon (fuel, oils, lubricants-cutting and coating oils), solvent or degreasers, paints.	Metals (full list), PCRs, VOCs (e.g. BTEX), SVOCs (e.g. phenol, and PAHs).
Saw mills	Timber cutting and shaping activities, mechanical machinery, fuels and lubricants storage.	Timber cutting and shaping activities, mechanical machinery, fuels and lubricants storage.	Wood treatment chemical, hydrocarbons (fuel, oils, lubricants-cutting and coating oils)	Metals (e.g. lead, chromium, copper, zinc), PCR, VOCs, and SVOCs.
Construction material and open storage areas	Loading, unloading and storage of goods, fuel storage and transfer, maintenance of equipment and vehicles.	Fuels, lubricants and various kinds of chemical storage	Heavy metals, hydrocarbon (fuel, oils, lubricants), various chemicals.	Metals (full list), PCRs, VOCs and SVOCs.
Uncontrolled dumping	Storage of general construction waste, vehicle and machinery parts, paints, fuels, oils, metals and batteries.	General construction waste, vehicle and machinery parts, paints, fuels, oils, metals, batteries.	Heavy metals, hydrocarbon (fuel, oils, lubricants-cutting and coating oils), paint, organic solvents, acids, lubricants and unidentified contaminants.	Metals (full list), PCRs, VOCs, SVOCs, free cyanide, and PCBs.

Type of Activities Based upon Site Surveys in 2009/ 2011	Potentially Polluting Activities	Potential Source of Contamination	Possible Contaminants	Key Chemical of Concern (COCs)
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.	Mechanical manufacturing equipments for chemicals and various kinds of chemical storage	Heavy metals, hydrocarbon (fuel, oils, lubricants), various chemicals, organic solvents, acids	Dependent on the materials handled, stored, used and produced on site but would generally include PCRs, VOCs, and SVOCs.
Industrial estate	Release of oils and fuels and lubricants from mechanical machinery, equipment maintenance and refuelling. Use of chemicals and solvents in maintenance activities. Storage of foundry metal works, scrape metals, debris, fuel and lubricants.	Mechanical machinery, foundry metal works, scrap metals and debris storage, fuel and lubricants storage.	Heavy metals, hydrocarbon (fuel, oils, lubricants), solvent or degreasers, paint, battery acid, lubricants and unidentified contaminants.	Metals (full list), PCRs, VOCs, SVOCs, free cyanide, and PCBs.
Several types of manufacturing facilities (electronic, umbrella, chemical manufacturing etc)	Release of oils and fuels and lubricants from mechanical machinery, equipment maintenance and refuelling. Use of chemicals and solvents in maintenance activities. Storage of chemicals for various manufacturing processes.	Mechanical machinery, paint spraying, fuels and lubricants storage, a range of chemicals associated with various manufacturing processes.	Paints, organic solvents and degreasers, acids, lubricants (cutting and coating oils), various kinds of chemicals.	Metals (full list), PCRs, VOCs, SVOCs, free cyanide, and PCBs.

Notes:

(1) In RBRGs, metals include antimony, arsenic, barium, cadmium, chromium III, chromium VI, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, tin and zinc.

(2) Petroleum carbon ranges (PCRs) include C6 – C8, C9 – C16 and C17 – C35.

(3) Volatile organic chemicals (VOCs) include BTEX (benzene, toluene, ethylbenzene, and total xylenes), MTBE (methy tert-butyl ether), acetone, bromodichloromethane, 2-butanone, chloroform, methylene chloride, styrene, tetrachloroethene, and trichloroethene.

(4) Semi-volatile organic chemicals (SVOCs) include polyaromatic hydrocarbons (PAHs) (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), bis-(2-ethylhexyl)phthalate, hexachlorobenzene, and phenol.

8.3.3 Site Contamination Rating

In order to determine those activities which pose the potential for contamination, a contamination rating was determined based on visual evidence and available historical records such as historical aerial photos and the findings of previous NENT Study Technical Paper 13 EIA Study (TP13), to evaluate the potential contamination of the site. The EPD's *Practice Guide for Investigation and Remediation of Contaminated Land* has been used to determine those activities which pose the potential for contamination. The rating categories used in the preliminary site evaluation are as follows:

- "***A***" rating indicates a significant potential for land contamination, with visual evidence and supplement with the historical records to suggest the potential for soil and groundwater contamination (i.e. spillage / leakage of oils and / or chemicals, heavy oil stains on the ground, burn pits, areas of uncontrolled dumping etc);
- "***B***" rating indicates a low potential for land contamination, with no major concerns observed during the site survey, and
- "***U***" rating indicates the site was limited for access for visual inspection during the survey and the potential for land contamination could not be evaluated.

The ratings "A" and "B" are based on visual inspection (i.e. conducted from the entrance and / or boundary of the site) and available historical records such as historical aerial photos and TP13's findings.

The development plans of the NDAs would be consisted of different facilities, such as residential buildings, education institutions, outdoor sport facilities, commercial, mixed development, police facilities, primary and district distributors, sewage treatment works, sewage pumping stations, wholesale market, railway, and monorail, pedestrian walkway, open space, car park and various of public utilities etc. Hence, the most relevant RBRG corresponding to its future land use should be adopted in assessing its land contamination level. Corresponding RBRGs landuse of the associated facilities are defined and given in **Table 8.4**.

Table 8.4 - Post-restoration land use and RBRGs land use

Landuse	Corresponding RBRGs Landuse
Commercial / Residential • Urban High Rise • Low Rise in Rural Area	 Urban Residential Rural Residential
Commercial / Business & Office	Urban Residential
School	Rural Residential
Public Park with Indoor Games Hall	Lower of Public Park or Urban Residential
Warehouse & Storage	Industrial
Government, Institution & Community	Urban Residential

Landuse	Corresponding RBRGs Landuse
Facilities	
Road including Pedestrian Walkway	Lower of Industrial or Public Park
Railway	Industrial
Open Space	Public Park
Public Utilities	Industrial

8.3.4 Preparation of Contamination Assessment Plan

According to the findings of desktop study and site surveys, the Contamination Assessment Plan (CAP) for the proposed NDAs and a Stand-alone CAP for the four accessible government sites (i.e. KTN-23b, KTN-35a, KTN-77,78 and FLN-9a) as given in **Appendix 8.1** and **Appendix 8.2** respectively were prepared and submitted to EPD. Sampling locations and sampling depths for soil and groundwater have been proposed for the site investigation (SI) works in the CAPs. The CAPs also specified the sampling and testing requirements for the SI works.

8.3.5 Site Investigation and Data Interpretation

After completion of the SI works (i.e. boreholes drilling, soil and groundwater sampling and testing) at 4 government sites, the analytical results of the soil and groundwater were interpreted using RBRGs. The nature, level and extent of the land contamination in these 4 sites were evaluated.

Site investigation was also proposed to be conducted in other identified inaccessible potentially contaminated sites in NDAs in accordance with the CAP **(Appendix 8.1),** once the sites are resumed and handed over to Project Proponent (PP). The potentially contamination sites identified in the NDAs that may be of concern is given in Tables 3.1 to 3.4 and Figures 3.1.1 to 3.1.4 of the CAP given in **Appendix 8.1.**

8.3.6 Preparation of Contamination Assessment Report

The findings of laboratory test results were documented in the Contamination Assessment Report (CAR) for 4 government sites. Copy of the CAR is given in **Appendix 8.3**.

8.3.7 Inaccessible Potentially Contaminated Sites

As certain potentially contaminated sites including private lot areas and government lot areas currently under a short or long term "land lease" / "tenancy agreement" are inaccessible during the course of this EIA Study, sampling work is not possible until they are redeemed and vacated. However, as stipulated in the Clause 3.4.9.6 of the EIA Study Brief, the CAP given in **Appendix 8.1** has included the following information even though there are potentially contaminated sites inaccessible for preparing sampling and analysis during course of the EIA study:

- A review of the available information;

- An initial contamination evaluation of these sites and possible remediation methods:
- A confirmation of whether the contamination problem at these sites would be surmountable;
- A sampling and analysis proposal which shall aim at determining the nature and the extent of the contamination of these sites; and a schedule of submission of revised CAP (if necessary), CAR, Remediation Action Plan (RAP) and Remediation Report (RR) upon these sites are accessible.

The Project Proponent shall clean up the contaminated lands or sites (if any) according to the approved RAP and a RR to demonstrate adequate clean-up should be prepared and submitted to EPD for approval. No development or construction works shall be carried out within the site before the approval of RR.

8.4 Description of the Environment

8.4.1 Existing Environment of Kwu Tung North (KTN) NDA

The KTN NDA covers an area of about 450 ha. It is located to the west and northwest respectively of the proposed FLN NDA and the existing Fanling/Sheung Shui New Town. It is generally bounded by the Shek Sheung River in the east, Castle Peak Road and the Fanling Highway in the south, Tit Hang in the west and Tai Shek Mo (Crest Hill) in the north.

Long Valley is located at the south-eastern part of KTN NDA. The area comprises a mix of active and inactive wet and dry agricultural land, together with small areas of semi-natural freshwater marsh and areas formed as compensatory wetlands. River Beas (Sheung Yue River) runs in a southwest to northeast direction along the western side of the Long Valley. It joins Shek Sheung River at the northern tip of Long Valley. On both sides of River Beas are strips of low-lying land, and there are some ponds with flat lands used for agriculture.

The majority of KTN NDA lies on a relatively flat area within the central and southern parts where the main developed areas are located. They involve mixed land uses which comprise small residential developments, scattered villages, agricultural lands, rural areas and rural industries including vehicle repair, construction material storage, container storage etc. In particular, Yin Kong Tsuen and Ho Sheung Heung are the recognised villages within KTN NDA. They are located at the southern end of Long Valley and to the west of River Beas respectively. The reserved location for Kwu Tung Station of Lok Ma Chau Spur line of MTRC (formerly KCRC) is located to the south of Tung Fong and to the north of Dills Corner Garden.

Within the northern portion of KTN NDA, the elevation of the topography rises gradually as a series of east-west striking hills to Fung Kong Shan. A number of smaller valleys branch off through this high ground in a northeast to southwest orientation. The Lo Wu Classification Range is

located near to the northern end of KTN NDA, and the Ma Tso Lung Restored Landfill is located at the north-western end of KTN NDA.

8.4.1.1 Potentially Contaminated Sites in KTN NDA

Except those 3 government sites were accessible for SI, other potentially contaminated sites identified in KTN NDA were inaccessible. SI would be required at these sites once the sites are resumed and handed over to Project Proponent (PP). The details, including the recommended no. of boreholes, of these sites are summarized in Table 3.1 and presented in Figure 3.1.1 of the CAP given in **Appendix 8.1.**

8.4.1.2 Site Re-appraisal

Although many of the sites were not identified as potentially contaminated or could not be accessed for visual inspection during the site survey, these sites would still in operation until commencement of construction. Any potential change of land uses (e.g. change of uses to say chemical storage area, dismantling workshop, etc) may result in potential land contamination. Re-appraisal of these sites is therefore required if they become part of the land requirement for KTN NDA development. The sites for re-appraisal are given in Appendix D of the CAP given in **Appendix 8.1**.

Given the sites were mainly based on peripheral inspection from outside, detailed site survey inside these sites to ascertain the land contamination potential through physical inspection is required if SI is to proceed.

8.4.2 Existing Environment of Fanling North (FLN) NDA

The FLN NDA covers an area of about 164 ha. It is located immediately to the north of the established Fanling/Sheung Shui New Town and to the southeast of the proposed KTN NDA. It is generally bounded by Wa Shan in the north, the Ma Wat River in the east, Ma Sik Road and Tin Ping Road in the south, Ng Tung River in the southwest and Sheung Yue River in the west.

The majority of FLN NDA lies on a relatively flat area with mixed land uses which comprise agricultural and rural areas with scattered villages, some small isolated buildings and residential developments. Rural industries including vehicle repair and material storage are concentrated on the two sides of Jockey Club Road with FLN NDA. There is no recognized village in FLN NDA.

Sheung Shui Slaughter House and Shek Wu Hui Sewage Treatment Works are located at the western end, and Sheung Shui Water Treatment Works is located immediately to the north of FLN NDA. San Wai Barracks and San Wai/Tai Ling Firing Range are located to the north-east of FLN NDA.

8.4.2.1 Potentially Contaminated Sites in FLN NDA

Except 1 government site was accessible for SI, other potentially contaminated sites identified in FLN NDA were inaccessible. SI would be required at these sites once the sites are resumed and handed over to

PP. The details, including the recommended no. of boreholes, of these sites are summarized in Tables 3.2 and 3.3 (Fanling Bypass) and presented in Figures 3.1.2 and 3.1.3 (Fanling Bypass) of the CAP given in **Appendix 8.1.**

8.4.2.2 Site Re-appraisal

Although many of the sites were not identified as potentially contaminated or could not be accessed for visual inspection during the site survey, these sites would still in operation until commencement of construction. Any potential change of land uses (e.g. change of uses to say chemical storage area, dismantling workshop, etc) may result in potential land contamination. Re-appraisal of these sites is therefore required if they become part of the land requirement for FLN NDA development. The sites for re-appraisal are given in Appendix D of the CAP given in **Appendix 8.1**.

Given the sites were mainly based on peripheral inspection from outside, detailed site survey inside these sites to ascertain the land contamination potential through physical inspection is required if SI is to proceed.

8.5 Site Investigation

8.5.1 Site Investigation for Four Government Sites

A total of 12 inspection pits and 3 boreholes were drilled for soil and groundwater sampling in accordance with the CAP for 4 government sites (3 in KTN and 1 in FLN) **(Appendix 8.2)**. The laboratory testing results showed that the “Arsenic (As)” levels (i.e. ranged from 24 mg/kg to 430 mg/kg) of 35 soil samples from 10 inspection pits and 2 boreholes at 3 government sites in KTN exceeded various RBRGs from Rural Residential (i.e. the stringent set of RBRG) to Industrial (i.e. the most relax set of RBRG) land uses while that (ranged from 1.4 mg/kg to 8.9 mg/kg)from 11 soil samples collected from 2 inspection pits and 1 boreholes at 1 government site in FLN was well below the stringent set of the RBRG.

As this high level of Arsenic level was considered anomalistic, a supplementary environmental SI (i.e. 1 inspection pit at each of 3 sites in KTN) with comprehensive “Arsenic Specimen” testing was subsequently conducted at the 3 government sites in KTN to investigate the toxicity of high Arsenic levels detected in KTN. An “Off-site” location in KTN (i.e. a location without significant human and industrial activities base on the review of historical aerial photos) is also selected for borehole drilling to provide further “background” information of Arsenic level in KTN. A total of 19 soil samples were collected. (i.e. refer to **Section 8.6.1.1** for the details)

The entire SI programme was supervised by the on-site Land Contamination Specialist. All soil and groundwater samples were analysed by a HOKLAS accredited laboratory.

8.5.2 Proposed Site Investigation of Potentially Contaminated Sites

Except the 4 accessible government sites, all other identified potentially contaminated sites in the proposed NDAs were inaccessible. Nevertheless, detailed SI for these sites should be conducted when they are resumed and handed over to the Project Proponent (PP). The PP would prepare and submit the Supplementary CAP to EPD prior to the commencement of SI works. Following on from the submission of CAP and completion of SI, the PP would prepare CAR, RAP and RR and submit to EPD for agreement prior to commencement of the development works on these sites.

8.5.3 Site Re-appraisal

Re-appraisal and site investigation of the sites which were not identified as potentially contaminated or could not be accessed for visual inspection would be required to ensure any potential contamination activities from land use changes after the approval of this land contamination assessment study is subject to a proper updating review prior to commencement of the construction works. In such case, the PP would prepare and submit the Supplementary CAP to EPD prior to the commencement of SI works. Following on from the submission of CAP and completion of SI, the PP would prepare CAR, RAP and RR for contaminants other than As (which should follow the recommendations of the HRA) and submit to EPD for agreement prior to commencement of the development works on these sites.

8.6 Identification and Evaluation of Land Contamination

8.6.1 Three Government Sites in KTN NDA

The laboratory test results of soil and groundwater samples collected at three government sites KTN-23b, KTN35a and KTN-77,78 have been reviewed. The locations of these 3 sites are presented in Figures 2.1.1 and Figures 3.1.1 to 3.1.4 of CAR **(Appendix 8.3)**.

8.6.1.1 Soil Contamination

A total of 38 soil samples were collected from 10 inspection pits and 2 boreholes from November 2009 to January 2010. The test results indicated that the concentration of metal “Arsenic (As)” (i.e. ranged from 24 mg/kg to 430 mg/kg) of 35 soil samples collected from all 12 sampling locations have exceeded the RBRGs from Rural Residential (i.e. the stringent set of RBRG) to Industrial (i.e. the most relax set of RBRG) land uses. The results are presented in Appendix C of CAR **(Appendix 8.3)**.

In view of the major group of contaminants such as BTEX (benzene, toluene, ethylbenzene, and total xylenes), Petroleum Carbon Ranges (PCRs), Lead, Chromium, Zinc and Copper etc of current industrial activities at 3 KTN sites (i.e. fuel filling station, vehicle repairing workshop and warehouse/metal workshop) were only recorded at low levels, the high levels of Arsenic at these 3 sites was considered anomalistic.

Desk-top review of geochemistry in northern New Territories was conducted. In accordance with "Geochemical Atlas of Hong Kong, GEO 1999", high levels of Arsenic were recorded in the Lok Ma Chau (117-492ppm), Ngau Tam Mei (118-922ppm), Lin Tong Mei (149-1145ppm) and Pat Heung (124-494ppm). The Geochemical Map of Arsenic also shows a broad distribution pattern of high Arsenic levels in northern New Territories which indicated the high natural background level of Arsenic in this region include KTN.

A supplementary environmental SI with comprehensive "Arsenic Specimen" testing was subsequently conducted for the 3 government sites in KTN to investigate the toxicity of high Arsenic levels detected in KTN. An "Off-site" location in KTN (i.e. a location without significant human and industrial activities base on the review of historical aerial photos) is also selected to provide further "background" information of Arsenic level in KTN.

The Total Arsenic levels of supplementary SI soil samples of 3 government sites were comparable with the testing results of previous SI. On the other hand, high Total Arsenic level was also detected at all sampling depths of the Off-site location ranged from 114 mg/kg to 947 mg/kg. The highest Total Arsenic level, 947 mg/kg, was detected at the depth of 18.0-18.45 mbgl, which indicated that the natural background level of Total Arsenic is extremely high in KTN.

The Arsenic specimen testing results revealed that the concentration of Inorganic Arsenite As(III), the most toxic inorganic form of Arsenic, were negligible in all soil samples, ranged from 0.122 mg/kg to 2.37 mg/kg, which only count for less than 0.5% of the Total Arsenic content.

The testing results also revealed that the Arsenic level in soil samples was dominated by Inorganic Arsenate As(V), the least toxic inorganic form of Arsenic, which contributed approximately 80 to 95% of Total Arsenic. The inorganic Arsenate As(V) usually dominates the soil solid phase in natural environment, and the testing results show the similar natural soil condition.

The aforesaid testing results have been summarized in the Contamination Assessment Report (CAR) for Government Sites as attached in **Appendix 8.3**.

8.6.1.2 Groundwater Contamination

Groundwater sample was taken from 2 boreholes at KTN-77,78. The test results indicated that the groundwater samples were below RBRG for Rural Residential (i.e. the most stringent set of RBRGs). The results are presented in Appendix D of CAR **(Appendix 8.3)**.

8.6.1.3 Other Potentially Contaminated Site in KTN NDA

All other potentially contaminated sites identified in KTN NDA were inaccessible and hence, no soil and groundwater sample has been collected during the course of this land contamination assessment study. (refer to **Section 8.5.2** for details).

The contamination problem in sites that are potentially contaminated would not be considered insurmountable in the supportive view that these sites are relatively small in size, the individual operation involving contaminating activities are likely to be small in scale, the extent of potential contamination are relatively localised, likely contaminants area generic and easily remediated, remediation methods available in the market are well established and nature of the possible contaminants can be dealt with by sufficient local remediation experience.

8.6.2 One Government Site in FLN NDA

The laboratory test results of soil and groundwater samples collected at a government sites FLN-9a have been reviewed. The location of site FLN-9a is presented in Figures 2.1.2 and 3.1.4 of CAR **(Appendix 8.3)**.

8.6.2.1 Soil Contamination

A total of 11 soil samples were collected from 2 inspection pits and 1 borehole in September 2009. The test results indicated that all soil samples were below RBRG for Rural Residential (i.e. the most stringent set of RBRGs). The results are presented in Appendix C of CAR **(Appendix 8.3)**.

8.6.2.2 Groundwater Contamination

Groundwater sample was taken from a borehole. The test results indicated that the groundwater sample was below RBRG for Rural Residential (i.e. the most stringent set of RBRGs). The results are presented in Appendix D of CAR **(Appendix 8.3)**.

8.6.2.3 Other Potentially Contaminated Site in FLN NDA

All other potentially contaminated sites identified in FLN NDA (include Fanling Bypass) were inaccessible and hence, no soil and groundwater sample has been collected during the course of this land contamination assessment study. (i.e. refer to **Section 8.5.2** for details).

The contamination problem in sites that are potentially contaminated would not be considered insurmountable in the supportive view that these sites are relatively small in size, the individual operation involving contaminating activities are likely to be small in scale, the extent of potential contamination are relatively localised, likely contaminants area generic and easily remediated, remediation methods available in the market are well established and nature of the possible contaminants can be dealt with by sufficient local remediation experience.

8.6.3 Submission Requirements of Supplementary CAP, CAR, RAP and RR

In order to avoid errors and misplacement of documents for the future SI works of potentially contaminated sites, the PP's appointed consultants should submit the supplementary CAP, CAR, RAP and RR for those inaccessible privately owned lot areas and government lot areas currently under a short or long term "land lease" / "tenancy agreement" in separate packages (e.g. one package for one project/development area) instead of

one set of report which includes all of the concerned sites as mentioned in aforementioned sections.

Prior to the commencement of any proposed construction works, the PP's appointed consultants should prepare a Remediation Report (RR) for contaminants other than As (which should follow the recommendations of the HRA) and submit to EPD to demonstrate that the decontamination work is adequate and is carried out in accordance with the endorsed CAR and RAP. Information such as soil treatment/disposal records (including trip tickets), confirmatory sampling results, photographs and, if applicable, certification of independent checker should be included in the aforesaid RR.

No construction works should be carried out before the endorsement of the RR (prepared for contaminants other than As) given by EPD.

8.7 Way Forward for Dealing High Background Arsenic in KTN

Soil samples have been further collected for arsenic testing from 17 more boreholes in KTN NDA in conjunction with the Phase 2 GI for the NENT NDAs works between February and August 2011. In order to further investigate the land contamination at KTN NDA after Phase 2 GI, further GI (i.e. Arsenic GI), comprising 18 boreholes, and associated LT were also carried out between December 2011 and March 2012.

In view of the high level of As is not due to anthropogenic activities, the guidelines and requirements under EPD's Guidance Manual for Use of Risk-Based Remediation Goals for Contaminated Land Management are not applicable. Instead, a HRA was carried out focusing on two major exposure paths, namely inhalation and ingestion of As, during the construction and operation stages respectively.

The summary of Phase 2 GI and Arsenic GI programmes and the health risk assessment findings on the health risk analysis on the ingestion of soil containing arsenic, and inhalation of arsenic-containing dust are given in the HRA Report **(Appendix 8.4)**.

8.8 Health Risk Assessment for Arsenic-Containing Soil

8.8.1 Health Risk Analysis of Ingestion of Arsenic-Containing Soil

The health risk of arsenic through soil ingestion reaches the 'threshold' of long-term minimal risk level (MRL) at a soil concentration of arsenic at ***571 mg/kg***, while the short-term MRL for children will be exceeded at a soil concentration of 625 mg/kg. Both are above the 96th percentile of soil concentration of arsenic in the collected soil samples. In order to minimize the long-term health risk, remedial action should be taken to maintain the soil concentration of arsenic at or below 571 mg/kg.

The detailed health risk analysis of ingestion of arsenic-containing soil and the remedial action (i.e. treatment of arsenic-containing soil) is given in the HRA Report **(Appendix 8.4)**.

8.8.2 Health Risk Analysis of Inhalation of Arsenic-Containing Dust

For the health risk of arsenic through inhalation, under the mitigated scenario, the estimated cancer risk levels based on different percentile (i.e. maximum, 95 percentile, mean value and median value) of 437 soil arsenic results collected in KTN are below the adopted lifetime risk level (1×10^{-5}). Cancer risk caused by the inhalation of arsenic-containing dust during construction stage with dust suppression is unlikely to be anticipated.

The estimated non-cancer risk levels (long-term) based on different percentile (i.e. maximum, 95 percentile, mean value and median value) of 437 soil arsenic results collected in KTN are also low. The estimated daily intake level of arsenic through inhalation of arsenic-containing dust under worst scenario is only 4.3% of the minimal risk level (MRL) as recommended by Agency for Toxic Substances and Disease Registry (ASTDR) “Toxicological profile for arsenic: US Department of Health and Human Services; August 2007”.

The health risk of arsenic through inhalation of arsenic-containing dust during construction stage of KTN NDA development is insignificant for both Cancer Risk Level and Non-cancer Risk Level.

The detailed health risk analysis of inhalation of arsenic-containing dust is given in the HRA Report **(Appendix 8.4)**.

8.9 Conclusion

This land contamination assessment has examined the potential contaminative landuses within NENT NDAs and their potential impacts to future use. The assessment involved site appraisal, site investigation, assessment of contamination level, and health risk assessment for high natural background of arsenic detected in KTN.

Site investigation works involving sampling and testing of soil and groundwater for land contamination were conducted at 4 identified government sites (i.e. 3 in KTN and 1 in FLN). No soil and groundwater contamination was detected, except the anomalistic high arsenic was detected in all 3 sites in KTN.

All other potentially contaminated sites identified in NENT NDAs (include Fanling Bypass) were inaccessible and hence, no soil and groundwater sample has been collected during the course of this land contamination assessment study. Nevertheless, detailed SI for these sites should be conducted when they are resumed and handed over to the Project Proponent (PP).

On the other hand, although many of the sites were not identified as potentially contaminated or could not be accessed for visual inspection during the site survey, these sites would still in operation until commencement of construction. Any potential change of land uses (e.g. change of uses to say chemical storage area, dismantling workshop, etc) may result in potential land contamination. Re-appraisal of these sites is

therefore required if they become part of the land requirement for NDA development.

The PP would prepare and submit the Supplementary CAP to EPD prior to the commencement of SI works. Following on from the submission of CAP and completion of SI, the PP would prepare CAR, RAP and RR for contaminants other than As (which should follow the recommendations given in the HRA report) and submit to EPD for agreement prior to commencement of the development works on these sites.

Anomalistic high arsenic detected in KTN was investigated. The investigation results indicated that the high arsenic in KTN is likely to be naturally occurred. A Health Risk Assessment has been conducted for assessing the health risk levels due to the inhalation of arsenic-containing dust during construction stage and incidental ingestion of arsenic-containing soil during operational stage. A Health Risk Assessment Report has been prepared to summarize the extent mapping of arsenic level, the health risk assessment findings and the treatment method for high background arsenic in order to minimize the long-term health risk via the incidental ingestion of arsenic-containing soil. The health risk of arsenic through inhalation of arsenic-containing dust during construction stage of KTN development is non-significant for both Cancer Risk Level and Non-cancer Risk Level.