Appendix A1

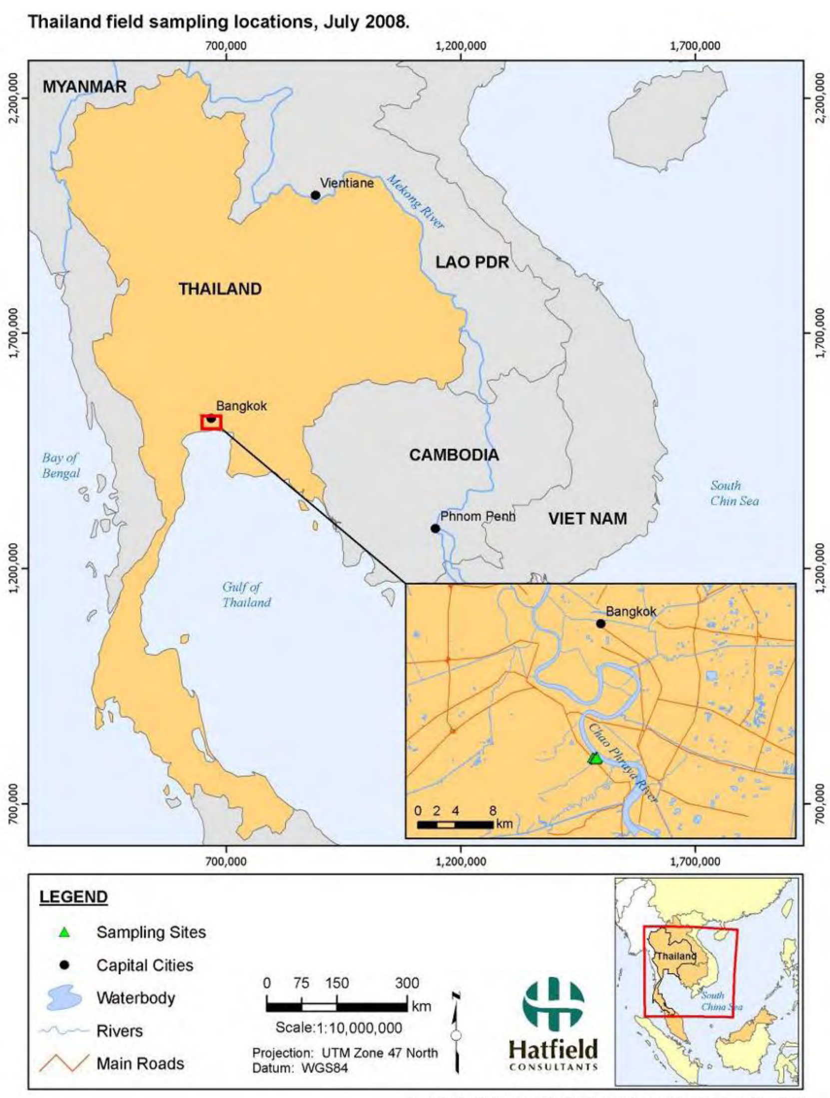
MEA Site Description

A1.1 MEA SAMUT PRAKAN (MEA) SITE DESCRIPTION

The National Focal Point Thailand POPs Team selected the Metropolitan Electricity Authority (MEA) Facility in Samut Prakan as an illustrative case-study site for a human health risk assessment concerning PCBs. The site was established on August 1, 1958 under the *Metropolitan Electricity Authority Act* of 1958 over a land area of 4,400 m^2. The site is used for collecting and storing old transformers and capacitors, electrical equipment and poles. It has also been used as a storage site for used PCB-containing capacitors and transformers since 2003.

The study site is located at the end of Suksawat 53 - UTM N 13.61713; E 100.54781 - south of downtown Bangkok on the banks of the Chao Phraya River (about 5 km from the river mouth where the Chao Phraya drains into the Gulf of Thailand).

Figure A1.1 Location of MEA Facility, Samut Prakan, Thailand.



The area is heavily industrialized - immediately adjacent to the MEA Facility is an asphalt factory, a garment factory, and a fuel storage depot. Directly opposite the site on the other side of the Chao Phraya River are Watt Bang Fai and the South Bangkok Power Plant. Immediately to the north of the site is an asphalt manufacturing facility, separated from the site by a stream. Table A1.1 and Figure A2.1 below show major land use classes in the vicinity of the site.

Table A1.1 Major land use classes[1] within 1 km radius from the MEA Facility, Samut Prakan, Thailand.

Land Use	Area (Ha)	Area (Percentage)
Agriculture Area	2.0	0.6%
Bare Ground	4.2	1.3%
Industry/Commercial	150.1	47.8%
Roads	8.4	2.7%
Infrastructure (Buildings)	9.2	2.9%
Residential Area	32.5	10.4%
Trees/Shrub/Bush	22.6	7.2%
River/Canals	85.2	27.1%
TOTAL	314.2	100%

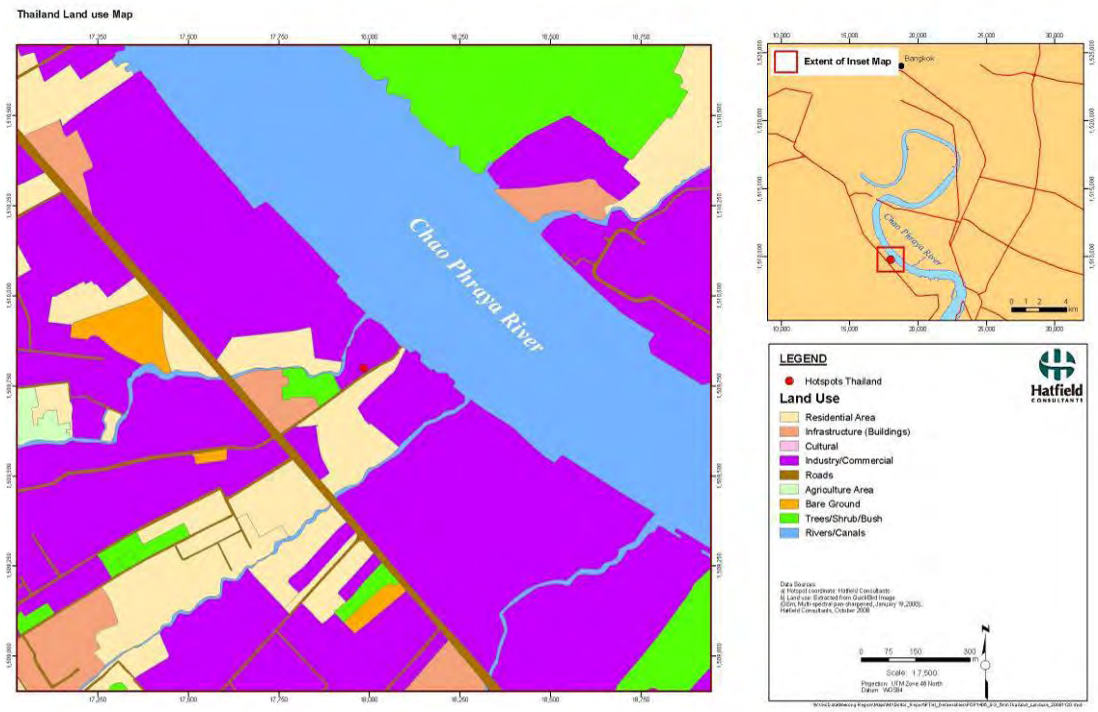
The major land use classes within 3 km^2 are predominantly industrial/commercial (48%); river/stream/water body (27%); and residential area (10%). The land use is not expected to change significantly in the next 10 years.

A1.2 SITE OPERATIONS AND SETTINGS

The site has been owned and operated by the Metropolitan Electricity Authority (MEA) for at least 20 years and was used for storing old transformers and capacitors, used and defected or broken electric equipment, as well as for repairing and dismantling electrical equipment. It has also been used for the storage and decommission of used PCB-containing capacitors and transformers until 2003. MEA is a state-owned enterprise in charge of distributing electrical power in the Bangkok Metropolitan area, which serves under the overall jurisdiction of the Ministry of Interior (MOI).

[1] Quickbird high resolution satellite imageries (0.6 meter resolution) covering an area of 25 km^2 were used as data input for land-cover delineation over the selected study site: UTM 47N WGS1984 (Thailand and Malaysia). Imaging Date - Thailand: 10 January 2005. The project team applied ‘heads-up’ digitizing approach (manual on-screen classification) for extracting land cover classes from satellite imagery, based on the general land cover types observed over the study sites.

Figure A2.1 Land Use Map of the Study Site, Samut Prakan, Thailand



The site is partially paved with concrete and asphalt. Transformers and transformer parts are visible in several areas of site, and based on visual observations alone appear to have been used as fill material. In general, the soils within and around the facility have been heavily disturbed. Soils in the facilities' storage area (in North West side corner of the site) are covered with pieces of ceramic insulators from old transformers and other electric equipment. The area is fenced and protected from public access.

There is a small office building in the center of the site (4 m x 7 m) made of wooden wall, concrete floor and the zinc roof. There is an open-air storage area (25 m x 70 m) next to the office and main entrance. A meeting hall built on silt (4 m x 20) is located on the Chao Phraya river bank about 60 m from the storage area.

In the open-air storage area, there are a few old transformers and capacitors stored with other electrical equipment. Most of the old transformers were dismantles at the site and packaged/transported to Europe for final disposal in recent years.

Table A1.2 below summarizes suspected activities that might have generated PCBs at MEA Facility site. They included storing of old transformers, leakage of fluids from transformers and during their decommissioning, and off-site transport of contaminants by rain-runoff, air, and trucks, improper handling of PCB containing equipment and fluids and disposing of old electrical equipment and waste. All these operations are performed in the warehouse compound – three warehouse building and open-air storage areas.

Table A1.2 Suspected Activities Generating PCBs at MEA Facility Site

	Activities	Status
1	Production of PCBs	No
2	Production of PCBs containing fluids	No
3	**Use of PCB-containing equipment and fluids**	Yes
4	**Handling of PCB-containing equipment and fluids**	Yes
5	**Storage of PCB containing equipment and fluids**	Yes
6	**Leakage of PCB containing equipment**	Yes
7	**Decommission of PCB containing equipment**	Yes
8	Retro filling	No
9	**Disposal of PCB containing equipment**	Maybe
10	Misuse of PCB containing fluids	No

The site is serviced by a fleet of trucks that are used to (i) bring the electrical equipment to and from the sites; and (ii) remove the equipment to other locations for uses or final disposal. Pictures showing land use in and around the MEA Facility Site are shown in the figure (A1.3) below.

The topography surrounding the site is generally flat. Observations during the site visit indicated that a number of man-made ponds and canals are located just off-site, which receive most of the rainfall run-off from the site. The site and its surrounding area are also influenced by the tidal effects from the Gulf of Thailand.

Adjacent to the site there are 83 residences, housing more than 400 people. These are located primarily at the South East and South West corners of the Facility, closer to main road (Suksawat Road). Some areas are subject to inundation during high tide and floods. The flow in the river and surrounding stream networks reverse depending on the tidal effect and flow regime in the Chao Phraya River. Because the area is subject to tidal flooding, most local residents live in houses elevated on stilts. Most of the local residents work in the garment industry in the area. There are some small fish ponds in the area that are used for recreation as well.

Figure A1.4 is a schematic map of the site showing the key components described above, and Table A1.3 provides an estimate of the size of these various components.

Figure A1.3 Land use in and around the MEA Facility Site, Samut Prakan

A1.3 KEY FINDINGS OF THE RISK ASSESSMENT

A1.3.1 CONTAMINATION LEVELS

The primary POPs of concern at the site are PCBs (from storing and handling of old transformers and capacitors). Accordingly, PCBs, associated coplanar dioxin-like PCBs, and chlorinated diobenzo-p-dioxins (TCDD/TCDF) are contaminants of concern. Organochlorine pesticides were considered a secondary concern, most likely attributable to off-site sources. No evaluation was made of non-POPs contaminants such as metals, hydrocarbons, or solvents.

Through problem formulation, all three elements of risks below are present at the sites were found to be present at the study site: i) Chemical Hazard – one or more chemical contaminants at concentrations capable of causing human health or ecological impacts; ii) Receptors – humans, animals or plants at the site; and, iii) Pathway – a way for chemical contaminants to reach the receptors.

Analytical results of the sampling program conducted as part of the POPs Project indicate potentially high concentrations of PCBs at various locations on the site (See Hatfield, 2009a). The maximum concentrations of PCDDs/PCDFs, and PCBs were measured (See Table A1.4).

Figure A1.4 Schematic map of the MEA Facility Site, Samut Prakan, Thailand

Table A1.3 Size of the key building/area of the MEA Facility site, Samut Prakan.

Building / area	Size (sqm)
Warehouse compound (total area)	**4,400**
Paved open air-storage area	**1,750**
Unpaved area	**2,550**
Road Access	**3,200**
Parking and loading area	**100**

Table A 1.4 Concentrations of PCDDs/PCDFs & PCBs in soil and sediments within site perimeter using CALUX, MEA Facility, Samut Prakan, Thailand (based on WHO-TEF 2005* and NATO I-TEF).

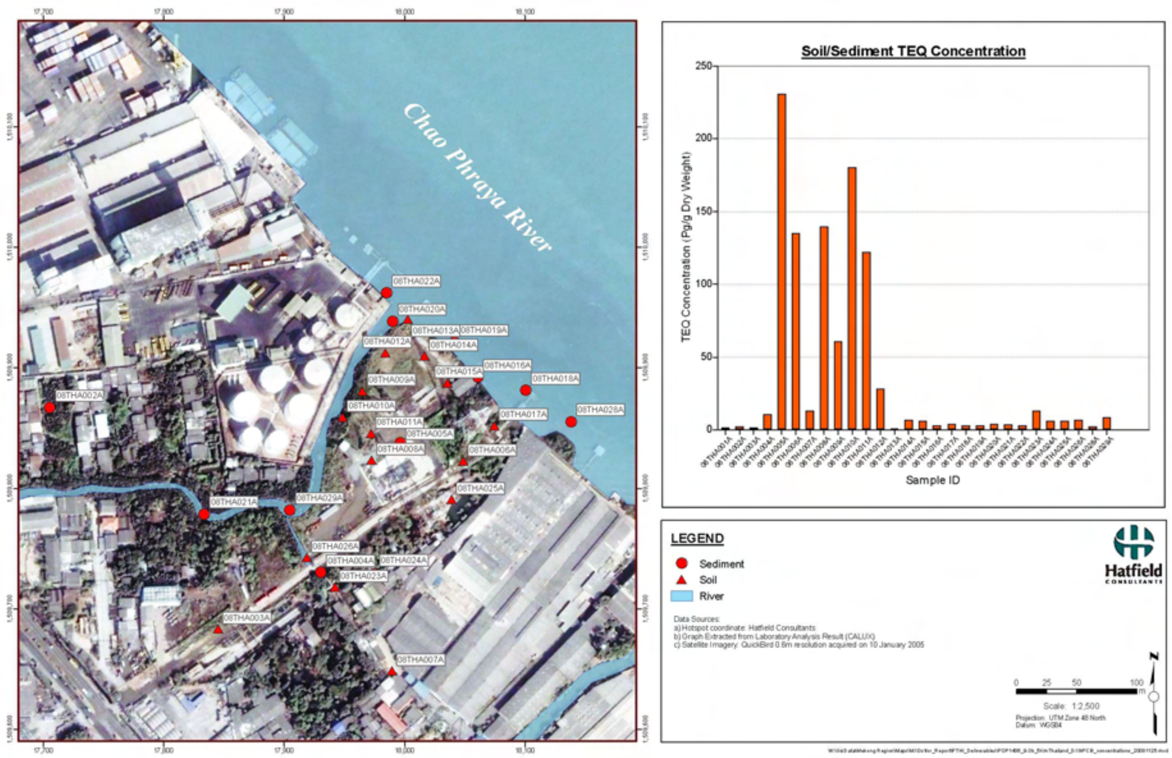
		WHO-TEF2005			I-TEF
		PCDDs/PCDFs	DL-PCBs	DXNs	PCDDs/PCDFs
Sample ID	**Site Description**	pg-TEQ(WHO2005)/g			pg-TEQ (I-TEF)/g
08THA004B	Drainage ditch close to the site.	1.8	8.2	10.0	2.5
08THA005B	Storage area (concrete floor).	13.8	216.9	230.7	14
08THA008B	Storage oil (oil soaked).	14.0	125.8	139.7	14
08THA009B	Perimeter of the site (drainage).	3.5	57.5	61.0	3.5
08THA010B	Ditch near the storage area.	8.8	171.3	180.1	8.7
08THA011B	Ditch on the storage area edge	13.1	109.3	122.3	13
08THA012B	Field closer to river bank.	2.3	25.6	27.9	2.2
08THA014B	Field (middle of property).	1.2	5.0	6.2	1.2
08THA015B	Field in front of MEA meeting room.	3.1	2.6	5.7	4.3
Average		**6.8**	**80.2**	**87.1**	**7.04**
Median		**3.5**	**57.5**	**61.0**	
Max		**14.0**	**216.9**	**230.7**	**14**
90th percentile		**13.8**	**180.4**	**190.2**	

* PCDD/PCDF and Dioxin-like PCB concentrations expressed as World Health Organization (2005) 2,3,7,8-TCDD toxic equivalence concentrations (Van der Berg, 2006).

The primary source of PCBs is the storage areas and its immediate vicinity (downstream of the storage area) where many old transformers were stored and decommissioned before their final disposal overseas (Figure A1.5).

The table does not present off-site samples (i.e., waterways) that can be contaminated by other sources of pollution transported in Chao Phraya River sediments.

Figure A1.5 PCB/Dioxin Concentrations in Soil and Sediment Samples (TEQ; pg/g) collected in July-August 2008 at MEA Facility Site, Samut Prakan, Thailand.



Screening the maximum concentrations for PCDDs/PCDFs and dioxin-like PCBs resulted in Exceedance Factors of 3.1 and 48.2 respectively. Because these Exceedance Factors are both greater than one, both PCDD/PCDFs and dioxin-like PCBs are considered contaminants of potential concern.

Based on the results of the preliminary risk calculation model (for non-carcinogens), there may be a potential human health risk associated with workers and local residents being exposed to PCBs and TCDD/TCDFs. Hazard quotients were as high as 58.5, several fold higher than the 0.2 threshold.

The results of the risk characterization assuming PCB and PCDDs/PCDFs as carcinogens record the highest calculated incremental lifetime cancer risk (ILCR) was 0.0036. This represents a one-in-278 probability above background that the MEA worker is going to die of cancer. This is 360 times greater than the Canadian upper limit of acceptable cancer risk (ILCR of 1 x 10^{-5} or a one-in-100,000 probability). Similar to the risk calculations for non-carcinogens (threshold contaminants), the greatest exposure, and greatest contributor to potential risk is the dietary exposure route.

A1.3.2 IDENTIFICATION OF RECEPTORS

Receptors are the living organisms (humans, animals and plants) that may be affected by exposure to a chemical hazard with resulting health risks and other impacts associated with this exposure. The risk assessment conducted as part of the POPs project - including a human exposure survey and the site reconnaissance and sampling program (Hatfield, 2008b) - identified several categories of receptors, corresponding to an estimated **733** people potentially exposed.

The full-time staff/workers at the workshop are considered to have the greatest potential of exposure. The staff, workers and security guards in the MEA Facility, may also be potentially exposed. Members of community, students of the nearby educational institutions and training centers, and frequent visitors and shift workers to the site are likely susceptible to exposure to environmental pollutants. Children may be especially sensitive to exposure. According to Thai national statistics, the population age group 0 - 14 years old makes up nearly 40% of the total population).

Table A1.5 provides the detailed inventory of these potential receptors.

Table A1.5 Potential Human receptors related to the MEA Facility Case Study site (within 1km radius).

Types of Potentially Exposed Persons	Estimated numbers
Residents of nearby village	400
Full time staff of the site	5
Full time security	3
Students and staff of nearby school	300
Shift workers and visitors	25
Total	**733**

(Source: Jarupong BL, 2008, Data Gathering/analysis and Identification of Hot Spot Report).

There was no blood sample of warehouse workers and other local villagers to confirm a clear linkage between direct contact with the workshop and exposure to PCBs to the identified human receptors.

Figure A 1.6 Potential receptors associated with the MEA Facility, Samut Prakan, Thailand.

Houses adjacent to the MEA Facility.

Canal located adjacent to the MEA Facility

Grass lands adjacent to the MEA Facility.

Foreshore of the MEA Facility on the Chao Phraya River.

Snails collected from the Chao Phraya River

Snake Head fish collected from aquaculture pond adjacent to the MEA Facility.

A1.3.3 IDENTIFICATION OF PATHWAYS

An exposure pathway is the route a chemical ***hazard*** follows to reach (and potentially affect) a ***receptor.***

A human exposure survey was conducted in August 2008. The results from the survey are very helpful to assess potential exposure pathways. There are several potential exposure pathways specifically related to the MEA Facility:

- On-site inhalation, accidental ingestion and dermal contact of contaminated soils;
- Wind erosion or surface water erosion of site soils off site, followed by exposure via inhalation, accidental ingestion and dermal contact;
- Transportation of contaminated soils off site on truck tires and subsequent inhalation, accidental ingestion and dermal contact; and
- Ingestion of potentially contaminated fish and wildlife.

A1.3.4 RISK MANAGEMENT OPTIONS FOR THE SITE

At the National Training Workshop which took place in Hua Hin, Thailand from 26-27 January 2009, the national participants used the MEA Facility site case study for developing risk management goals, sub-goals (objectives), and indicators. The Workshop participants also reviewed a proposed long-list and short-list of management options (using the POPs toolkit). They categorized the MEA site as a **Level B - actions likely required.** The site is a concern because of:

- The preliminary quantitative risk assessment suggests that the human health risk level is high, and the concentration of PCBs in the environment samples;
- There are currently no specific actions undertaken by the responsible authorities to mitigate the potential PCB exposures at the site;
- The potential risk also increases with rapid population growth, and land use changes occurring in the area; and
- Responsibility/liability that it might pose to the owners (e.g. cost of remediation, reputation and relation with community, and affected parties such as workers at the site, nearby property owners.

From the risk assessment, it was clear that all three elements needed for a human health risk (from PCBs), were present at the site: chemical hazards, receptors and pathways linking hazard and receptors. Consequently, risk management objectives and options have to be developed by taking into account the need to address three elements of risk – hazard, pathway and receptors. The risk management goals for the site should be to support the site management and surrounding community for:

1. More effective reduction in health risks to sensitive groups of people arising from PCBs contamination (through addressing receptors); and

2. Avoiding or, when avoidance is not feasible, minimizing off-site transfer of PCBs (in soil and sediments).

Achieving the above goals will also assist the overall *accelerated growth strategy*. It is evident that any disabilities or premature death of the principal income-earners and other family members, as well the loss of other sources of food and income (salary and potential devaluation of property), will compromise the accelerated growth strategy.

Indicators were developed to help the concerned managers to assess the progress and success of the site mitigation strategy, plan and project. One of the key indicators was "by year 2012, daily exposure to PCBs is reduced to the lowest acceptable level (i.e., HQ<0.2) <u>or</u> monitor success of implementing specific risk management approaches".

Based on the National Training Workshop's outputs, the following 3 risk management scenarios were developed for the MEA Facility Site economic valuation.

Scenario 1: Implementation, enforcement and monitoring of workers' Health and Safety

The first scenario relies on "soft" measures aimed at limiting exposure to POPs for the site workers, and to some extent, of the surrounding population. The purpose of this measure is to prevent the MEA Facility site employees from coming into contact with hazardous substances (mostly through handling of contaminated soils, transformers and their oils) and the subsequent release of contaminants in the environment (soil, water, air, and biota).

By focusing on breaking the pathway between the chemical hazard and the potential receptors, Scenario 1 is expected to significantly reduce or eliminate exposure to POPs both in the human population and the environment. It comprises of the following key components:

- Awareness raising: both among the site workers and the surrounding population about basic PCB hazards, site specific hazards, and prevention/mitigation measures;

- Health and Safety/Spill Prevention Plan: Plan must describe the safe operating and materials handling procedures, safe work practices, and basic emergency and decontamination procedures that need to be implemented at the site;

- Training: site workers must be adequately trained about the purpose and implementation of the above-listed procedures;
- Implementation/enforcement of the Health and Safety Plan; and
- Monitoring and Evaluation:
  - Regular inspection and testing of all health and safety features and procedures;
  - Periodic monitoring of environmental and human health conditions at the site (soil, water and blood testing); and
  - Investigation and reporting of occupational accidents (injuries); dangerous occurrences and incidents (near misses) and suspected occupational diseases.

Scenario 2: Containment of existing contamination + intervention under scenario 1

Scenario 2 aims to prevent or mitigate this hazard by containing the PCB contamination originating from transformers and used oils and contained in the soils. Soil, dust and sediment contamination can migrate in ground and surface water (through runoff) as well in the air, sometimes over long distances (through wind erosion).

Key containment measures that can be proposed for the MEA site are briefly outlined below:

- **Conduct test-based inventory of PCB contaminated equipment and oils -** this is required to develop a detailed needs assessment regarding possible containment; and **conduct soil testing program** to define in greater detail the scope of the containment measures to be implemented;
- **Build a secured containment facility** to safely store contaminated transformers and oils on site; the characteristics of the facility (in particular soil protection/insulation, access restriction, and safety features) must be defined through a detailed design study based on site characterization and needs assessment;
- **Store contaminated transformers and oil in secured containers and drums -** these secured items must meet high-level standards in terms of watertightness, durability, etc.;

- **Move and store PCB contaminated equipment and oils in the separate containment facility** for controlling accidental release into critical environments;

- **Cap and pave the most contaminated areas** (e.g. where large or frequent spills are known to have occurred);

- **Improve drainage and sediment control systems**: possible options include, but are not limited to: creation of settling ponds/catch basins to prevent contaminated runoff from reaching watercourses; and installation of silt fences along drainage channels to retain contaminated soil particles; and

- **Reduce contamination along the roads by** ensuring that vehicles leaving the site (and especially the workshop area) are not carrying contaminated soils on tires; improving road surface material, compaction and maintenance; and providing adequate road drainage.

A detailed scope for these measures (characteristics of the infrastructure to be built, material to be used, etc.) cannot be defined without significant design work being undertaken, including characterization of the extent and level of contamination, comparison of available technologies, engineering design studies, etc.

It can be assumed that, given the size of the MEA Facility site and the results of the sampling undertaken for the risk assessment, containment measures may need to be implemented over large areas and entail substantial costs.

Scenario 3: Disposal of contaminated equipment, oil, sediment and soils + intervention under scenario 1

The most comprehensive risk management scenario would include cleaning up the MEA site, i.e. dispose of all existing contamination whether it comes from PCBs containing equipment (transformers), oil, soils or sediments.

Scenario 3 is an engineering and expensive option. A detailed inventory is required to identify all the items and quantities of materials to be disposed of, and engineering works to be planned and conducted (excavation of contaminated soils, channel dredging, etc.). In addition, it is likely that the contaminated materials would be treated off site. A reasonable assumption is that they will have to be shipped to Europe where most of the facilities licensed to handle and destroy PCBs are located (UNEP, 2004).

It must be noted that the descriptions presented are only an outline of what the risk management scenarios should be. Detailed feasibility studies are needed to define in detail the nature and extent of the measures to be implemented, especially with regard to the containment and remediation scenarios.