LEBANON

RAPID ENVIRONMENTAL ASSESSMENT FOR

GREENING RECOVERY, RECONSTRUCTION AND REFORM 2006

SOLID WASTE

7.1 INTRODUCTION

One of the notable impacts of the war in Lebanon was the generation of very large amounts of solid wastes. Two waste streams are of particular importance: construction mixed demolition wastes and oil-spill related solid waste. These are notorious for the very large quantities produced and their quality, which may require special equipment and means for treatment and/or disposal.

The quantity and composition of other types of wastes were also affected in one way or another during the war. These include agricultural wastes, domestic municipal wastes, industrial wastes, medical wastes, and other special wastes.

Demolition wastes are covered in the construction chapter. Oil-spill related wastes are covered in more detail in this chapter. Options for disposal of the different oil waste streams are analyzed to provide guidance to decision-makers on the best alternative for waste disposal. Other waste streams are covered to a lesser extent, however enough to document the facts and provide general recommendations for their management that can be used to improve existing policies and practices in the country.

7.2 OIL-SPILL RELATED WASTE

On 13 and 15 July 2006 the Jiyeh power utility located 30 km south of Beirut and directly on the coastline was hit by Israeli bombs. The estimated amount of oil spilled is 15,000 m^3; another 60,000 m^3 in storage at the Jiyeh tank farm are thought to have burned, causing extensive atmospheric contamination in a plume reportedly reaching 60 km (Steiner R., 2006).

Preliminary survey conducted by the Ministry of Environment (MoE) revealed 31 polluted sites spread over 150 km on the Lebanese shoreline to the north of Jiyeh. Seven sites with high priority have been identified by MoE, amongst which Byblos port and Raouche Fishermen's Wharf were categorized as first priority. Thirteen "confined" sites are categorized as second priority (Steiner R., 2006). Table 7.1, prepared by MoE, indicates the name and characteristics of the sites affected according to surveys conducted between July 18 and August 3, 2006. Figure 7.1 shows one stretch contaminated with oil in Beirut.

Table 7.1. List of Surveyed Sites by MoE Impacted by Oil Spill (July 18 to August 3, 2006)

Site #	Site Name	From		To		Length (km)	Area (sq.m.)	Open/ Confined*	Rocky/ Sandy/ Other	Length of Confined Space Entrance (m.)
		Coordinates N	Coordinates E	Coordinates N	Coordinates S					
1	Jyeh	33º 38' 58.07"	35º 23' 59.88"	33º 39' 13.77"	35º 24' 55.27"	1.5	-	Open	Sandy	-
2	Rmaileh	33º 39' 09.83"	35º 24' 53.17"	33º 40' 03.55"	35º 25' 02.78"	1.6	-	Open	Sandy	-
3	Damour	33º 42' 01.91"	35º 26' 23.91"	33º 44' 22.85"	35º 26' 49.04"	4	-	Open	Sandy	-
4	Ramleh Baida	33º 52' 14.45"	35º 28' 52.48"	33º 52' 59.59"	35º 28' 39.05"	2.1	-	Open	Sandy	-
5	Movenpick	33º 53' 00.23"	35º 28' 21.19"	-	-	-	12,000	Confined	Rocky	25
6	Sporting	33º 53' 35.02"	35º 28' 01.81"	-	-	-	900	Confined	Rocky	71
7	Raouche (fishermen)	33º 53' 12.85"	35º 28' 17.07"	-	-	-	1,800	Confined	Rocky	17
8	Long beach	33º 53' 38.47"	35º 28' 01.48"	-	-	-	6,300	Confined	Rocky	53.2
9	Tabarja	34º 01' 06.61"	35º 37' 25.74"	34º 01' 24.02"	35º 37' 20.48"	3	-	Open	Rocky	-
10	Byblos sandy beach	34º 06' 04.89"	35º 39' 02.46"	34º 06' 58.60"	35º 38' 48.54"	1.7	-	Open	Sandy	-
11	Byblos port	34º 07' 17.96"	35º 38' 36.12"	-	-	-	7,700	Confined	Rocky	30
12	Byblos sur mer (Marina)	34º 07' 21.20"	35º 38' 31.57"	-	-	-	1,500	Confined	Rocky	42
13	Byblos gravel beach	34º 07' 23.50"	35º 38' 34.90"	34º 07' 45.89"	35º 38' 29.89"	0.7	-	Open	Gravel	-
14	Batroun	34º 13' 41.40"	35º 39' 19.09"	34º 14' 48.80"	35º 39' 35.12"	1.5	-	Open	Sandy	-
15	Batroun Bay	34º 15' 08.22"	35º 39' 25.12"	-	-	-	76,320	Confined	Pebbles	188.32
16	Heri (Rocca Marina)	34º 18' 26.98"	35º 42' 00.66"	-	-	-	15,000	Confined	Sandy	56.5
17	Saint Antoine	34º 18' 18.82"	35º 42' 06.93"	-	-	-	2,000	Confined	Sandy	61
18	Blue beach	34º 18' 22.52"	35º 42' 36.17"	34º 18' 38.38"	35º 42' 55.31"	0.7	-	Open	Sandy	-
19	Chekka	34º 18' 41.34"	35º 42' 56.00"	34º 19' 31.81"	35º 43' 20.45"	0.7	-	Open	Sandy	-

Site #	Site Name	From		To		Length (km)	Area (sq.m.)	Open/ Confined*	Rocky/ Sandy/ Other	Length of Confined Space Entrance (m.)
		Coordinates N	Coordinates E	Coordinates N	Coordinates S					
20	Ras El Sakhr & Mina Public Beach	34º 32' 47.25"	35º 49' 14.76"	34º 25' 05.24"	35º 49' 13.68"	0.7	-	Open	Rocky	-
21	Ras Maska- Bahsas	34º 25' 10.16"	35º 49' 13.83"	34º 25' 37.38"	35º 49' 04.08"	1	-	Open	Sandy	-
22	Al Zreira (Borders of Kfarabida)	34º 14' 38.68"	35º 39' 37.19"	34º 14' 44.90"	35º 39' 38.41"	0.22	-	Open	Rocky	-
23	Sawari Beach	34º 14' 48.86"	35º 39' 31.61"	-	-	-	5,292	Confined	Sandy	-
24	Saint Stephano Beach	34º 14' 53.30"	35º 39' 28.81"	-	-	-	2,220	Confined	Rocky	-
25	Aqualand	34º 14' 55.81"	35º 39' 29.08"	-	-	-	630	Confined	Rocky	-
26	National Center for Marine Sciences	34º 15' 04.37"	35º 39' 23.41"	34º 15' 11.33"	35º 39' 22.84"	0.23	-	Open	Rocky	-
27	Phoenician Wall	34º 15' 10.89"	35º 39' 21.58"	34º 15' 28.12"	35º 39' 23.06"	0.53	-	Open	Rocky	-
28	Fishermen's Wharf- Batroun	34º 15' 27.68"	35º 39' 26.60"	-	-	-	11,776	Confined	Pebbles	-
29	Al Ghalaghili Beach	34º 15' 53.83"	35º 39' 31.12"	34º 16' 15.90"	35º 39' 22.04"	0.8	-	Open	Rocky	-
30	Palm Island Nature Reserve	34º 27' 43.31"	35º 48' 01.48"	34º 27' 48.10"	35º 48' 03.43"	0.2	-	Open	Sandy	-
31	Anfeh	34º 20' 48.59"	35º 43' 37.36"	34º 21' 37.74"	35º 43' 41.23"	1.4	-	Open	-	-
32	Kfar Abida	34º 13' 35.13"	35º 39' 14.54"	34º 14' 47.67"	35º 39' 34.96"	2	-	Open	-	-
33	Monsef- Pierre and Friends (Madfoun)	-	-	-	-	-	-	-	-	-
TOTAL						**21.18**	**143,438**	**-**	**-**	**544.02**

Figure 7.1. Beach Sand and Solid Waste Contaminated by Oil Spill at Ramlet Al Baydeh-Beirut

7.2.1 QUANTITY AND CHARACTERISTICS OF WASTE GENERATED

The oil that has leaked in the sea was characterized as Intermediate Fuel Oil (IFO) 150 (refer to energy chapter). One of the most difficult problems to deal with the oil spill clean-up is related to the quantity of waste generated in a very short period of time and the difficulty to predict the waste quantity and quality generated. Historical data shows that oil spills impacting the shoreline can, in extreme cases, produce up to 30 times more waste than the volume of oil originally spilt (IFPMA, 2006).

Table 7.2 presents a list of the different types of oily waste generated and current storage and disposal methods adopted (MoE, 2006). By end of November 2006, MoE records showed that close to 1,000 m^3 of liquid oil had been removed as well as about 4,800 m^3 of contaminated sand, gravel and solid wastes (MoE, 2006). REMPEC had apparently under-estimated that about 4,000 tons of waste were to be treated or stored, in the form of liquids, pastes, sands, and pebbles, macro-wastes and contaminated cleaning equipment (GEIDE, 2006), quantity which has already been exceeded. Table 7.3 presents the typical waste streams generated by alternative oil response methods.

7.2.2 POST-CONFLICT INITIATIVES

A national oil spill cleanup operation for the Lebanese coast could not start immediately after the spill occurred or even after the cease fire due to the air and marine blockade enforced by the Israeli army on Lebanon as well as due to the lack of human, material and financial resources. The effective cleaning up started few weeks (52 days after bombardment) after cease fire (CNRS, 2006; Steiner R., 2006; MoE 2006).

Current ongoing cleaning activities involve several entities, local and international organizations as described in more detail in the biodiversity chapter. However the waste management issue remains relatively a major problem to be addressed.

Table 7.2. Different Oil Contaminated Waste Streams[132] (MoE, 2006)

Type of Waste	Intermediate Storage	Temporary Storage Location and Capacity
Liquid Oil (recovered by dredge, skimmers or manually - pooled oil)	- tanks in plastic containers watertight	Soliver glass manufacture (Khalde) 4,000-tonne tank
Sunken oil collected in plastic bags (more or less burnt oil)	- oil in plastic bags placed in plastic containers watertight	Temporary storage out of beaches to be organised (private owned)
Sunken oil collected by vacuum pump/manually with minor quantity of sand (Italian team)	- watertight plastic containers - metallic drums	One safe temporary storage area to be prepared on private owned land and built by private company (2000 m^2)
Oily debris (plastic, woods, textile, protective suits, boots, sorbents, scrapers, etc.)	- drums - tanks - watertight plastic containers	
Oily sand	- more or less oily sediment collected in plastic watertight containers or plastic bags	-if minor contamination, material is sent back to the sea with oil recovery - if major contamination, material is sent to safe temporary storage

7.2.3 ENVIRONMENTAL CONCERNS

A large portion of the spill has emulsified and solidified along the Lebanese shore, clinging to sand, rock and stone. Oil that remained on water was more fluid, but it rapidly dried to a tarry residue once it was left on the beach.

The oil spill raises an important concern with respect to marine biodiversity. Oil spills may have an immediate impact on animals that use the surface of the sea such as birds, seals and dolphins; birds in particular are among the possible victims. The presence of Mediterranean monk seals, a listed endangered species, in the Palm Island region should be noted. Four species of turtles, including the green turtle, an endangered species, reproduce on the Lebanese coasts. Reproduction sites are indicated in the Tyre and Palm Island reserves. Concurrence of soiling of beaches and the egg hatching period, the eggs being laid from May to August and hatching 1 to 2 months later, could lead to severe negative impacts (Steiner R., 2006).

[132] MoE Daily Situation Reports

Table 7.3. Response Strategies and their Effect on Waste Generation[133]

Clean-up Technique		Effect on Waste Stream	Waste Generated
Dispersant application	Dispersant chemicals are used to break down the oil slick into small droplets so that the diluting effect of the ocean is better able to reduce hydrocarbon concentrations. This strategy will not work with all oils and is not appropriate for use in certain environments.	Waste concentrations are minimal as the oil is suspended in the water column and allowed to biodegrade naturally.	• No hydrocarbon waste is generated. • PPE • Empty dispersant drums/considerations
At-sea response operations	Recovery devices, e.g. booms and skimmers, are deployed from ships or small craft to recover oil from the sea surface. Suitably sized storage systems may be needed which, in the case of highly viscous or waxy oils, will require heating elements. Transfer systems and reception facilities will also be needed to sustain operations over the long term.	Recovery operations will potentially give rise to a large quantity of waste oil and water for treatment. The volume of the storage systems available must be consistent with the recovery capacity of the skimmers. The type of oil spilled will have an effect on the resultant waste; viscous and waxy oils in particular will entrain debris and can create large volumes of waste. They can also present severe handling difficulties.	• Oiled equipment/vessels • Oiled PPE and workforce • Recovered oil • Oily water • Oiled sorbent materials • Animal carcasses
Shoreline clean-up	Oils are recovered from shorelines either using mechanical or manual means. Manual recovery is the preferred method because it has the effect of minimizing the amount of waste generated. Machines can be used to transport the waste from the shoreline to the primary storage site. Portable tanks or lined pits can be used to consolidate recovered oil at the operating site. The shoreline type, and degree of access to it, will dictate the types of strategies used which, in turn, will determine the amount of waste recovered.	The type of spilled oil will often have a profound effect on the amount of oily waste generated. Waste segregation and minimization techniques are critical to ensure an efficient operation. These should be established at the initial recovery site and maintained right through to the final disposal site otherwise waste volumes will spiral out of control. Waste sites should be managed in such a way as to prevent secondary pollution.	• Oiled equipment/vessels • Oiled PPE and workforce • Recovered oil • Oiled vegetation • Oily water • Oiled sorbent materials • Oiled beach material (sand, cobbles, etc.) • Oiled flotsam and jetsam • Animal carcasses • Oiled transport

[133] IPIECA, 2004

Clean-up Technique		**Effect on Waste Stream**	**Waste Generated**
In-situ burning	This involves a strategy of burning spilled oil using fire booms to thicken the oil layer to sustain combustion. Weathering and emulsification of oil will inhibit the process. The strategy cannot be used on all oil types or in all environments. The resultant air pollution and the production of viscous residues can limit the application of the strategy.	In-situ burning can reduce the amount of oil in the environment. However, the remaining material may be more persistent.	• Burnt oil residues • Oiled/fire damaged boom • Oiled vessel • Oiled PPE

In some cleaning locations, limited attention was paid to segregation of waste and several temporary storage areas have already been created on the working sites, some of them being "uncontrolled", while others are stored near the boarder coast line with possibility of being easily re-located by water waves (Figure 7.2), such as in Enfeh near "Phoenician wall", 3 meters from sea (GEIDE, 2006).

Figure 7.2. Oil waste collection bags

In other cases, it was reported that PVC containers were used as temporary storage for removed oil waste which adds to the problem of final waste disposal. Stored oil waste tends to emulsify making it very difficult or impossible to be emptied. Incineration of PVC containers can lead to the production of dioxins due to the presence of chlorine. The Danish EPA found that doubling PVC feed in an incinerator increased dioxin levels by 32 percent (Hammer, 1998).

According to SEACOR, the American contractor cleaning the stretch from Byblos to Enfeh, the wastes collected on the beach are separated into clean wastes and contaminated wastes and subsequently put in containers. Containers of clean wastes were sent by truck in a "municipal discharge" with the approval of the mayor. Another potential critical impact is related to the final disposal of removed oily waste. Inadequate storage, handling and disposal of recovered oil waste could result in transporting the pollution inland with high possibility of secondary contamination of water resources, soil and air, depending on the selected option.

7.2.4 WASTE MANAGEMENT OPTIONS

7.2.4.1 Typical Oil Waste Management Options

The objective of an oil spill clean-up operation is ultimately to treat, recycle or dispose of the oily waste in the most efficient and environmentally sound manner. The disposal option chosen will depend upon the amount and type of oil and contaminated debris, the location of the spill, environmental and legal considerations and the likely costs involved.

Based on literature review, Table 7.4 identifies the typical treatment and disposal options with regard to different categories of collected oil-spill waste (IPIECA, 2004). Table 7.5 describes in further detail the various treatment and disposal techniques for oil waste, and presents recommendations and limitations of these alternatives. It should be noted that the tables present general guidelines for the management of oil-spill wastes, whereby the feasible techniques are currently being implemented in Lebanon by MoE and its partners.

Table 7.4. Waste Types and Disposal Methods[134]

Waste Type	Treatment and Disposal Methods								
	Re-processing	**Oil water separation**	**Emulsion breaking**	**Stabilization**	**Bio-remediation**	**Sediment washing**	**Landfill**	**Thermal treatment**	**Heavy fuel use**
Pure oil	√	X	X	X	X	X	X	X	√
Oil & water	√	√	√	X	X	X	X	X	√
Oil & sediment	√	X	X	√	√	√	√	√	X
Oil & organic debris	X	X	X	√	√	X	√	√	X
Oil & PPE	X	X	X	X	X	X	√	√	X

134 IPIECA, 2004

Table 7.5. Disposal and Treatment Options and Relevant Considerations[135]

Treatment method	Techniques	Considerations
Re-processing	▪ Oil is recovered with a low water and debris content and is then reprocessed through an oil refinery or recycling plant. ▪ Oil can then be reused - the preferred option, as identified in the waste hierarchy	▪ Refineries cannot accept oil with a high salt content because it can cause irreversible corrosion damage to the pipe-work. ▪ Oil that is heavily contaminated with water, sediment and debris is also unacceptable.
Oil/water separation	▪ Separation generally occurs by gravity i.e. oily water is put into a lined pit and allowed to separate out. A skimmer is then used to remove the oil from the surface. ▪ Special separation equipment, found at oil processing installations, is also often used.	▪ Oily water residue from separation techniques may then have to undergo further treatment through a system of weir separators, as the hydrocarbon content will still be too high for release into the environment.
Emulsion breaking	▪ Heating of emulsions can be used to break them down to oil and water phases. ▪ In some cases specialized emulsion breaking chemicals will have to be used. ▪ Once separated the recovered oil can be blended into refinery feedstock or reprocessed.	▪ Any chemicals used will remain in the water after separation so care will be needed when disposing of the water.
Stabilization	▪ The oil can be stabilized using inorganic substances such as quicklime (calcium oxide), fly ash or cement. ▪ Stabilization forms an inert mixture that reduces the risk of the oil leaching out and thus can be sent to landfill with fewer restrictions than free oil.	▪ Contact with quicklime can cause irritation to eyes, skin, respiratory system, and gastrointestinal tract. The material reacts with water, releasing sufficient heat to ignite combustible materials.

[135] IPIECA, 2004

Treatment method	Techniques	Considerations
Bioremediation	▪ Bioremediation is used to accelerate the natural, microbial break-down of oil. ▪ One example of bioremediation is landfarming. Oily debris, with relatively low oil content, is spread evenly over the land and thoroughly mixed into the soil promoting natural breakdown of oil by micro-organisms.	▪ Bioremediated material may need mixing at intervals to encourage aeration; fertilizer may be added if necessary and consideration should be given to the suitability of location e.g. adequate distance from ground water supplies. ▪ Landfarms suitable for bioremediation are becoming difficult to find.
Beach washing	▪ Involves the cleaning of pebbles and cobbles, either in-situ or at a separate treatment site. ▪ For boulders and rocks coated in oil, cleaning may be carried out through washing on a grill allowing the oily water to drain off for treatment. ▪ For light oiling, boulders and pebbles can be moved into the surf zone for natural cleaning. The wave energy will move them back into their original position over time.	▪ This technique should only be considered when the sediments hold a large quantity of oil because it is time consuming, costly, produces a lot of oily water waste requiring treatment, and there is often difficulty in defining when material is oil free and can be returned to the beach.
Sand washing	▪ For sandy sediments, specialist sand cleaning equipment can be used. ▪ A suitable solvent may also be added to aid the process.	▪ This method is time consuming; costly; produces a lot of oily water waste requiring treatment; and it is often difficult to define when sediment is oil-or solvent-free and so can be returned to the beach.

Treatment method	**Techniques**	**Considerations**
Landfill	▪ Oily waste typically containing less than approximately 5 per cent oil can be co-disposed with non-hazardous, domestic waste and taken to designated landfill sites. ▪ Established landfill sites are usually lined which suits oily waste as it prevents the oil leaching out into surface water and aquifers. ▪ They are also usually covered daily which prevents infiltration of rainwater thus reducing the potential for an increase in contaminated water.	▪ The sites will need special permission from the local regulatory authority to receive this type of waste and volumes are often limited. ▪ Chemical testing should be conducted to determine the hazardous content of the oil at this stage. ▪ Facilities able to receive this waste are becoming more difficult to find.
Incineration	▪ A treatment technology involving the destruction of waste by controlled burning at high temperatures. In the instance of oiled waste, the hydrocarbons are broken down by the high temperatures which also reduces the remaining solids to a safe, non-burnable ash. ▪ Cement factories and kilns are an effective method and will keep costs down, as treated waste can sometimes be used as a raw material or for power generation.	▪ The use of portable incinerators is often prohibited by legislation which stipulates that the location must be licensed and an environmental impact assessment carried out because of atmospheric pollution. ▪ Permanent incinerators used for the disposal of domestic waste can be considered, although the highly corrosive nature of the salt in the oil may render these unsuitable. ▪ High temperature industrial incinerators are able to deal with the waste, although they are limited in supply, making them unable to deal with large quantities, and are often costly.

7.2.4.2 Oil Spill Waste Management Options in Lebanon

Lebanon generally lacks the necessary infrastructure for waste management. While facilities for treatment and disposal of municipal solid wastes exist, hazardous waste management facilities do not exist. Particularly lacking are hazardous waste landfills and industrial incinerators, which are options typically used in developed countries to treat and dispose of hazardous or special wastes.

Nevertheless, local options for the management of oil-related wastes were identified and are alternatives are compared in this section. Table 7.6 to Table 7.9 present an analysis of the different oil waste streams and their different treatment and disposal options available in Lebanon. These waste streams are removed liquid oil, low to medium contaminated sand, heavily contaminated sand, and contaminated solid wastes.

Table 7.10 presents a comparative analysis of different treatment technologies. When applicable, the option of exporting the waste to be treated in a facility outside Lebanon, in the framework of the Basel convention, is also considered.

Table 7.6. Options for Liquid Oil Waste Treatment in Lebanon

Waste stream #1[136]: Liquid Oil Waste				
Options	**Local Options**	**Benefits**	**Constraints**	**Estimated cost**
Option 1: Re-processing / oil recovery into original intended products	Processing equipment available in Zahrani refinery and in Dora	■ Recovered oil could be treated as "Material" rather than "Waste" if intended to be sent to refinery ■ Recovery of oil ■ Reduction of waste quantity disposal	■ Requires modern & expensive equipment only found in refinery ■ Requires approval of refinery management & MoEW ■ Requires pre-processing and screening ■ Quality of oil recovered could be a limiting factor	Re-processing cost not available Transportation cost estimated at $20 →$60/trip at $10m^3$/trip[137] Average transportation cost =$6,000
Option 2: Re-use directly as fuel source	Several heavy energy demand industries are available in the country such as: 1- Cement industry 2- Glass industry 3- Smelting industry	■ Recovery and re-use of valuable energy source ■ Cost recovery option ■ Demand in market for energy sources includes liquid oil waste	■ Need de-emulsification (solid to liquid) and decanting (separate oil/water) ■ Potential corrosion to equipment due to expected high salinity level ■ Oil should be free of mercury ■ Oil should be free of MgO and zinc (for cement industry) ■ Requires testing	Estimated at $40/tonne Transportation cost estimated at $20 →$60/trip at $10m^3$/trip[138] Total cost = $42,000 Average transportation cost =$6,000 Estimated total cost for liquid oil incineration = $48,000

[136] Total waste represents only those recovered until end of November 2006, calculations were based on these figures. Quantity = 1,000 m^3
[137] Taken from the cost for rubble removal in Beirut southern suburb
[138] Taken from the cost for rubble removal in Beirut southern suburb

Table 7.7. Options for Low to Medium Contaminated Sand in Lebanon

Waste stream #2[139]: Low to Medium Contaminated Sand & Pebbles				
Option	**Local Options**	**Benefits**	**Constraints**	**Estimated cost**
Option 1: Re-use as raw material in cement industry	■ Cement industries are available ■ Sand is a natural raw material consumed in cement production	■ Permanent elimination of contaminated sand	■ Transportation cost ■ Loss of natural beach sand resources	■ Removal and Transportation cost (around \$20→\$60/trip) ■ Mostly no additional cost if lightly contaminated soil with oil and solid waste[140] ■ Estimated cost =\$12,500→\$25,000
Option 2: Re-use in construction material and asphalt industry	■ High demand for raw material due to ongoing reconstruction activities in road construction	■ Reduces the demand on raw material needed for re-construction efforts ■ If non-hazardous can be reused	■ If test reveal hazardous then cannot be re-used ■ Requires pre-processing ■ Cost of raw material might be cheaper than cleaning of contaminated sand ■ Mishandling could result offsite contamination	■ Removal and transportation cost (around \$20→\$60/trip) ■ Pre-processing cost ■ Estimated cost = \$ 12,500→\$25,000 (excluding pre-processing cost)
Option 3: Natural Bioremediation or with Enzymes	■ Lack of available space especially for in situ treatment options	■ Recovery of natural resource (sand) ■ Low cost only for large quantity ■ Larger quantity will result in more economy of scale	■ Must meet hydro-geological and physical requirement for site selection criteria ■ No recovery of oil ■ Increase of VOC emissions ■ Requires a lot of testing, monitoring, foundation and mechanical work ■ Requires large surface area ■ Dispersed quantity of contaminated soil increases cost	■ \$4→\$67/m^3 for natural treatment (without leachate treatment) ■ \$26→\$220/tonne for bioremediation with enzymes (without leachate treatment) [141] ■ Estimated cost range =\$160,000 without enzyme→\$528,000 with enzyme (without testing, land, leachate treatment)

139 Values of light to medium contaminated waste not available; it is assumed for purpose of this assessment as 50 percent of total waste collected by end of November 2006. Quantity recovered until end of November 2006 = 4800 m^3; assumed volume of light to medium contaminated sand: 2,400 m^3

140 Cost provided by Holcim cement industry in Lebanon

Waste stream #2[139]: Low to Medium Contaminated Sand & Pebbles				
Option	**Local Options**	**Benefits**	**Constraints**	**Estimated cost**
Option 4: Oil extraction by surf-washing	▪ Specialized equipment already purchased as part of oil clean up	▪ Recovery of oil ▪ Recovery of natural resource ▪ Reduces quantity of waste to be disposed or treated	▪ Increase in operational cost	Not Available but mainly human-resource cost

[141] USEPA, 2003

Table 7.8. Options for Treatment and Disposal of Heavily Contaminated Sand

Waste stream #3[142]: Heavily contaminated sand & pebbles				
	Local Options	**Benefits**	**Constraints**	**Estimated cost**
Option 1: Co-processing in cement kilns	▪ Cement industries are available ▪ Could be used as solid fuel in cement kilns	▪ Final elimination of contaminated sand ▪ Previous successful experience in Holcim France for treatment of waste generated from Erika spill[143] ▪ Contaminated solid waste (woods, plastic, and other macro-waste) could be processed in kiln ▪ High feed capacity (around 3 tons/hr)[144]	▪ Transportation cost ▪ Loss of natural beach sand resources ▪ Should be Free of mercury, zinc, MgO and ferrous metals as it effects kiln operation ▪ Permit required ▪ Requires EIA ▪ Short-medium period implementation	▪ Removal and Transportation cost (around \$20→\$60/trip at 10m^3 per trip) ▪ Cost of treatment in kiln could reach up to \$200/tonne according to waste condition[145] ▪ Total cost estimated at \$20,500 (treatment & transport cost) for 100m^3
Option 2: Stabilization and storage in cells	▪ Quick Lime available and cheap ▪ Ex situ disposal space available ▪ <u>North Zone:</u> IPC Tripoli refinery. Already (50m x 30 m) of land found suitable for storage of 50 containers[146]. ▪ <u>South Zone:</u> Zahrani refinery under study	▪ Stabilizing the leachate of toxic compounds	▪ Requires written agreement between MoE and MoEW[147] ▪ Weatherproof containers and cover layer ▪ Subject to stringent long term monitoring ▪ Will no permanently eliminate the waste ▪ Requires EIA ▪ Medium-Long period for implementation	▪ Cost ranges from \$65→\$130/m^3 [148] ▪ Minimum feasible installation area required is 4,000 m^2 capable of handling 3,000 m^3 of oil waste, total cost for construction around \$200,000 to \$400,000 for construction of an engineered storage cell (similar to landfill cells).

[142] Total waste as heavily contaminated sand assumed to be 100 m^3 for the sake of this assessment
[143] (GTZ/Holcim, 2006; ITOPF)
[144] Personal communication with Holcim cement industry-Lebanon
[145] Personal communication with Holcim cement industry-Lebanon
[146] (GEIDE, 2006)
[147] (GEIDE, 2006)

Waste stream #3[142]: Heavily contaminated sand & pebbles				
	Local Options	**Benefits**	**Constraints**	**Estimated cost**
Option 3: Export under Basel convention	▪ AUB has been implementing this practice to dispose of its chemical wastes. Waste is exported to Europe (through Basel convention).	▪ Useful solution for disposal of hazardous waste ▪ Eliminates oil waste problem ▪ Preserve space and environment	▪ If non-hazardous, it could be treated locally at lower cost ▪ Regulated by Basel Convention ▪ Potential high cost ▪ Very long and complex process (from 3 months to one year for preparation) ▪ Requires approval of third party country to accept waste treatment ▪ Subject to conditions of third party treatment capacity and cost	▪ AUB's one tonne of chemical waste disposal cost about USD 10,000. This covers the charge of disposal per consignment, transport and contingency fee[149]. ▪ Economy of scale could play role in reducing the cost. ▪ Assuming each m^3 = tonne and cost = $10,000/tonne → total cost could reach $ 1,000,000 for exporting only $100m^3$

148 (GEIDE, 2006)
149 (Ecodit/MoE, 2001)

Table 7.9. Options for Treatment or Disposal of Contaminated Oil Solid Waste

Waste stream #4[150]: Contaminated solid waste *(miscellaneous detritus found on beach , PPE , cleaning equipment and containment products[151])*				
	Local Options	**Benefits**	**Constraints**	**Estimated cost**
Option 1: Landfilling	▪ No industrial or hazardous waste landfill available ▪ Only two municipal sanitary landfills available in the country namely, Naameh (Mount Lebanon) and Zahle (Bekaa).	▪ Suitable for disposal of non-oil contaminated waste or waste with less than 5% oil contamination ▪ Most cost effective solution	▪ Naameh landfill out of space ▪ Restriction on accepting all oil solid waste types ▪ Potential release of toxic compounds ▪ Potential higher cost for landfilling of oil waste compared to normal domestic waste disposal cost	▪ Current disposal costs of municipal waste in Naameh estimated at 25→41 USD/tonne and in Zahle at 10→13 USD/tonne[152] ▪ Disposal in Naameh mostly will be restricted due to space issue and waste type ▪ Zahle is not suitable due to higher transportation cost (60km to the east from Beirut) and possibly will not accept waste type
Option 2: Co-processing in cement kilns	▪ Available kilns ▪ No need for new investment in incinerators	▪ Accepted by cement industry as alternative fuel material ▪ Permanent elimination of most solid waste material	▪ No carcasses allowed in waste stream[153] ▪ Change in emission characteristics due to waste characteristics ▪ Requires pre-processing ▪ Requires EIA and permit	▪ Estimated cost range between $ 40→$200/tonne for treatment only[154] ▪ Total cost from $ 96,000 up to $ 480,000 without transportation
Option 3: Separation, decontamination, washing and recycling	▪ Could be implemented effectively since oil spill clean up activity is still on going ▪ Waste separation is already taking place	▪ Recovery of recyclable material ▪ Reduction in waste streams ▪ Recovery of oil	▪ Labor intensive ▪ Cost will increase	▪ Not Available

[150] Quantity assumed to be 50 percent of total waste recovered until end of November 2006, ie 4800 m^3. Assumed quantity of contaminated solid waste = 2,400 m^3
[151] Containment products consists of marine containers, sacks, big bags, oil drums, and other waste containers
[152] (Ecodit/MoE, 2001)
[153] (GTZ/HOLCIM, 2006)
[154] Total costs are only rough estimates and reflects only total waste recovered until end of November 2006.

Table 7.10. Analysis of Different Treatment Options in Lebanon

Treatment Option	General comments	Benefits	Constraints & limitations
Industrial Incineration	▪ No industrial incinerators available	▪ Permanent solution for oil waste elimination	▪ Not available ▪ High capital cost ▪ Long period to implement ▪ If available, cost would be very high in the range of 350→800 USD/tonne[155]
Waste incinerators	▪ Estimated 21 waste incinerators available for medical waste disposal only	▪ Permanent waste elimination ▪ Could achieve up to 99% volume reduction ▪ Operated at very high temperature (at 1,200°C) suitable for destruction of many hazardous air pollutants	▪ All active waste incinerators in the country are used for medical waste disposal only ▪ Capacity is limited ▪ Public opposition ▪ No energy recovery ▪ Air pollution control devices might not be suitable ▪ Possibly not approved by hospital management ▪ Salt in recovered oil could increase corrosion in system
Co-processing	▪ Cement kilns are available in Lebanon ▪ North zone: Holcim-Chekka/North Tripoli and Cimenterie Nationale ▪ South zone: Sibline-North Saida	▪ Erika spill in France treated in Holcim cement kilns ▪ Completely eliminates oil waste ▪ Provides alternative fuel and Raw material (AFR) to cement kilns ▪ High cost recovery (alternative fuel)	▪ Waste should meet stringent technical specifications (compounded halogens, some metal) meeting Stockholm convention requirements; additional monitoring requirements should be followed by kiln operators ▪ Additional cost for waste pre-processing (demulsification) and screening (absence of heterogeneous elements) ▪ Volume limitation ▪ No permit for co-processing of oil waste in cement kilns exists

[155] (USEPA, 2003)

Treatment Option	**General comments**	**Benefits**	**Constraints & limitations**
Mobile incinerator	■ Not available in Lebanon ■ Need to be purchased or leased from outside	■ Flexible ■ Reduces cost of transportation ■ Could be cost effective for large quantities	■ Public opposition ■ Most stored waste are located near sensitive receptors ■ No energy recovered ■ Generally of low operation capacity ■ Procedure refused by MoE for problems of potential air pollution and equipment control difficulty ■ Will require an EIA and permit
Exporting	■ This procedure has been experienced one with AUB. In this case, AUB chemical waste was exported to England (through Basel convention). ■ Lebanon ratified Basel convention in Dec. 94	■ Eliminates oil waste treatment & disposal problem ■ Preserve space and protect local environment	■ Regulated by Basel Convention ■ Possibly high exportation cost ■ Complex and very long process (from 3 months to one year for preparation) ■ Requires approval of third party country to accept waste treatment ■ Subject to conditions of third party treatment capacity and cost
Oil recovery	■ Liquid oil is being recovered ■ De-emulsification of solid oil is possible (heated tanks + chemicals) ■ Sand washing will result in additional oil recovery	■ Recovery of valuable energy source ■ Reduces waste quantity difficult treatment ■ Produces oil quality re-usable many heavy energy industry (glass industry)	■ Air emissions in industrial furnaces not equipped with air pollution control units will result in local air quality degradation
Reconstruction material + asphalt industry	■ Suitable for on going reconstruction efforts	■ Saves raw material demand	■ If tests proves hazardous, it can not be re-used
Landfilling	■ Only two sanitary landfills available in Lebanon ■ Naameh Landfill: Over capacity ■ Zahle landfill: 60 km to east of Beirut	■ Suitable for waste not contaminated by oil	■ Restriction on acceptability by landfill operators ■ Accepts only municipal waste ■ No cost recovery

Treatment Option	**General comments**	**Benefits**	**Constraints & limitations**
Burial cells (engineered landfill cells)	■ Two sites are defined as suitable by MoE ■ North Zone: Tripoli old refinery (Al Badawi –IPC) ■ South zone: Zahrani refinery	■ Available and adequate space ■ Meets most design conditions ■ Secured and isolated locations ■ Strategic locations ■ Willingness to accept waste under some conditions	■ Liquid oily waste not acceptable ■ Requires written agreement between MoE and MoEW (12) ■ Requires long term monitoring ■ Leachate control and treatment ■ No cost recovery ■ Does not eliminate the waste
In situ treatment	■ Land constraints (close to communities, private ownership, access control, small areas, etc.)	■ Reduce transportation cost	■ At lower quantities, treatment cost increases ■ Difficult to monitor, confine and control

7.2.5 RECOMMENDATIONS

7.2.5.1 Recommendation for Liquid Oil Waste: Recovery & Co-processing

It is recommended that liquid oil be reprocessed in local refineries to improve quality level of recovered oil. The recovered oil could be mixed with crude oil or used as a fuel source.

The main issue about using recovered oil in its raw state is the level of salinity which increases the chance of equipment corrosion. The refined oil should be tested for halogens, metals and total hydrocarbon parameters to assess final quality. The final product could be used as a fuel source for heavy energy consuming industries available in the country such as cement, glass and smelting industries. This method will provide immediate and permanent disposal of liquid oil.

Cost includes primarily testing (to check adequacy of oil) and transportation. As of end of November, about 1,000 m^3 were generated. Transportation costs would reach USD 6,000. Processing costs are not known and should be checked with existing facilities (Zahrani and Dora). Heavy industries in the country can re-process the oil (de-emulsification and decanting) at a cost of USD 40 per tonne. Using this estimate, total cost of processing would reach for 1,000 m^3 about USD 40,000.

7.2.5.2 Recommendations for Light Contaminated Sand: Washing & Bioremediation

It is recommended that light contaminated sand be washed and treated using biological methods, if needed. The washing process reduces oil level in contaminated sand which reduces pollution load, eventually treatment duration and cost. It is understood that surf washing is actually being used in some stretches of the coast. The recovery of this natural resource is valuable for the environment. The cleaning process can be accelerated through the use of special enzymes to the soil to enhance the bacterial activity and natural bioremediation of the organic matter. Even though this method is time consuming, it ensures the recovery of a valuable natural resource.

Until end of November, the total reported quantity of low-to-medium contaminated sand and pebbles is assumed to have reached 2,400 m^3 (based on total waste contaminated volume generated of 4,800 m^3). The cost of using enzymes to accelerate bio-remediation could reach up to USD 528,000 (at enzyme cost of USD 220 per tonne).

The option of sending the sand to be used as raw materials at cement factories or glass manufacturing can be a more cost-effective option (factories should not charge disposal costs), however the natural beach resource would be lost.

7.2.5.3 Recommendations for Heavy Contaminated Sand: Stabilization (neutralization) & Co-processing as Solid Fuel

Heavy contaminated sand can be used as solid fuel for cement industry. The polluted sand should be mixed with quick lime to neutralize toxic release (as leachate) during storage and transportation. Cement industry can process the neutralized heavily contaminated sand with mixture of variable solid waste type (except for ferrous metals). Estimated cost for treatment in cement kilns could reach up to $200 per tonne to account for pre-processing costs and additional monitoring requirements to abide by the Stockholm Convention, as would be requested by MoE. This process provides an immediate and permanent disposal option of waste.

For a total quantity of heavily contaminated sand of 100 m^3, transport and treatment cost would be in the range of USD 20,000. Alternatives could be mode costly; the construction of an engineered storage cell would cost in the order of USD 200,000 and would not provide a final solution to the problem, as risks of leakage in the future would always exist. Costs of exporting the waste through Basel Convention can be extremely high, in the order of several thousands of dollars per tonne.

7.2.5.4 Recommendations for Oil -contaminated Solid Waste: Burial in Engineered Cells or Co-Processing in Cement Kilns

Oil contaminated macro-waste such as PPE, bags, plastics, cleaning products, shredded PVC tanks, and wood can be neutralized and disposed in secured engineered burial site or be co-processed in a local cement kiln.

For burial, feasible and secure sites might be the old refinery in Tripoli or/and in Zahrani. Both sites are secured and confined within industrial zones, which are from an environmental stand, eligible for such use. However, a hydro-geological and environmental assessment studies are necessary to confirm the suggestions. The construction cost for such engineered cells may be estimated at 65-130 USD/m^3. The necessary area will be determined once total quantity of waste need to be disposed is available. Additional costs include environmental and hydrogeological assessments and monitoring costs. The disadvantage is that the waste will remain and is not destroyed.

Co-processing in a cement kiln will require some pre-processing on-site. Cost of disposal will not exceed 200 USD per tonne and could be as low as 100 USD per tonne or even less, depending on negotiations with existing factories. MoE should request from the cement kiln operator that monitoring requirements as stipulated in Stockholm convention be followed. The total cost of disposal includes the additional cost incurred by the factory for environmental monitoring.

Assuming a total quantity of 2,400 m^3 of contaminated solid wastes based on a total of 4,800 m^3 collected by end of November 2006, the disposal of such wastes at an average cost of USD 150/m^3 would be USD 360,000.

7.3 AGRICULTURAL WASTES

Several types of wastes were generated from the agriculture sector during the war. These are further described and possible treatment and disposal options are discussed.

Most types of wastes generated during the conflict from the agriculture sector are scattered in several locations, primarily in the South and the Bekaa. Animal wastes from damaged husbandry farms were reported in Baalbek area (Tanmia, Libanlait), Ksara (Nahhas), Choueifat-Dahieh (few farms for sheep, goat and cow meat production) and South Lebanon [156](Buda and Al-Khudairy, 2006). Other hotspots include Assi River (freshwater aquaculture) and Ouzaii fishing port (boats).

7.3.1 QUANTITY AND CHARACTERISTICS OF WASTE GENERATED

7.3.1.1 Main types of Agricultural Waste

The main types of wastes from the agriculture sector generated during the conflict are:

- Organic waste from damaged crops;
- Dead animals and fisheries (carcasses);
- Damaged and dead trees from forests and orchards;
- Damaged equipment (water pumps, generators, etc.) and trucks;
- Green houses nylon sheets and steel structures;
- Irrigation networks (PVC pipes and concrete channels);
- Damaged aquaculture farm ponds; and
- Fishermen boats.

7.3.1.2 Quantity of Damaged Material Related to the Agricultural Sector

The available information on quantities of wastes is listed below (Buda and Al-Khudairy, 2006):

- Directly hit greenhouses (7 destroyed in the plain of Tyre). No data for areas to the north of Litani.
- Destroyed tractors and agriculture machinery: 150 in South Lebanon (Saida, Sour, Nabatiyeh, Bent Jbeil and Marjayoun).
- Mulch, plastic of greenhouses, and pots: besides the damaged greenhouses, there are 100 nurseries affected in South Lebanon. No data about the quantities of these wastes are available.
- 170 agriculture warehouses affected in South Lebanon, without any further details about the type and area of these constructions.

[156] There are many small scale farmers in Sour, Bent Jbeil, Marjayoun, Jezzine and Nabatiyeh cazas.

- More than 300 fishing boats (wood, fiber glass, nets, traps and engines) were partially or totally damaged in Ouzaii fishing port (Figure 7.3).
- Dead carcasses amounting to 3,050 head of dairy cattle, 1,250 bulls, 15,000 head of goats and sheep, 18,000 beehives and over 600,000 broilers (FAO, 2006).

Figure 7.3. Damaged Fishermen Boats at Ozai Port-Beirut

Figure 7.4. Dead trout fish stocks in aquaculture farms at Assi River-Hermel

7.3.1.3 Other Potential Post-Conflict Waste Sources

Despite the end of the conflict, the agricultural sector is still suffering from its outcomes. Cluster bombs present a major obstacle impeding agricultural recovery resulting in increase of damaged crops. Agriculture is the third largest contributor of the Lebanese economy after tourism and industry, and is under serious threat even after the cease-fire as the presence of cluster munitions prevents agricultural workers from returning to their land eventually resulting in the increase in damaged crops.

There is a potential for increase of dead/injured cattle's due to direct contact with UXO while grazing in contaminated areas (70% of south Lebanon), water/soil pollution or loss of grazing lands (PCM, 2006b).

Cutting of trees resulting in increase in uncontrolled charcoal production in impacted zones is also possible.

Figure 7.5. Charcoal production in open environment

7.3.2 POST-CONFLICT INITIATIVES

The following initiatives can be highlighted:

- Rapid re-construction works took place immediately after cease fire to fix damaged water irrigation channels and pipes, as was the case with Canal 900 near Qaraoun Dam in Bekaa region (ELARD, 2006).
- It was observed that carcasses were left to decompose in the open air or left to burn after direct bombing. On a later stage, carcasses were either dumped in rivers or burnt (ELARD, 2006).
- Damaged crops also were mostly left to decompose in open air due to difficulty to clean up and compost during conflict resulting in odor emissions. On later stage, some of the damaged/rotten crops scattered in agricultural fields were removed to decompose in piles (composting) or burnt.
- Destroyed green houses or those contaminated by the oil smoke from Jiyeh tanks fire are removed and disposed with municipal waste or near river banks (ELARD, 2006).
- For damaged boats, no actions have been undertaken yet, except the personal initiatives of some concerned farmers or fishermen to remove the damaged boats and repair the partially damaged machinery or recovery of their equipment; international assistance to support fishermen has however been mobilized.
- Intentional fires in open areas set by local people as an initiative to clear these lands from UXO's resulting in aggravating the biodiversity loss in these burned lands.
- Recent surveys revealed that an increase in charcoal production is taking place near damaged area with high level of tree damage. Charcoal production is generally unorganized and lacks the basic environmental control measures especially on air quality control. The extent of damaged and dead trees attracted the charcoal producers resulting in the increase in the number of producers eventually leading to deterioration of local air quality, noticeable from odor and smoke (ELARD, 2006).

7.3.3 ENVIRONMENTAL CONCERNS

7.3.3.1 Environmental Impacts of the Disposal of Carcasses

Disposal of dead carcasses presents the following main issues of environmental concern:

- Smell and pathogen spores released due to the degradation of dead cattle and aviary or the smoke released from burned carcasses;
- Dumping of dead carcasses and aviary, milk, products, manure into rivers (mainly the Litani River and its tributaries in the Bekaa) which leads to the depletion of oxygen, with detrimental impacts on flora and fauna. In extreme cases, where the rate of utilization of oxygen is greater than the rate at which oxygen is replenished (i.e. in slow-flowing rivers in late summer), all the available oxygen may be consumed. These conditions favor anaerobic bacteria, which produce toxic hydrogen sulfide and ammonia.

7.3.3.2 Environmental Impacts of the Disposal of Other Agricultural Waste

Issues of environmental concern related to other agricultural waste types include:

- Air pollution due to smoke and unpleasant smell from burning of damaged crops and trees;
- Loss of biodiversity in freshwater ecosystems due to the depletion of oxygen, such as in Assi River due to the presence of dead fish;
- Soil pollution from disposal of oil contaminated agricultural waste or damaged equipment and trucks.

7.3.4 WASTE MANAGEMENT OPTIONS

7.3.4.1 Options for Treatment and Disposal of Dead Carcasses

Composting: The disposal of dead animals is a major environmental concern. Composting can be an economical and environmentally acceptable method of handling dead animals. This process produces little odor and destroys harmful pathogens. Composting of dead poultry is the most common process. The process does apply equally well to other animals. Some operators have composted dead animals weighing as much as 45 kg by grinding or cutting them into smaller pieces (7 kg). Dead animal composting facilities should be roofed to prevent rainfall from interfering with the compost operation. Dead animal composting must reach a temperature in excess of 55 °C to destroy pathogens. However, the addition of rainfall can elevate the moisture content and result in a compost mix that is anaerobic. Anaerobic composting takes much longer and creates odor problems (Fraser, 1994).

Incineration: One of the more attractive aspects of incineration relative to other carcass disposal options, such as composting and burial, is the complete destruction of pathogens. Another advantage is the relatively small mass of residual material (ash) requiring some form of ultimate disposal. Moreover, incineration has a relatively low labor requirement. Limitations associated with incineration include the potential air pollution problem resulting from improper operation or equipment in addition to the high initial investment cost. Another limitation of incineration for carcass disposal is fixed capacity. This can be problematic when disease or other factors such as conflicts cause a sizable increase in the rate of mortality (Fraser, 1994; UNDP/MoE/ELARD, 2002).

Burial pits: Any dead animal (i.e. horses, goats, sheep, swine or cattle) must be either picked up by a dead animal collector within 48 hours of death, or buried on the farm in an environmentally-safe place away from watercourses under 0.6 meters of soil or in a designed pit, within 48 hours of death. Poultry mortalities should be stored in a freezer as soon as possible after death and held for pickup by a dead animal collector, or buried on the farm in an environmentally safe place away from watercourses and under 0.6 meters of soil (UNDP/MoE/ELARD, 2002). The burial sites need to be at least 45 m down-gradient from any ground water supply source. Sites that have highly permeable soils, fractured or cavernous bedrock, and a seasonal high-water table are not suitable and should be avoided. In no case should the bottom of the burial pit be closer than 1.5 m from the ground water table. Surface water should be diverted from the pit. For large animals (cattle and mature swine), individual pits should be opened for each occasion of burial. The pits should be closed and marked after burial. For small animals (poultry and small pigs), pits can be constructed for use over a period of time. Typical pit sizes for small animals are 1.5 to 2 m wide, 1.5 to 4 m long, and 1.5 to 2 m deep. The sides of the pit should be constructed of concrete block, treated timber, or pre-cast concrete. The side walls must have some openings to allow for pressure equalization. The bottom of small animal pits is not lined. The top should be airtight with a single capped opening to allow for adding dead animals.

Composting and incineration of dead animals are not a viable option in Lebanon due to the absence of such specialized treatment plants, equipment, high capital & operational cost on small and medium size farms. Site burial with quicklime neutralization is the most recommended solution on smaller scale farms.

7.3.4.2 Disposal Options for Agricultural Wastes that can not be Composted

Disposal options for different agricultural waste streams other than animal carcasses, mainly animal health-care products, packaging, containers and related materials, farm building materials, machinery and equipment and preservatives are summarized in Table 7.11 (UNDP/MoE/ELARD, 2002).

Table 7.11. Summary of Preferred Disposal Options for Agricultural Wastes that cannot be Composted

Waste Category	Specific Waste	Reuse	Recycle	Return	HWD [157]	LWDS [158]
Animal Health-Care Products	Leftover But Usable			X	X	
	Leftover But Unusable			X	X	
	Banned Products			X	X	
	Biomedical Wastes			X		
Packaging Containers & Related Materials	General Packaging	X	X			X
	Petroleum Product Packaging	X	X			X
Farm Building Materials	Building Materials	X	X			X
	Restricted-Use Materials	X	X			X
Machinery & Equipment	Inert Components	X	X			X
	Restricted-Use Components	X	X	X		
	Tires	X	X			
Preservatives	Leftover But Usable				X	
	Used Oil	X	X			

7.3.5 RECOMMENDATIONS

The following recommendations can be made:

1- The Ministry of Agriculture could launch an awareness campaign among farmers on the environmental and health impacts from improper disposal of carcasses in the environment and disseminate and encourage proper disposal and recycling options among them; UNDP and the SPASI project had published a study on best practices for farm waste management which could be further disseminated (UNDP/MoE/ELARD, 2002);

2- Dumping or burning of animal carcasses and dead aviary and veterinary products as such, should be prohibited.

3- The Ministry of Agriculture and local authorities could collaborate to:

  a. Prohibit un-necessary tree cutting;
  b. Prohibit local people from setting intentional fires in open areas to clear UXOs;
  c. Minimize land clearance for opening new by-passes;
  d. Organizing and effectively monitoring charcoal production industry; and
  e. Control licenses issued to tree trimming activities.

[157] Hazardous Waste Depot
[158] Licensed Waste Disposal Site

7.4 INDUSTRIAL, HAZARDOUS AND SPECIAL WASTES

Sources of special waste generated from the conflict include:

- Hazardous waste possibly generated from destroyed industrial facilities (around 9 major industries) (ELARD, 2006);
- Bulky items and household hazardous waste generated in large quantities from destroyed residential units and commercial centers (around 30,000 units) (PCM, 2006b);
- Storage tanks used for temporary storage of oil-spill waste;
- Damaged fuel tank structures (25 underground tanks in damaged petrol stations, 40,000 m^3 jet Kerosen fuel tanks in air port and 75,000 m^3 oil fuel Jiyeh tanks) (Kelly, 2006; ELARD, 2006; PCM, 2006b);
- Damaged vehicles of different types (estimated to be in hundreds due to intentional attacks on vehicles by IDF, official record could be released by mid December, 2006), (PCM, 2006b);
- Radioactive contaminated soil;
- UXO's.

7.4.1 QUANTITY AND CHARACTERISTICS OF WASTE GENERATED

1- The conflict resulted in the damage of petrol fuel stations, several damaged industries in addition to the main fuel storage tank farms in Rafik Hariri Air Port and Jiyeh Power Plant (Figure 7.6). The waste includes the sludge, ashes, filled tanks and tanks steel structures itself.


Figure 7.6. Different Types of Damaged Fuel Tanks in Jiyeh

2- Special household waste generated from 30,000 damaged residential/commercial units and storage house typically includes:

- Cleaning solvents;
- Cathode ray tubes and fluorescent light bulbs;
- Damaged electronic appliances;

- Household chemicals storage containers (made from plastic material);
- Dry cell batteries (containing Cadmium, Zink and Mercury) (Figure 7.7);
- Lead batteries (mostly used as backup energy source in houses);
- Shattered glass windows;
- Treated furniture (treated wood); and
- Damaged white goods.

Figure 7.7. Partially Incinerated Dry and Liquid Batteries in Plastimed and Jiyeh (from left to right)

3- Many electronic devices contain individual components made with hazardous constituents, primarily heavy metals. For example, some appliances include transformers and capacitors containing PCBs, others containing chlorofluorocarbons, HCFC, HFC, and equipment containing free asbestos. Cathode ray tubes (CRTs) found in color televisions and color computer monitors contain significant amounts of lead. Printed circuit boards and complex circuitry found in computers and other electronic devices may contain lead, chromium, and silver (SC-DEH, 2004).

4- Oil spill waste recovery activity is expected to generate significant number of variety size storage containers some being made of PVC (Figure 7.8). The significance is related to the fact that these tanks once emptied from its contents are contaminated and cannot be disposed with regular waste streams, burned or simply recycled without proper cleaning (VA-WRRC, 1998).

Figure 7.8. Large PVC containers used for storage of oil waste

5- Despite the fact that no figures are available on the number of damaged vehicles and trucks, it is estimated that hundreds were damaged during the conflict ranging from small passenger cars to large six wheel trucks (Figure 7.9).

Figure 7.9. Damaged Vehicles from Conflict-South Lebanon

6- Radio active waste is considered as a hazardous waste. The waste could be in the form of contaminated soil or structures or in debris. Debate regarding the presence of depleted uranium in the Lebanon took place after the release of two contradicting test results on this matter. CNRS reported that no DU was found in the samples measured at 25 different sites in the impacted areas, but stressed that available measuring devices might not be enough to detect DU (CNRS, 2006). However, independent scientists studying samples of soil after Israeli bombing in Lebanon have shown high radiation levels, suggesting that uranium-based ammunitions were used. Samples taken from two bomb craters in Khiam and Al-Tiri have been sent for further analysis to the Harwell laboratory in Oxfordshire, southern England, for mass spectrometry (British Daily news paper).

7- Millions of bombs, rockets, shells were fired on Lebanon during the conflict period. It is standard assumption that some 10 percent of total bombs do not explode on impact or considered having default in manufacturing; these UXO's need to be disarmed and disposed of safely. The majority of recovered UXO's are disposed in 15 special burial sites located by the Lebanese army and Mine recovery teams working in Lebanon.

8- Site visits to damaged industries in Lebanon revealed that most of the industrial waste has been incinerated (Plastimed), removed from site during land clearance (Ghabris soap) or considered as demolition and non-hazardous waste. One exception is at Safia el Deine medical plastic industry in Tyre; the industry is expected to have stocks of supplying medical plastics containing toxic components such as Vinyl chloride and PVC.

7.4.2 POST-CONFLICT INITIATIVES

7.4.2.1 Fuel-Tank Waste Management Initiatives

- Several petrol station owners already rebuilt their stations and many of them are already operational today. No data is available on the handling and disposal of the damaged underground tanks in these stations.
- No actions were reported dealing with the damaged fuel tanks in the Jiyeh and Air port.
- No actions were reported for disposal of contaminated oil waste storage tanks.

7.4.2.2 Household Hazardous Waste (HHW) Management Initiatives

- HHW is not collected separately and is co-disposed with the MSW stream. However, it was generated in relatively small quantities prior to the conflict and it is expected that due to the extent of the damaged residential units and commercial units, the amount generated post conflict will have increased significantly.
- HHW is generally not being recovered in an efficient manner or not recovered at all, except for those with high value such as damaged white goods, re-useable furniture and electronic appliances. One should take into consideration that part of the wastes has burned as a consequence of IDF bombardment and explosions, and the non-recovered part is possibly still mixed with the debris waste piles removed or already being disposed off with the regular municipal waste stream.

7.4.3 ENVIRONMENTAL CONCERNS

7.4.3.1 Impacts from Fuel and Oil Storage Tanks

For disposal purposes, tank wastes can be seen as consisting of two largely separate streams: the contents of the tank, both liquid and solid, and the tank itself. Even though these entities may both eventually be deposited in a landfill, either separately or while still intact from removal, their chemistry and environmental interactions remain sufficiently disparate to warrant separate treatment schemes (VA-WRRC, 1998).

The discussion of disposal strategies focuses on the fate of the tank itself since, in each case, most of the product and sludge is supposed to be removed beforehand and treated separately (VA-WRRC, 1998).

Impacts of Abandonment in Place: Because of the amount and type of material that is or may be left in the ground, tank abandonment presents probably the largest environmental threat of the various disposal choices. Under ideal circumstances - that is, when a tank is located above the ground and away from water table and is completely freed of product and sludge before filling -this environmental threat will be fairly small. More serious impacts are likely from tanks with damaged platforms or damaged structure tanks (mostly fuel barrels) leaking into ground water and contaminating nearby wells, if present.

Impacts of uncontrolled dumping of Tanks: The dumping of tanks and their contents presents risks of production of potentially toxic or hazardous leachate. The main components of potential contamination are sludge or product residuals. The long time periods involved and the potential for eventual interaction of different kinds of leachate may give rise to unexpected and unpredictable results. For this reason, dumping as a disposal alternative is not recommended especially that Lebanon does not have hazardous waste landfills.

Impacts of Recycling of Tanks: In the case of steel tanks, the recycling of tank steel is the most environmentally desirable method of tank disposal, since the steel is never, in fact, land-disposed but is melted down for recasting into other products. Heavy metals that may be of concern in land disposal become air contaminants in the steelmaking furnace; these are removed before emission and are treated as part of a hazardous solid waste. No metal foundries are located in Lebanon, however there are scrap dealers. Most recovered metals are shredded and exported to international markets.

7.4.3.2 Impacts from Dry Cell Batteries Disposal in Dumpsites

The Danish Environmental Protection Agency has reported that Ni-Cd batteries are the most substantial source of cadmium pollution, expected to account for up to 90 per cent of future human exposure to the metal in Denmark. Long-term exposure to cadmium, a known human carcinogen, can cause liver and lung disease.

Emissions of heavy metals (Cd, Hg, Pb, Cr) are also a major concern during waste burning. After combustion, metals are either emitted as particulate matter or vaporized into their gaseous state. Mercury is of particular concern for public health reason as it volatizes at low temperature. Virtually, all of the mercury in MSW is due to the disposal of household dry cell batteries (mercury, alkaline, and carbon-zinc type) with less extent to broken temperature thermometers (Tchobanoglous et al., 1993).

7.4.4 WASTE MANAGEMENT OPTIONS

7.4.4.1 Damaged Fuel Tanks (above and underground tanks)

The available means for fuel tank disposal are represented by a well-established set of technologies operating within tight and changing regulatory and industrial constraints. While innovative developments have refined some aspects of cleaning waste treatment and disposal, the available options for fuel tank disposal consist of two general sequences: 1) abandonment-in-place; and 2) tank removal, followed by either landfilling or recycling. Although differentiated largely by the final disposal location or treatment of the used vessel, both are preceded by a certain amount of tank cleaning.

Tank Cleaning: Most forms of disposal (with the exception of a hazardous waste landfill, in some cases) require that the tank be emptied and cleaned to an extent, depending on the final disposal site of the vessel. For all tanks (out of service or damaged), excess product must be pumped out and the interior space rendered gas free; sludge, if found, must be removed and disposed of according to national regulations for all tanks except those destined for a permitted hazardous waste landfill. Recycling usually requires, further, that the metal in contact with the sludge be scraped clean and that any scale or rust also be eliminated.

Tank cleaning is preceded by a thorough removal of the excess product, usually accomplished by a vacuum truck or - if no sludge is present - by filling the tank with water and pumping the floating product off the top. For tanks that have been removed from the ground and/or can be entered, sludge can be collected manually by individuals inside the tank provided that vapors are reduced to safe levels and proper protective clothing and respiratory devices are used.

Although some mixing of sludge and product is inevitable during external pumping, once the sludge clearly becomes the predominant component it should be diverted to suitable hazardous waste containers and handled accordingly; since it has different characteristics from the petroleum supernatant, it usually requires different treatment. Properly drummed, this sludge may be left on the site for up to 180 days before removal and disposal according to international guidelines. Tanks that contained unleaded gasoline or those free of sludge and scale from leaded gasoline, generally require no further cleaning. For tanks that do require cleaning for any reason, however, three technologies are available: commercial steam cleaning, sandblasting or abrasion cleaning, and chemical treatment. These can be implemented by local contractors.

Abandonment in-place: Abandonment in place is a relatively straightforward means of disposal that avoids the expense and difficulty of tank removal and transportation off-site. Although obviously involving the commitment of land to long-term storage of the out-of-service or damaged vessel, it is often the disposal strategy of choice in those cases where removal is difficult, unsafe, or otherwise unsuitable. Abandoned tank should be filled with a solid material to prevent eventual tank collapse and subsidence of the overlying surface (in case of underground fuel tanks). Sand has traditionally been the filler material of choice because of its ready availability and low cost, although mixtures of sand and earth or sand and rock have also been used. Typically, some water must be added during filling to spread the mixture throughout the tank and prevent coning beneath the fill hole.

Tank Removal: In most cases, land use imperatives, or preferred management practices necessitate the complete removal of the old tank from the site, followed either by backfilling or replacement with a new vessel. Although some of the pumping and cleaning steps are the same as abandonment, the need to excavate, elevate, and transport the tank makes this process more expensive, technically complex, and potentially dangerous. Once the tank has been withdrawn from the ground, it is either recycled at a scrap metal dealer or disposed of at an industrial or hazardous waste landfill. In Lebanon, only the former option is available (scrap metal dealers).

Tank Recycling: For many reasons, the recycling of steel vessels as scrap metal is the most desirable form of tank disposal. Several facilities are available in Lebanon to recycle scrap metal. However these facilities will normally require that the tanks be cleaned prior to accepting them.

Tank Landfilling: In some cases, where the condition of the tank (structure burnt) or distance to the scrap dealer discourages recycling, tank disposal in a landfill may be the preferred option. Although the tank then remains a rusting source of potential contamination for many years, a well-designed landfill is built to at least mitigate and contain the effects of all deposited substances, many of which are more harmful than gasoline residues. For tanks of material other than steel, especially PVC, or that have contained substances that render the steel unsuitable for recycling, landfilling is often the only option for disposal. The requirements for tank cleaning are rather less stringent for landfilling than for recycling. Tanks must be usually drained of liquid and free of hazardous sludge; if sludge is present it must be shown by analysis to be non-hazardous. Because of space and safety considerations, operators often require that tanks be cut up or that the ends be cutoff to facilitate compacting. A hazardous waste landfill will accept both the tank and the sludge, if present; an absorbent filler is often then poured into the tank to immobilize the residues and prevent collapse of the structure. Unfortunately, such facilities are not available in Lebanon.

7.4.4.2 Options for Dry Battery Recycling/Disposal

Recycling: The main advantage of battery recycling is the environmental benefit arising from a reduction in the primary production of materials and energy, and lower emissions of mercury, lead and cadmium from landfills and waste incinerators. Recycling silver oxide batteries is also currently economically viable, although as with lead - acid types the economics of recycling fluctuate according to the changes in the metals market (Residua, 2000). However recycling facilities in Lebanon are not available.

Export to other countries: A number of specialized plants now recycle batteries using the technique of pyrolysis. The Batrec process in Switzerland, for example, extracts most metal compounds in batteries, without generating toxic emissions. Spent batteries are heated in the absence of air (at 300 -750^{o}C). The mercury evaporates, is condensed and recovered. Other metallic components can be recovered in a subsequent induction furnace stage of the Batrec process. More than half of the materials in spent batteries can be recovered in this type of facility (NZ-MFE). This option would be very expensive and could cost several thousands of dollars per tonne of material to be disposed.

Landfilling: Damaged batteries should be disposed of in hazardous waste landfills. Unfortunately such facilities do not exist in Lebanon. Nevertheless, and given the small quantities of such wastes generated during the war, the possibility of building a special cell to bury these wastes could be investigated. The costs would be similar to those shown in the oil waste section.

7.4.4.3 Options for Electronic Waste Management

Management of discarded electronic equipment is often considered alone in an electronic wastes management plan, given the characteristics of such wastes. E-waste includes those electronic products that are at or near the end of their useful lives. Computers, televisions, VCRs, DVDs, cell phones, stereos, speakers, microwaves, copiers, printers, and fax machines are common electronic products that fall into this category (SC-DEH, 2004). These wastes are expected to be mixed with demolition wastes. Unfortunately, options for disposal remain limited. The waste is most likely being dumped with demolition wastes. When disposed in dumpsites, these products (mostly the transformers and electronic boards) have the potential to contribute with significant levels of toxic materials to the leachate produced. These include lead, polychlorinated biphenyls (PCBs), mercury, cadmium, arsenic, zinc, chromium, and selenium. The CRTs found in computer monitors and television sets can contain 20 percent lead oxide by weight. According to a recent U.S. EPA report on electronics, CRT-containing products may contain four pounds of lead on the average. Possibility of re-use and recovery of these wastes, although preferred, remain limited.

7.4.4.4 White Goods, Damaged Vehicles and Demolition Wastes

The conflict generated considerable amounts of bulky items, damaged vehicles/trucks, tires and demolition waste. Available options for disposal of generated special waste includes: 1) re-use, 2) recycling and 3) construction of artificial reefs.

Re-use: Working or partially damaged white goods can be re-used if economic value of repair is justified. Re-use provides additional markets for low cost equipment and contributes to minimizing waste disposal. It is understood that such goods are being recovered from demolition wastes when possible.

Recycling: There are several facilities and collection centers in Lebanon for the recovery of scrap metal and end-of-life or damaged vehicles including (UNEP-CEDARE, 2000):

a) *Vehicle dismantlers* who typically strip vehicles for parts and send residual metals to metal merchants or shredder operators;
b) *Metal merchants* who collect and sort scrap metal. A certain amount of processing, for example crushing or coarse shearing, is sometimes carried out by metal merchants; and
c) *Shredder operators* who perform many of the same functions as metal merchants but also operate large scale shredding machinery to shred vehicles and other metal waste.

Construction of artificial reefs (AR):

The benefit of constructing AR in the Lebanese coast has two-fold: 1) potential increase in fish yield; and 2) enhancement of scuba-diving activities. With the current degradation of the marine environment due to the oil spill, construction of AR, when properly performed, could support the regeneration of marine ecosystems while offering a solution of some of the waste problems.

In Lebanon, it is indicated that there are between 3,000 to 4,000 fishermen and 8 major fishermen ports. One of the damaged ports during the conflict was the Ouzaii port in Beirut, whereby, 300 boats were completely or partially damaged (Nader, 2005).

Monitoring of AR from around the world showed that fish yields or catches increased between 10% and 50% (and more) when introducing AR (average of 30% in fish yields). Other expectations that AR would increase local dive club average diving trips ranged from a low of 5% to a maximum of 100%. Eliminating the upper value of a 100%, the average expectation with respect to the percentage increase in 'extra' dives is about 30%. There are at least twelve known diving clubs in Lebanon (Nader, 2005).

Concrete materials could be used for reef building (such as culvert, bridge decking or demolition debris). These materials perform very well and have a much longer lifespan as reef materials than might be predicted (between 30 and 50 years) for several reasons. Concrete, either in fabricated units specifically designed for artificial reefs or imperfect concrete manufactured products, such as culvert or rubble from razed buildings, sidewalks, roadways and bridges, has a demonstrated high success rate as artificial reef material in both marine and estuarine environments. The obvious reason for this high rate of success is the strong compatibility of the material with the environment in which it is placed, and for the purpose for which it is placed. Concrete is generally very durable and stable in reef applications (AGSMFC, 2004; Yip, 1998; Figure 7.10).

The total costs involved in collecting, transporting and submerging the AR material off the Lebanese coast will vary depending on the material used, quantity, condition and pre-processing level (AGSMFC, 2004; Yip, 1998). Table 7.12 presents an analysis of the different material that could be used in the construction of AR; materials are relevant to those generated from the conflict.

Introducing AR would potentially boost local tourism through diverse aquatic activities, and the local fishing industry through higher fish yield. Two of the main outcomes therefore of the AR are the enhancement of the standard of living of one of the poorer sectors of society and most impacted from the recent conflict, the fishing community, and secondly a boost to tourism through the provision of a new activity for divers and marine sport enthusiasts. However such a practice must be carefully studied prior to its implementation to avoid negative impacts.

Figure 7.10. Rubble and Prefabricated Concrete Material used for AR Construction

Table 7.12: Advantages and Disadvantages for use of different material in artificial reef construction

Material	Advantages	Disadvantages	Considerations
Vehicles	- Automobile bodies are readily available, inexpensive, and are relatively easy to handle, not requiring heavy equipment to move.	- *Automobile bodies require a great deal of preparation and removal of material prior to being ready for deployment. This activity can be labor-intensive.* - *Automobile bodies are not durable, lasting for one to five years in the marine environment.* Considering that about one year is required to establish an encrusting or fouling community, along with a relatively stable population of fish, and considering that significant deterioration has likely begun to take place at about year four, automobile bodies may have about three years of useful life as an artificial reef. - *Automobile bodies are not stable,* and likely can be moved easily by storm surge or a boat pulling a trawl, resulting in the material being moved from its original location. - Fiberglass, rubber, and plastics attached to automobile bodies, if not removed when deployed, may become unattached and free in the water column after the metal corrodes away. - *Recycling of the steel may be a more economically beneficial use of automobile bodies than allowing them to corrode within a few years on the ocean floor.*	- Automobile bodies must be carefully inspected prior to deployment as artificial reefs. - Fuel tanks must be drained and perforated to prevent flotation. - Oil must be removed from the engine block. - The engine, break line, electrical components should be steam-cleaned or removed. - Plastics that are not attached securely to the automobile body must be removed. - Electrical components capable of emitting PCBs must be removed. - The rear axle differential on rear-wheel-drive automobiles must be drained of oil or should be removed. - Steering sectors, both power and standard steering, should be drained of fluids or removed. - Transmissions, both standard and automatic, should be drained of fluid or removed. - The coolant system should be drained of fluid, mostly antifreeze, or removed.

Material	Advantages	Disadvantages	Considerations
Concrete	- Concrete materials are extremely compatible with the marine environment. - *Concrete is highly durable, stable, and readily available.* - The flexibility to cast concrete into a great variety of forms makes the material ideal for developing prefabricated units. - *Concrete provides excellent surfaces and habitat for the settlement and growth of encrusting or fouling organisms, which in turn provide forage and refuge for other invertebrates and fish.*	- A major drawback with the use of concrete material is its heavy weight, and the consequent need for heavy equipment to handle it. This increases the costs both at the landside transportation stage and loading and transport at sea. - Deployment of large concrete pieces or prefabricated units requires heavy equipment at sea, which is hazardous and expensive. Another drawback related to the weight of concrete materials is the potential for subsidence into the bottom. - Competition for scrap concrete, for such uses as roadbed construction, as well as the ability to recycle this material is currently reducing the availability of concrete for use as artificial reef construction in some areas.	- Concrete rubble from parking lots, buildings, or other sources may have other materials mixed in with it. Examples include dirt, plastic sheeting (moisture barrier), building materials (wood, fiberglass, etc.), among others. Loads of concrete rubble should be inspected for such associated, undesirable materials prior to deployment. - To enhance durability, use concrete materials which have Type II or greater Portland cement as the binding agent. Type II concrete should be used in designed structures and concrete ballasted tire units produced for reef applications. - Some scrap concrete may contain fly or other combustion ash, thus ash laden material could be inadvertently deployed.

Material	**Advantages**	**Disadvantages**	**Considerations**
Tires	- Vehicle tires are lightweight and easy to handle, particularly un-ballasted tires on small boats. - Vehicle tires may be readily available in large quantities, depending on regional scrap tire market value, and alternative government incentives. - Vehicle tires may be acquired free or at low costs, depending on local regulations and regional scrap tire market value. - Tires will last indefinitely in the marine environment. This is considered a benefit in the context of the material being durable. - Tires used as artificial reefs can be effective in attracting and holding fish and invertebrate populations	- Handling and access to waste tires is no longer unregulated. The storage, handling, and transportation of tires are carefully managed by all Gulf coast states. Tire collection sites must be permitted, and vehicles transporting tires must be registered with appropriate cargo manifests. - Tire recycling alternatives are available. Large scale deployment of tires at sea as a waste disposal activity under the umbrella of artificial reef construction is no longer viewed by management and regulatory agencies as environmentally acceptable. - Minor leaching of petrochemical or heavy metal toxicants from tires into the marine environment may occur under certain conditions, causing adverse effects to fish and epibenthic organisms (more research is needed from the marine environment on this subject). - Un-ballasted tires are unstable in open water marine environments. As a consequence, they must be properly ballasted in order to assure that tire units do not move in response to currents or storm wave forces. - Properly ballasted tire units are more expensive, bulky, heavy, difficult to handle, and difficult to transport without heavy equipment. - The expense and labor involved in creating a stable and durable tire unit may not make them as cost effective as other materials that can accomplish the same objective. - Tires must be stable in order for fouling or epiphytic communities to attach to tires, although there is some disagreement. Loose, mobile tires do not allow for invertebrate growth due to chafing and flexing. - Single tires lay flat on the bottom and provide little or no habitat value for fish. - Assuming that tires will last indefinitely in the marine environment, tire units will last only as long as the connectors or binding material holding them together remains intact (even when ballasted, multiple tire units that use steel reinforcement rods as a connector will	- If used, tires should be clean and free of petroleum or other environmentally incompatible substances prior to deployment. - Tires should not be deployed under environmental conditions expected to cause leaching of toxicants. - Tire unit design should be ballasted and placed at appropriate depths according to recognized engineering principles. - • Each tire used should be ballasted in concrete. Compressing tires and connecting them with steel reinforcement rods can result in tires breaking free due to corrosion of the steel rods. - Tires can be chipped and incorporated into concrete as an aggregate; however, an engineering study has shown that this approach can reduce the density, thus the stability, of the units when compared to the same unit without the chipped tires

Material	Advantages	Disadvantages	Considerations
Fiber glass boats	- Discarded fiberglass boats are readily available	- Use of derelict, fiberglass, recreational vessels has been tied to their value as a delivery system for other readily available materials. These transported materials by themselves may have little long-term value as reef habitat due to instability, lack of durability, or the lack of proper preparation. Often the material transported is poorly secured. Once the boat and its contents are on the bottom, storm conditions may eventually detach and scatter the cargo. - Low density fiberglass, sometimes with floatation intact or incompletely removed, is then prone to movement. - Under turbulent conditions, hulls may break up, with gelcoat, fiberglass fibers, etc. becoming widely scattered. No information is available on the impact of broken up fiberglass, gelcoat, and resin products in the marine environment.	- Availability should not be the determining factor in accepting fiberglass boat hulls or any other secondary use material. - Better follow-up assessment of existing fiberglass boat and boat mold sites, which have been in place for some years but have not been recently evaluated, is needed. - Fiberglass hulls or boat molds should not be considered appropriate artificial reef material without heavy concrete ballasting. - With the use of any vessels it is highly recommended that coastal engineers provide an assessment of the forces to which any vessel would be exposed in a major storm.
Bulky goods (fridges, dryers, washers, etc.)	- White goods are readily available and are easy to handle, both onshore and at sea.	- White goods are thought to be short lived in the marine environment. If that is true, sites would have to be replenished regularly, in order to maintain habitat. - White goods are thought to be unstable, and may easily be moved offsite by storm surge or being dragged in nets. - Material such as appliances, while readily available, is not dense, and their durability and stability in the marine environment is poor.	- The use of white goods should be avoided. - Ballasting or chaining several units together may increase stability; however, this practice will not increase the durability of the material. - Motors and compressors should be removed or drained of all lubricants, where applicable. - All plastic knobs, valves, and wiring should be removed. - Removing the compressors and motors during predeployment preparation would eliminate the heaviest component of the materials, thus contributing to their instability

7.4.5 RECOMMENDATIONS

1- Fuel tank disposal must be considered from the separate standpoints of tanks and contents. Fuel tanks of all kinds should not be treated as ordinary municipal waste due to the potential toxic compounds attached. The most environmentally sound method is reclamation of product in tanks, followed by cleaning and recycling of the tank steel. Future selected contractors for large fuel tanks in Jiyeh and Airport should present strict compliance with tanks cleaning, health & safety procedures.

2- It is recommended that the deployment of AR should be complemented with the implementation of proper measures to curb and eventually stop illegal fishing practices, over fishing and pollution that negatively impact the productivity of the marine environment in general and the reef in particular. Lobbying for the adoption of appropriate fisheries management policies coupled with the establishment of AR ought to ensure the sustainable use of local resources, preserve fish stocks while increasing the standard of living of the fishermen and boosting local and foreign diving activities and tourism (Nader, 2005). Table 7.13 summarizes the applicability of the different wastes possibly generated during the war for AR.

Table 7.13: Recommended Post Conflict Material for AR Construction in Lebanon

Type	Life time	Recommended for AR construction
Vehicles and streetcars	≈ 6 years	Not recommended; they are subject to corrosion to debris –better off recycled
Wooden materials	< 1-6 years	Not recommended; they collapse even sooner from wave surge and destruction by marine borers-better off recycled
Household appliances (stoves, refrigerators and freezers)	≈ 6 years	Not recommended because they are buoyant and difficult to sink and keep in place-better off recycled
Tires, rock, concrete rubble and others	Very durable (30-50 years)	Highly recommended for prefabricated concrete structures (raw demolition waste is not highly favorable) and tires

7.5 MEDICAL AND PHARMACEUTICAL WASTE

The quantities and quality of health care waste were certainly affected during the conflict. Increased number of injured persons and fatalities has placed pressure to hospital facilities in some areas.

7.5.1 QUANTITY AND CHARACTERISTICS OF WASTE GENERATED

Hospital waste generated during the conflict includes non-risk waste, such as waste from cafeteria and administrative departments, as well as risk waste classified by the Ministry of Public Health into five categories:

(1) Highly infectious waste;

(2) Non-sharp infectious waste (pathological and anatomical waste);

(3) Sharps (discarded syringes, broken scalpels, etc.);

(4) Pharmaceutical and chemical waste, and

(5) Special waste (radioactive and cytotoxic waste, pressurized containers, etc).

As a direct cause of the conflict, medical waste generation increased significantly due to increase in causality numbers and hospital bed occupancy number (reported 1,200 deaths and 4,400 injured). Based on the figures above, it is calculated that around 200 to 250 tonnes of medical waste were generated during the conflict period.

However, this number does not include post-conflict health care waste quantity generated. It is expected that medical and pharmaceutical waste are generated in higher quantity compared to generation rate in the same period before the conflict.

Lebanon received large quantities of medical and pharmaceutical aid during and after the conflict. One of the medical aid providers is the International Federation of Pharmaceutical Manufacturers & Associations; the aid included anesthetics, antibiotics, anticonvulsants, antidepressants, antidiarrheals, antifungals, antiinflammatories, antiretrovirals, heart medicines (antiarrhythmic, anticoagulant, anticholesterol, antiplatelet & hypertension treatments), laxatives, stomach medicines (beta-blockers and H2- antagonists), painkillers and tranquilizers.

7.5.2 POST-CONFLICT INITIATIVES

It can be assumed that limited, if any, initiatives for separation, treatment and proper disposal of medical waste took place.

During the conflict large quantities of pharmaceuticals were donated to Lebanon as part of humanitarian assistance. Undoubtedly, many of the pharmaceuticals save lives and alleviate suffering, but some donations given by well-meaning but uninformed people may cause problems. Pharmaceuticals may arrive past or near their expiry date, may be inappropriate for the needs, and be unrecognizable because they are labeled in a foreign language or may have been sent in unwanted quantities. Donated pharmaceuticals with a long shelf-life may be mismanaged, particularly in the confusion during and after armed conflict. Staff and storage space may be lacking and the pharmaceutical management system in disarray. Such problems also occur when drug donations form part of development assistance. Smaller quantities of pharmaceutical waste may accumulate in the absence of emergency situations, due to inadequacies in stock management and distribution, and to lack of a routine system of disposal. Safe disposal of these unwanted or expired drugs often creates a major problem (WHO, 1999).

7.5.3 ENVIRONMENTAL CONCERNS

This section will focus mainly on the environmental issues related to disposal of pharmaceutical waste which is expected to be of concern regarding its disposal during post conflict phase.

In general, expired pharmaceuticals do not represent a serious threat to public health or to the environment. Improper disposal may be hazardous if it leads to contamination of water supplies or local sources used by nearby communities or wildlife. Expired drugs may come into the hands of scavengers and children if a landfill is insecure. Pilfering from a stockpile of waste drugs or during sorting may result in expired drugs being diverted to the market for resale and misuse. Most pharmaceuticals past their expiry date become less efficacious and a few may develop a different adverse drug reaction profile (WHO, 1999). There are some categories of expired drugs or defective disposal practices that carry a public health risk. The main health risks are summarized below:

- Contamination of drinking water must be avoided; inappropriate dumping of such wastes can pose a threat to groundwater resources;
- Non-biodegradable antibiotics, antineoplastics and disinfectants should not be disposed of into the sewage system as they may kill bacteria necessary for the treatment of sewage; antineoplastics should not be flushed into watercourses as they may damage aquatic life or contaminate drinking water. Similarly, large quantities of disinfectants should not be discharged into a sewerage system or watercourse but can be introduced if well diluted;
- Burning pharmaceuticals at low temperatures or in open containers and dumps results in release of toxic pollutants into the air. Ideally this should be avoided;
- Inefficient and insecure sorting and disposal may allow drugs beyond their expiry date to be diverted for resale to the general public. In some countries scavenging in unprotected insecure landfills and dumpsites is a hazard;
- In the absence of suitable disposal sites and qualified personnel to supervise disposal, unwanted pharmaceuticals present no risk provided they are securely stored in dry conditions.

7.5.4 WASTE MANAGEMENT OPTIONS

Waste management options focus on pharmaceutical wastes, as these are the ones mostly related to the war and the additional quantities generated may require special attention. The various disposal methods are briefly described and summarized in Table 7.14.

Table 7.14. Disposal Options of Pharmaceutical Wastes (WHO, 1999)

Disposal methods	Types of pharmaceutical	Local condition suitability
Return to Donor / Manufacturer *(trans-frontier transfer)*	All bulk waste pharmaceuticals, particularly antineoplastics.	Usually not practical due to high costs - if transferred across frontiers, become regulated and subject to the Basel Convention on the Transfrontier Shipment of Hazardous Wastes
High-Temperature Incineration *(>1200°C)*	Solids, semisolids, powders, antineoplastics, controlled substances.	Expensive. No specialized incinerator in Lebanon. Cement kiln incineration is an option available in Lebanon
Medium temperature incineration or co-processing *(2-chamber incinerator with temp > 850°C)*	In the absence of high temperature incinerators, solids, semi-solids, powders. Controlled substances.	Antineoplastics best incinerated at high temperature. Local incinerators are available
Immobilization		
Waste encapsulation	Solids, semi-solids, powders, liquids, antineoplastics, controlled substances.	Requires monitoring. Occupies valuable space
Inertization	Solids, semi-solids, powders, antineoplastics, controlled substances.	Requires monitoring. Occupies valuable space
Landfill		
Highly engineered sanitary landfill	Limited quantities of untreated solids, semi-solids and powders. Disposal of waste pharmaceuticals after immobilization preferable. PVC plastics.	Occupies valuable space
Open uncontrolled non-engineered dump	As last resort untreated solids, semi-solids, powders – must be covered immediately with municipal waste. Immobilization of solids, semi-solids, powders is preferable.	Not for untreated controlled substances.
Fast–flowing watercourse	Diluted liquids, syrups, intravenous fluids; small quantities of diluted disinfectants (supervised).	Antineoplastics, and undiluted disinfectants and antiseptics not recommended.
Chemical decomposition	Not recommended unless special chemical expertise and materials available.	Not practical for quantities >50 kg.

7.5.5 RECOMMENDATIONS

Co-processing of pharmaceutical waste in cement kilns offers advantages for the authorities responsible for pharmaceutical waste management. This waste recovery method uses an existing facility, eliminating the need to invest in a new, purpose-built incinerator or secure valuable landfill site. Export of the waste is also an expensive alternative.

Cement kilns are characterized by sufficient process conditions and primary measures to minimize the formation and release of chemicals listed in Annex C of Stockholm Convention and achieve concentrations of PCDD/PCDF in flue gas lower than 0.1ng TEQ/Nm^3 (GTZ/HOLCIM, 2006).

Estimated treatment cost: The cost for co-processing of pharmaceutical waste in cement kilns in Lebanon is estimated at USD 400 to 500 per tonne (*personal communication with Holcim-Lebanon*). The high cost is justified by cement industry due to relatively low quantities of waste that could be received as well as additional monitoring costs that will be required to comply with the Stockholm Convention.

7.6 MUNICIPAL SOLID WASTE (MSW)

While the war has only exacerbated an existing municipal solid waste management problem, this section briefly tackles its impacts on MSW.

7.6.1 QUANTITIES AND CHARACTERISTICS OF WASTE GENERATED

7.6.1.1 Quantities

The variation in the quantity of municipal solid waste can not be easily estimated, however the following can be noted:

- More than 3 million cubic meters of demolition waste mixed with household damaged waste was generated in the country as a result of the conflict (PCM, 2006a).
- The new incoming 15,000 UNIFIL personnel and 15,000 Lebanese military forces settling in the south, several new military posts are established to accommodate them. These posts will generate significant quantities (calculated around 15 to 30 tonnes/day) of mixed solid wastes. The majority of these posts are usually located in remote areas on the boundaries of villages with limited to no access to proper municipal waste services.
- According to the last inventory of distributed aid material by the higher relief commission it is expected that there will be an increase in waste generated from packaging aid material mostly cartoon, plastic bottles, tin cans, nylon bags, etc. which mostly will end up in the waste dumps. Table 7.15 is an estimated number of packaging waste generated from aid supply distributed in impacted areas (PCM, 2006b).

Table 7.15. Estimated Number of Packaging Wastes Generated from Aid Supply

Type of waste	Quantity (No.)[159]	Expected Final destination
Nylon Packaging Bags	5,830,995	Mostly disposed
Plastic Bottles & Containers	19,751,577	Partially recovered for recycling
Carton (box + bottles)	6,161,010	Partially recovered for recycling
Flour Nylon Packages	9,848	Mostly recovered for reuse by local flour mills and for other domestic uses
Glass Bottles	17,258,814	Mostly disposed
Tin cans	19,600,524	Partially recovered for recycling

7.6.1.2 Characteristics

Domestic municipal waste characteristics were mostly affected by increase of incoming food aid, temporary change in social behavior and early recovery and rehabilitation works (such as disposal of rotten food, shattered window glass, damaged bulky items, damaged furniture, greenery waste, etc.). Table 7.16 presents the expected changes in waste composition before and after the conflict.

Table 7.16. Expected Change in Waste Composition in Post-Conflict Phase[160]

Components	AUB study 1994			Post-conflict (Short Term)
	Summer	Winter	Annual (%)	General condition
Organic material	62.4	61.0	61.7	Returned to normal
Paper & cardboard	11.3	16.1	13.7	Increased
Plastics	11.4	10.9	11.1	Increased
Metals	2.9	2.6	2.7	High increase
Textiles	4.2	2.4	3.3	Increased
Glass	5.6	4.8	5.2	High increase
Others[161]	2.6	2.0	2.3	High increase

7.6.2 POST CONFLICT INITIATIVES

The following initiatives can be highlighted:

- Municipalities, volunteers and private collection companies immediately initiated an active waste removal, clean up and collection of waste piles from streets and storage bins. The collected waste in each village and town was channeled to regular disposal sites i.e. mostly to local dumpsites.

159 Quantity was calculated based on the aid supply figures released by HRC, 2006
160 MoE / Ecodit, 2001
161 Others include bulky items, electronics, light bulbs, batteries, packages, etc.

- Dumping and open burning is the prevailing method for waste disposal in the majority of the impacted areas mostly in the South (except for very few villages served by material recovery and compost facilities) and Bekaa (except in Zahle caza which is served by a sanitary landfill).
- Beirut southern suburb, served by Sukleen, a private collection company, have removed stock piled waste during the first few days and transported the waste to the Naemeh sanitary landfill.
- Scavenging activities became an active business in the country mostly targeting highly valuable recyclable material (Figure 7.11). Typical recovered material in the Lebanese recycling industry includes are listed in Table 7.17.

Table 7.17. List of Recyclable Material Recovered in Lebanese Market[162]

Recyclable Material	Types of Materials Found
Aluminum	Damaged window frames and soft drink bottles *Represents the most valuable recyclable metal in the market.*
Corrugated cardboard (CCB), Carton Box (CB), Old mixed paper (OMP) and High Grade Paper (HGP)	Bulk packaging material and paper. *Contaminated paper/carton is not accepted*.
Plastics (PETE, PVC, HDPE, PS and LDPE)	Bottles, outdoor recreational chairs/tables, water storage tanks, drinking water bottles, packaging for electronic equipment, Styrofoam trays used for vegetables/fruits, etc.
Glass	Clear, green and brown glass bottles and containers *Not all kinds of glass can be recycled such as mirrors, light bulbs, car wind shields, heat resistant glass, and window glass enforced with wire mesh*.
Ferrous metals	Tin cans, white goods, boilers, scrap iron, etc.
Non-ferrous metals	Aluminum, copper in electric wirings, lead in water piping, and stainless steel
Lead acid batteries	Automobile and truck batteries shredded to recover plastic and lead
House hold items	Partial damaged furniture, appliances and equipment
Textile	Cloth, rugs, sheets, etc.

[162] UNEP-Blue plan, 2000.

Figure 7.11. Scavenging Activities at Ouzaii Debris Disposal Site

Scavenging was conducted by house owners (to retrieve what is left from their houses), private scavengers and licensed scavenger network groups. Appendix 7-A lists some of the recycling industries in the country.

7.6.3 ENVIRONMENTAL CONCERNS

7.6.3.1 General Issues

The environmental damage caused by burning of MSW during the conflict and post-conflict phase is irreversible and cannot be mitigated at this stage. However, the main resulting impacts are briefly described.

Waste dumps are directly contaminating soil, groundwater, surface water and air. Typically no liners and control measures are set to stop generated leachate from intermixing with water being used for irrigation or reaching surface water or marine water. The situation is further aggravated by the fact that open dumping is not limited to household waste, but also includes slaughterhouse, medical and industrial waste (Ecodit/MoE, 2001). It is expected that during the conflict the wastes disposed in the existing dumpsites have increased in both quantity and toxicity.

7.6.3.2 Air Pollution

Typical air emissions resulting from incomplete combustion related to open burning of mixed municipal waste includes CO_2, NO_x, SO_2, HCL, PM, and toxic byproducts such as polycyclic aromatic hydrocarbons, benzene and carbon monoxide (Tchobanoglous et al., 1993). In addition, POPs such as polychlorinated dioxins and furans are major products of incomplete combustion from open dump burning. According to the POPs inventory conducted in Lebanon, uncontrolled open burning (mostly dumpsites) is the major source of Dioxins and Furans releases in the country (UNEP/UNDP/MoE/ELARD, 2004).

Emissions of heavy metals (Cd, Hg, Pb, Cr) are also a major concern during waste burning. After combustion, metals are either emitted as particulate matter or vaporized into their gaseous state. Mercury is of particular concern for public health reason as it volatizes at low temperature.

On the other hand, biologically active dumpsites are exposed to anaerobic conditions resulting in the formation of CH_4, CO_2 (sources of green house effect), H_2S (highly corrosive, and toxic), and NH_3. These pollutants are discharged uncontrolled to open air (Tchobanoglous et al., 1993).

7.6.3.3 Water and Soil Pollution

Leachate generated from uncontrolled dumpsites are similar to industrial waste in its impact, whereby the contaminants of concerns are mainly the extremely high COD (~18,000 mg/L), TOC (~6,000 mg/L), and BOD (~10,000 mg/L for fresh leachate) with noxious odor and appearance. The presence of trace compounds (some of which are hazardous) depends on the concentration of these compounds in the gas phase (Tchobanoglous et al., 1993). UNEP post-conflict assessment team conducted leachate sampling for Tyre dumpsite; the results should be published by mid December (ELARD, 2006). Given the increase in the quantities of solid wastes generated during the war and the possible increase in overall toxicity, leachate strength and level of hazard may have also increased.

7.6.4 RECOMMENDATIONS

The impact of the war on solid wastes, whether hazardous or non-hazardous domestic wastes, calls for the urgent need to address the waste management problem in Lebanon. The insufficient number of adequate waste management facilities poses significant threats on the countries water resources and overall health of the population. The following recommendations can be made:

1. The draft integrated solid waste management law prepared by MoE should be adopted by the parliament to provide a comprehensive legal framework for waste management in the country;

2. A national waste management plan should be finalized and implemented, including the implementation of the necessary waste management facilities such as municipal and hazardous waste landfills;

3. In the short-term, an assessment of the impacts of the war on waste dumps is recommended to identify those dumps that received large quantities of wastes and could be posing increased impacts on the environment; the proper closure and rehabilitation of such dumps could be necessary; proposed actions are:

    a. Conduct a survey of dumpsites in affected areas (South and Bekaa) and collect initial information on post-war increase in quantities of wastes disposed and types of wastes disposed based on interviews with local population, waste collectors, etc.

b. Prepare a list of priority dumps to be further assessed based on pre-determined criteria including size, level of impact from war, possible environmental and human receptors, etc.

c. Conduct a detailed study on the selected dumpsites (ownership, size, capacity, age, methane emissions, impacts, , etc.) including detailed site assessments

d. Prepare rehabilitation plans based on findings of the assessment with detailed costing and needs.

e. Rehabilitate one priority dump to serve as a model for replication and remediate a major source of environmental impact identified by the assessment.

f. Assist local municipalities in preparing proposals to international agencies/organizations (Example: World Bank) under relevant funding programs (example: CDM, etc.) to finance the remaining rehabilitation plans.

The total budget of such an intervention is estimated at USD 730,000. Cost breakdown is as follows:

1. Field survey and selection of priority sites: USD 15,000
2. Detailed studies per priority sites (assuming 5 sites are selected and USD 20,000 per site) including rehabilitation plans: USD 100,000
3. Pilot rehabilitation project: USD 600,000
4. Back-stopping and resource mobilization: USD 15,000

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APPENDIX 7- A: DATA BASE OF DIFFERENT RECYCLING COMPANIES IN LEBANON

Company	Contact person	Type	Precondition	Transportation	Revenue	Location	Telephone
Liban Fonderies	Sami Nassar	Metal (all types)	Separation of different types of metals	40-50$/tonne	50% of stock market	Roumieh	01-897619
Ohanis Kasarjian	Ohanis Kasarjian	Metal (steel, fonts, cupper, aluminum)	less than 40cm and 4mm thick. Separated	not provided	not provided	Kfarchima	05-462462
Soliver	Khaled Ammourieh	Glass (all types and colors)	Free from metals, aluminum and lead. Separated	to be discussed	white: 40-45$/tonne, green: 30-35$/tonne, brown: 25-30$/tonne	Chwaifet	05-803903
Maliban	Hagop Chaparian	Glass (bottles and jars; all colors)	Free from metals and plastics. Separated	not provided	White: 50$/tonne, green: 40$/tonne, brown: 40$/tonne	Chtaura	08-510115
Nafekh Yadawi	Hsein Khalileh	Glass (all types without opaque glass)	Free from metals and plastics. Separated	50$/tonne	50$/tonne for each color	Sarafand	03-644747
Mazar plast	Ibrahim El-Aalawi	Plastic (PETE, PP)	Separated and free from organic matter	to be discussed	100-150$/tonne	Bekaa	03-843929
Rocky plast	Robert Khoury	Plastic (most common types)	Free from any organic or inorganic matter. Each type should be grouped alone	not provided	To be discussed	Jbeil	03-634400
Lebanese Recycling works	Elie Debs	Plastic, paper, metals	PETE and PVC should be separated other types could be sent mixed.	Plastic: 25$/tonne, paper: 15$/tonne	Plastic without PETE: 75$/tonne, PETE: 25$/tonne. Cartoon:35$/tonne, other: 35$/tonne, mixed metals: 40-50$/tonne, iron: 70-80$/tonne	Roumieh	01-890383

Company	Contact person	Type	Precondition	Transportation	Revenue	Location	Telephone
	Dikrane	used oil and car parts		included	Used parts: 40-50$/tonne, used oil: 40$/1000l.	Dora	03-376499
Daou	Elie Daou	Textile	Free from food, plastic, zippers, bottoms	not provided	40$/tonne	Mazraet Yachouh	04-913 300
Daou	Charbel Daou	Textile	Free from food, plastic, zippers, bottoms	could be provided	transported from site: 33.3$/tonne, without transportation: 50$/tonne	Mtaileb	03-620850
SOLICAR	Tony Bedrane	Paper	Free from waxed kraft, carbon kraft, plastic, food products	not provided	50$/tonne	Wadi shahrour	05-940248
SIPCO	Mohamed Ghandour	Paper	Free from plastic and food products	30$/3-4 tons Jbeil	45-55$/tonne	Kfarchima	05-431048
SICOMO	Jihad Aazar	Paper	Sent in ballet form	to be discussed	50$/tonne	Qab Elias	08-500550
NINEX	George Abou Jawdeh	Paper	Free from waxed kraft, carbon kraft, plastic, food products	not provided	40-75$/tonne	Zouk Mosbeh	09-218400
Unipack-Tissue mel	Imad Khoury	Paper	Free from plastic, metals and food	not provided	50-60$/tonne	Halat	09-477191

Company	Contact person	Type	Precondition	Transportation	Revenue	Location	Telephone
Mimoza	Pierre Abou Malham	Paper	Free from food, plastic, zippers, buttons	25$/tonne	45$/tonne	Qaa El-Rim	08-803052
(Collection and Separation)	Elie Sawma	Paper	Free from plastic, metals and food	25$/tonne	45$/tonne	Dekweneh	01-689105
DIAMETAL	George Salame	Ferrous and non-Ferrous Scrap (All types of metals)	Not contaminated by oil	NA	150$ - 200$/tonne	Mansourieh	01-566801
HATCO	Khatchig Hagopian	Secondary lead processing (used car batteries)	Acid free lead batteries	Not provided	NA	Dora-Burj hammoud fishermen port	
Lebanese Metal Industry	M. Ghazi Yaseen	Secondary Lead processing (used car batteries)	Acid Free lead batteries	Not provided	NA	Tripoli-El Baddaoui	03-281434