Appendix A1

Sambour EDC Workshop

Site Description

A1.1 CAMBODIA SAMBOUR EDC (SEDCW) SITE DESCRIPTION

The National Focal Point in Cambodia at the recommendation of the Project Team selected the Electricite du Cambodge (EDC) Sambour warehouse ("the SEDCW site" or "the site"), as a case study for a human risk assessment of poly-chlorinated biphenyls (PCBs).

The site is situated along the Cheung Ek Road (Road No. 303), about 9 km from Wat Phnom (point zero of Phnom Penh City) and located in Sambour village, Dangkor Commune, Dangkor District, Phnom Penh (UTM 48P 0487681 x 1272498). Khan Dangkor is a sub-urban district of Phnom Penh.

The SEDCW site is situated on a plot of land of about 1.5 hectares (15,000 m^2) located next to the EDC training center and its dormitory. Road access to the site is through the training and dormitory, and newly built multi-unit condominium.

The major land use classes in the vicinity of the site (within 1 km) are predominantly residential and agricultural (13% and 60%, respectively). This land use is expected to change in favor of residential area and industrial/commercial use in the near future as the area has experienced rapid residential development during the last five years. The construction of a large scale multi-unit condominium over an area of more than 3 hectares immediately east of the SEDCW site is nearly completed for the prospective owners to occupy in late 2009 and 2010.

Table A1.1and Figure A1.2 illustrates major classes of land use in the vicinity of the site.

A1.2 SITE OPERATIONS AND SETTINGS

The SEDCW site is managed and owned by the Electricite du Cambodge (EDC). It was opened in 1997 by combining three large warehouses that were once located in various parts of Phnom Penh and contains facilities for collection, storage and repair of electrical equipment including transformers, capacitors and their oil. The SEDCW site is the country's biggest site for storing transformers most of which are planned for disposal. Most of them (about 239 transformers) were moved into SEDCW site in 2004 from the former Tek Thla warehouse (now turned into Vocational Training School).

There are three main warehouses buildings (15 m x 50 m) in the SEDCW compound made of concrete wall, concrete floors and the zinc roof. There are also numerous open-air storage areas outside of the warehouse building. The largest open-air storage area where over 100 old transformers were stored with other electrical equipment is located in the centre of the compound located just west of the training center, dormitory, and newly built multi-unit condominium.

Figure A1.1 Location of SEDCW Hot Spot in Phnom Penh, Cambodia.

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Table A1.1 Major Land Use Classes Within 1 km Radius from the SEDCW Site in Sambour, Phnom Penh.

Land Use	Area (Ha)	Area (Percentage)
Agriculture Area	187.9	59.8%
Bare Ground	18.9	6.0%
Cultural	0.6	0.2%
Industry/Commercial	21.9	7.0%
Roads	7.5	2.4%
Infrastructure (Buildings)	6.3	2.0%
Residential Area	40.7	13.0%
Trees/Shrub/Bush	8.1	2.6%
Water Body (Pond/River/Canal)	22.3	7.1%
TOTAL	**314.1**	**100%**

(Source: extracted from Quickbird high resolution satellite imageries - 20 June 2007).

Figure A1.2 Land Use Map of the Study Site, in Sambour, Phnom Penh, Cambodia

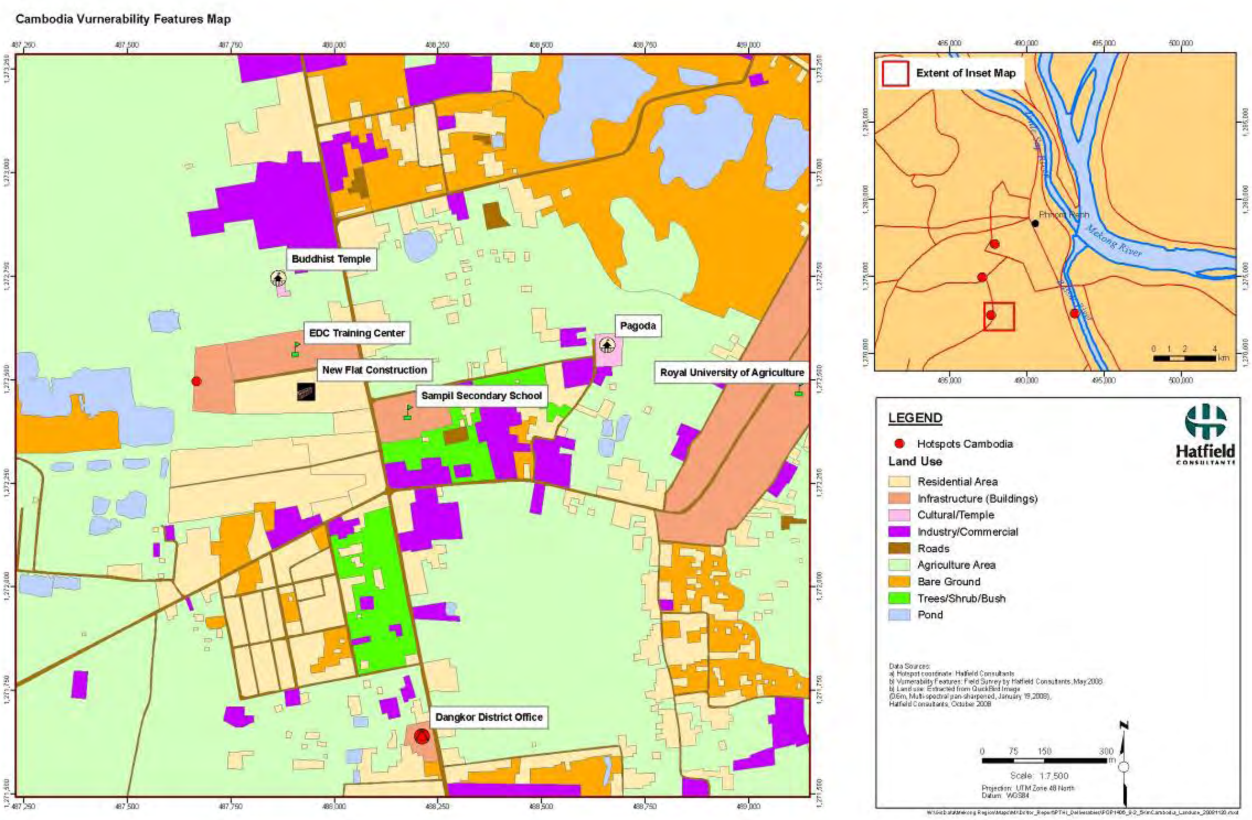


Table A1.2 below summarizes suspected activities that might have generated PCBs at SEDCW site. They included storing of old transformers, leakage of fluids from transformers, and off-site transport of contaminants by rain-runoff, air, and trucks, improper handling of PCB containing equipment and fluids 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 SEDCW 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	**Maintenance and Repair of PCB containing equipment**	Yes, partially
8	Retro filling	No
9	**Disposal of PCB containing equipment**	Yes
10	**Misuse of PCB containing fluids**	Yes

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.

The site topography is generally flat, with surface water runoff from the east to the west, north-west, and south west (based on site observations). The compound is equipped with rudimentary drainage of storm water run-off from the site through numerous outlets from the site into agricultural farm land and fish ponds just west of the SEDCW compound. A number of man-made ponds are located behind the site, which receive most of the case study site.

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

Figure A1.3 Land use in and Around the SEDCW Site, Phnom Penh.

A1.3 KEY FINDINGS OF THE RISK ASSESSMENT

A1.3.1 CONTAMINATION LEVELS

Contamination at the SEDCW site is caused primarily by the handling and storage of transformers containing PCB-contaminated oil, and spillages associated with it. Open/uncontrolled burning of waste has also been carried out regularly on the site. Accordingly, PCBs, coplanar (dioxin-like) PCBs, and dioxins/furans are contaminants of concern for the site. These contaminants migrate to the soil, sediments, water and biota from their original source.

The SEDCW site is the country's biggest site for storing old transformers most of which are planned for disposal. Many units were produced well before 1990; some are in poor condition, with dielectric fluid leaks on the ground. The PCB inventory (2004) led by the Ministry of Environment confirmed through density tests and screening tests (using test kits), that a number of these transformers contained PCBs dielectric fluid. Based on site visits and the National Inventory

Figure A1.4 Schematic Map of the SEDCW Site, Sambour, Phnom Penh, Cambodia.

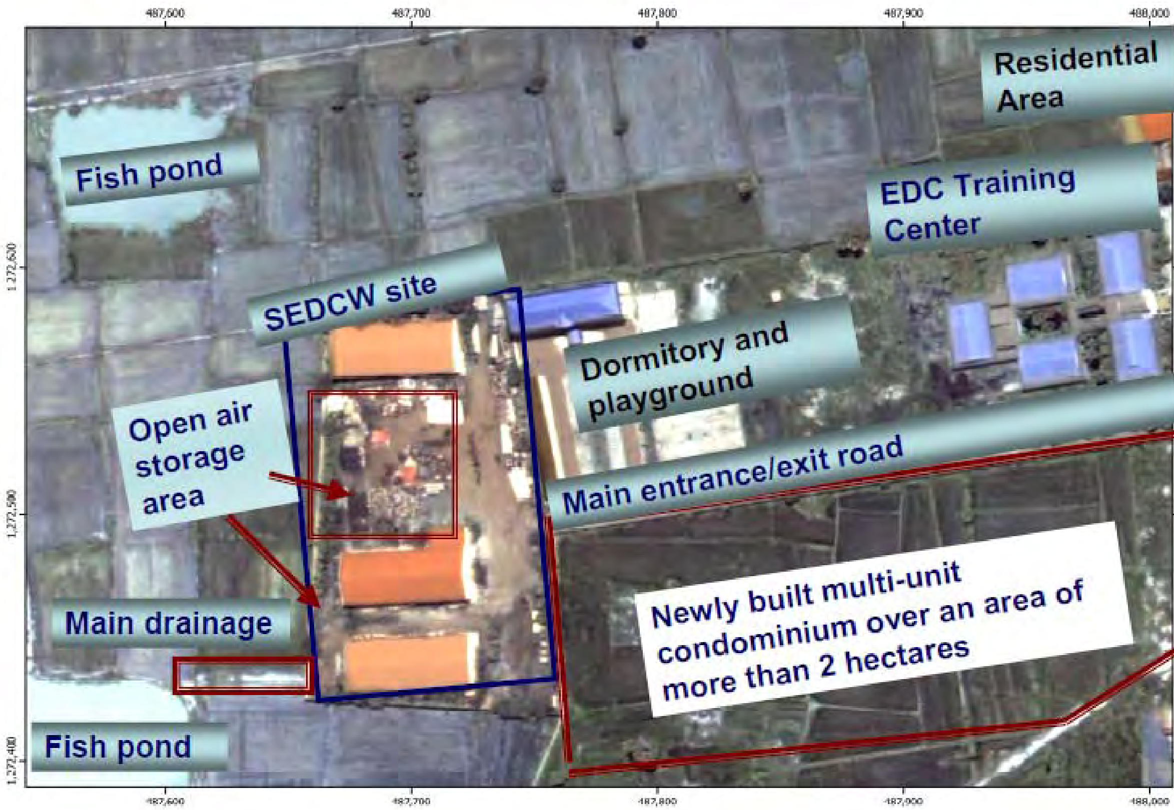


Table A1.3 Size of the key Building/Area of the SEDCW Site.

Building / area	Size (sqm)
Warehouse compound (total area)	15,000
Warehouse building 1	750
Warehouse building 2	750
Warehouse building 3	750
Open air-storage area (centre of the site)	5,250
Parking and loading area	900

report (2004), the number of olds transformers on site is estimated to be around 235, and 153 (about 66%) of them were assumed to be PCBs contaminated. It was estimated 10 additional transformers "transit" the site annually for storing while awaiting the final disposal.

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 highest levels of contamination were measured:

- Two samples collected from open-air storage areas;
- Dust collected from one of the storage buildings;
- Soil collected near chicken coop in the warehouse compound;
- Dust off entrance road; and
- Crab tissue.

The primary source of PCBs is the warehouse where many old transformers are stored in both the warehouse and in the yard.

The TEQ concentration in the soil, dust, and crab tissue ranged from 1.84 pg/g to more than 44.31pg/g which is well above the acceptable limit of 1.3pg/g dry weight (CCME, 1999). The chemical data were also screened against environmental quality guidelines (the USEPA Risk Based Concentration (RBCs; USEPA 2008) to determine if a chemical is present at potentially hazardous concentrations (See Hatfield, 2009a). Screening the maximum TEQ concentrations for PCDD/Fs and dioxin-like PCBs resulted in exceedance factors of 2.6 and 10 (based on WHO 2005 toxicity equivalence factors, Van den Berg 2006). The toxicity assessment results of the site were also >10 times higher than 0.2 threshold (2.66). Since these exceedance factors are both greater than one, both PCDD/Fs and dioxin-like PCBs were considered contaminants of potential concern at the SEDCW site.

The results of the risk characterization for PCB and dioxins/furans as carcinogens showed that the calculated incremental lifetime cancer risk (ILCRs) were all greater than the Canadian upper limit of acceptable cancer risk (an ILCR of 1.0×10^{-5}). Similar to the risk calculations for non-carcinogens (threshold contaminants), the greatest exposure, and greatest contributor to potential risk, is the ingestion of contaminated food (crabs) from the site.

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 1,438 people exposed.

The full-time workers and guards at the SEDCW site are considered to have the greatest potential of exposure. Staff and students in the EDC training complex may also be potentially exposed, as well as regular visitors and shift workers. Over 1,286 people living in 168 households (over 7.6 persons per household) within 1km radius of the site are also a potentially exposed population.

Table A1.4 provides the detailed inventory of these potential receptors.

Figure A1.5 PCB/Dioxin Concentrations in Soil and Sediment Samples (TEQ; pg/g) collected in May 2008 at SEDCW Site, Cambodia.

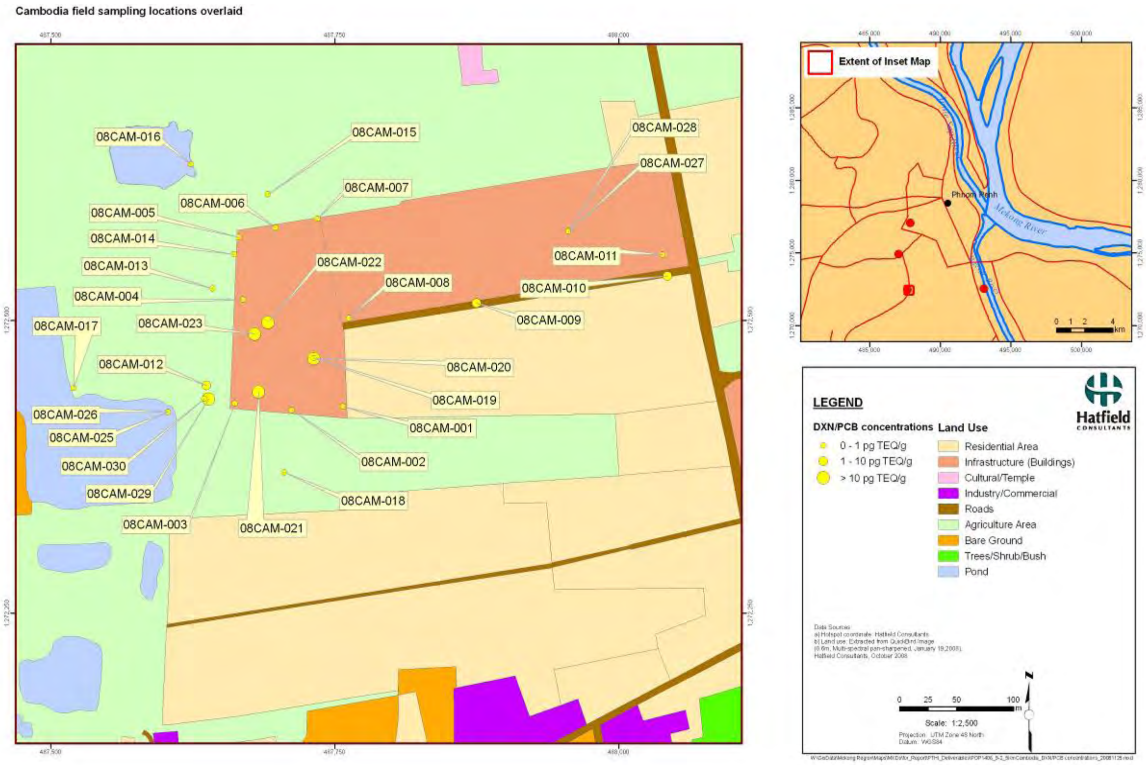


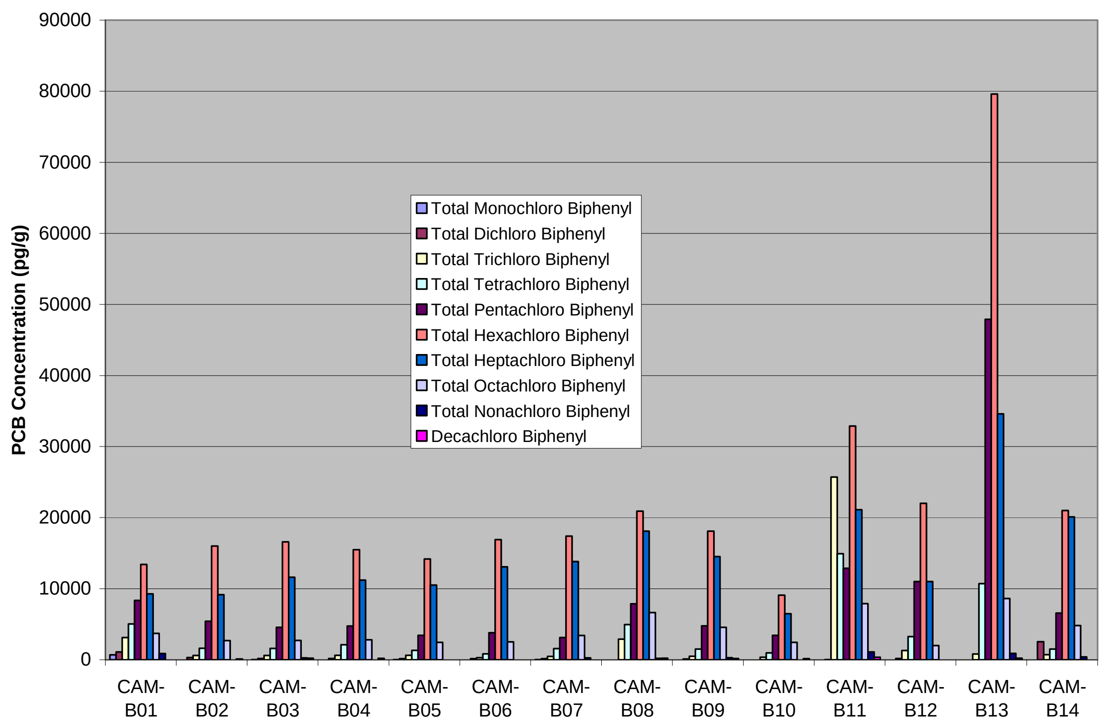
Table A1.4 Potential Human Receptors Related to the SEDCW Site (within 1 km radius).

Sambour Site, Phnom Penh, Cambodia	
Types of potentially exposed	**Estimated numbers**
Sambour village residents Within 1 km radius	1,286
Full time staff of warehouse	22
Full time policemen	3
Full time EDC training center staff	25
Full time security staff of Center	7
Students (short-term training courses)	110
Shift workers and visitors	25
Total	1,438

(Source: May and August 2008 field works by the Project Team and socio-economic survey by Cambodian National Consultant in July 2008)

The analysis of the blood of warehouse workers and other EDC Training Center employees generally indicates little variation in concentration (Figure A1.6) and generally indicated that blood concentrations of PCBs were low. This finding is not surprising, considering that the warehouse is relatively new (less than 10 years old) and employees generally did not have a history of working with or near electrical transformers. However, there were a few notable exceptions for three people who had higher concentrations than other samples. Information on these individuals indicated that they had a higher level of exposure related in particular to their seniority at the site or in dealing with transformers.

Figure A1.6 Blood PCB Concentrations (homologues) of EDC Employees and Family Members (pg/g lipid), SEDCW Study Site, Phnom Penh, Cambodia.



A1.3.3 IDENTIFICATION OF PATHWAYS

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

There are several potential exposure pathways specifically related to the SEDCW site:

- On-site: inhalation, accidental ingestion and dermal contact of soils/dust inside the warehouse buildings and outside on the SEDCW site;

- Off-Site: wind erosion and surface water transport of exposed soils followed by : inhalation, accidental ingestion and dermal contact;
- Transportation of sediments off site either on tires of trucks and subsequent inhalation, accidental ingestion and dermal contact;
- Transportation of transformer oils off site for use as cooking fuel (oil impregnated coconut husks are used to start cooking fires) and subsequent inhalation, accidental ingestion and dermal contact; and
- Ingestion of potentially contaminated fish and wildlife.

Figure A1.7 Selected Potential Exposure Pathways Associated with the SEDCW Site, Phnom Penh, Cambodia.

Crab collected from rice field outside SEDCW site.

Local resident collecting snails outside SEDCW site.

Chickens foraging on the SEDCW site.

New housing complex adjacent to the SEDCW site. Warehouse is at the end of the driveway.

Figure A1.7 (Cont'd.)

Local resident fishing from a pond behind the SEDCW site, Phnom Penh, Cambodia

A1.3.4 RISK MANAGEMENT OPTIONS FOR THE SITE

At the National Training Workshop which took place in Siem Reap, Cambodia from 19-21 January 2009, the national participants used the SEDCW 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 SPL site as a **Level B - actions likely required.** The SEDCW site is a concern because of:

- The preliminary quantitative risk assessment suggested that the human health risk level is high, and the concentration of PCBs in the environment samples;
- Risk was expected to evolve with time if proper risk management actions are not undertaken now. The greatest concern was for health of the workers, families and local ecology, as oil leakage from rusted transformer increasingly release into the environment;

- 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 goals set for the site by the National Training Workshop were to support the site management and surrounding community for:

1. More effective reduction in health risks to sensitive groups of people arising from PCB contamination through primarily eliminating the pathway; and

2. Avoiding or, when avoidance is not feasible, minimizing uncontrolled releases of PCB hazardous materials or accidents (including explosions and fires) during their handling, storage and use (addressing chemical hazards and pathways).

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) or 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 SEDCW 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 SEDCW 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. These soft measures can be readily implemented (since little design is required) and costs are expected to be low (no major infrastructure construction is needed).

The key components of Scenario 1 include:

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

- **Develop, implement and enforce a Health and Safety Plan**: the 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. Measures prescribed by the plan may include (but not be limited to):

  - Mandatory use of personal protection equipment;

  - Labeling of hazardous equipment, containers and areas to communicate their level of hazard; signage must follow recognized standards and be easy to understand;

  - Frequent cleaning of surfaces, structures and vehicles prone to accumulating or transporting contamination;

  - Hazardous material storage and handling policy (including a ban on transformer oil recycling by workers); and

  - Spill response procedures.

- **Training personnel**: site workers must be adequately trained about the purpose and implementation of the above-listed procedures;

- **Ensure integrity of the workplace:**

  - Provide facilities for showering and changing into and out of street and work clothes;

  - Provide clean eating areas where workers are not exposed to hazardous or noxious substances; and

  - Define and enforce the policy of "restricted entry into contaminated areas without proper protection or authorization".

- **Monitor health and environment:**

  - 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

- o 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 Scenario1

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 SPL 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 SEDCW 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 Scenario1

The most comprehensive risk management scenario would include cleaning up the SEDCW 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.