SUMMARY REPORT

Environmental Site Assessment and Preliminary Risk Assessment for Mercury

Kodaikanal Thermometer Factory, Tamil Nadu

Prepared for

Hindustan Lever Limited (HLL)

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Introduction

SECTION 1

URS Dames & Moore has been commissioned by Hindustan Lever Limited (HLL) to conduct an environmental site assessment and preliminary risk assessment for mercury at its wholly owned thermometer manufacturing facility located at Kodaikanal in Tamil Nadu State. This follows publicity by Greenpeace and the Palini Hills Conservation Council after their discovery of glass scrap illegally disposed from the manufacturing facility to a scrapyard in Kodaikanal townsite.

The site location plan is shown on Figure 1.

History

The Kodaikanal thermometer factory of former Ponds (India) Limited, commenced its manufacturing operations in early 1984 using equipment relocated from a thermometer factory at Watertown, USA belonging to Chesebrough Ponds. Kodaikanal was chosen as the most suitable location in South India because of similar cool climatic conditions to those at Watertown. This was beneficial in terms of occupational health and safety, and the manufacturing processes.

The factory came under the ownership of Hindustan Lever Limited (HLL) in 1998 consequent to the merger with Ponds India Limited. It manufactures thermometers mainly for export to Europe, USA, South America, Australia and in recent years a small proportion within India under permission from the Ministry of Commerce.

Thermometers in the factory are manufactured from imported glass and imported mercury. The mercury used in thermometers is triple distilled (99.999%) and its importation requires clearances from the Ministries of Commerce and Finance of the Government of India. Entry of glass or mercury on to site and dispatch off site of finished products and wastes are carried out under certification by the customs official posted at the Factory and recorded in the Annual Bond Account.

The factory operates under valid Consents for Discharge of Sewage and Trade Effluents granted by the Tamil Nadu Pollution Control Board (TNPCB). In addition, the factory has authorisation from the TNPCB for collection/storage of hazardous wastes under Rule 3(c) and 5(5) of The Collection/Storage of Hazardous Waste (Management and Handling) Rules 1989 enacted under the Environmental Protection Act 1986. This licence is for sludge derived from treatment of industrial effluent containing heavy metals and was renewed in April 2000 with a validity of two years.

2.1 Process of Manufacture

The factory is divided into two main areas:

- Non Mercury Area; and
- Mercury Area.

Non Mercury Area

This is where glass-forming operations are carried out before mercury is filled into thermometers. This area covers departments 1 and 2. Various processes that are carried out in this area are:

- Stem cutting; Bulb cutting; End opening; End cutting; and Bulb forming.

Mercury Area

This is where all operations from mercury fill through to final thermometer manufacturing operations are carried out and covers departments 3 and 4. Various processes that are carried out in this area are:

- Mercury fill; Top chambering; Annealing; Contracting; Airpassing; Test for shake; Scale setting; Grading; Screening; Baking; Top making; Final inspection; Quality assurance; and Packing.

The Mercury and Non Mercury areas are physically separated by partitions and walls.

2.2 Scrap Handling and Disposal

Glass scrap from the Non Mercury area departments 1 and 2 is bagged and has either been disposed or is held in the Custom Bonded Storage area on site. Another 45 tonnes was also buried in four shallow pits on site. This scrap is mercury free.

The glass scrap from the Mercury area departments 3 and 4 contains residual mercury and until 1990 was stored as such. Residual mercury in this non-treated scrap approaches 6% by weight.

In 1990 recovery was commenced using a crusher and twin recovery ovens, which operated until 1998. Approximately 60 tonnes of 3 and 4 glass have been processed, however this operation was not considered particularly efficient as the grinder was unable to crush the glass to the desired level. Residual mercury in this treated scrap is approximately 1%.

At the end of 1998, a new crusher and vacuum activated mercury recovery plant were commissioned and has been in operation since that time. This new plant is able to process and recover mercury from 200 kg per day of glass on a round the clock basis. An order has been placed for three additional units to augment the capacity for mercury recovery from the accumulated backlog of 3 and 4 glass scrap. Residual mercury in this scrap is approximately 0.15%.

Sale of glass scrap commenced in 1992. A total of 98.3 tonnes was sold during this period and comprised both 1 and 2 glass scrap and mercury-recovered 3 and 4 glass scrap. All sales up to October 1994 were made to MLC Industries, a lamp/lamp casing manufacturer in Mysore. These sales were discontinued when lead glass was replaced with soda lime glass. Thereafter, besides sales of 1 and 2 glass scrap, 11.5 tonnes of mercury-recovered 3 and 4 glass scrap was sold to a dealer in Coimbatore in September 1998. Of this quantity, approximately 8.0 tonnes was sold to Philips India Limited and 3.5 tonnes was sold to glass marble manufacturers. Of the 3.5 tonnes, about 1.3 tonnes (including mud) was traced by HLL in Bangalore and retrieved in March 2001.

A further quantity of 19.42 tonnes of 1 and 2 glass scrap was sold to a glass recycler in Coimbatore between June 1997 to June 1999 for manufacture of glass marbles. This manufacturer has confirmed that all the material has been consumed except for 30 kg which has been retrieved by HLL. Another 6 tonnes of 1 and 2 glass scrap has been retraced to a glass marble manufacturer who has consumed the total quantity of the materials. Eighteen tonnes of 1 and 2 glass scrap were sold to a scrap dealer in Chennai in December 1995 of which approximately one tonne has been retrieved, the remainder has been consumed in glass marble manufacture.

The last sale in November 1999 of 5.3 tonnes was made to a scrap dealer in Kodaikanal (which is the material referred to by Greenpeace) and is lying in the dealer's yard in Kodaikanal.

2.3 Kodaikanal Offsite Scrapyard

Approximately 5.3 tonnes of glass cullets, as 3 and 4 glass scrap, are stored in a scrapyard in Kodaikanal. This was sold to the scrapyard in November 1999 and is currently located in two small stockpiles amongst other scrap waste. The glass scrap was treated for mercury recovery before disposal from the factory and contains between 0.15% and 1.0% metallic mercury. On this basis the material contains slightly more than 50 mg/kg of mercury and is classified as a Hazardous Waste.

The scrapyard is located within the residential/commercial area of Kodaikanal, where granite bedrock is exposed and soil cover is no more than 0.2 to 0.3 m. There is surface runoff from the site during rainy periods which discharges across the adjacent road and then downhill across other roads which are located at progressively lower elevations. It is considered essential that the glass scrap be removed from the scrapyard before the onset of the monsoon season.

A preliminary protocol for recovery, transport and on-site storage of the glass scrap was prepared by URS Dames & Moore, and submitted to the Tamil Nadu Pollution Control Board (TNPCB) on 18 March 2001. Comments made by Navroz Mody of the Tamilnadu Alliance Against Mercury were returned on 3 May 2001. These comments have been reviewed by URS Dames & Moore and its expert subconsultant Dr Van Teunenbroek of TNO in the Netherlands. Together a revised protocol has been agreed and resubmitted to TNPCB for approval. The protocols are in line with internationally accepted Guidelines for Chemical Hazards of the U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH) as published on their website http://www.cdc.gov/niosh/npg/nengapdx.html.

It should be recognised that retrieval, drumming, transport and storage of the waste will occupy an elapsed time of no more than two days and will involve no more than 20x 200 litre drums of waste glass and soil. The potential exposure of workers and nearby residents to mercury vapour and dust during the operation is therefore limited. The proposed protocol involves the following steps:

i. Cordon off access to the scrapyard immediately prior to commencement of operations and secure the area with police.

ii. Use a fine spray of water on the stockpiles, avoiding any surface runoff, to minimise dust generation.

iii. Erect tarpaulin/HDPE partition above man height around the perimeter of that part of the scrapyard, which is to be disturbed to further minimise any dust emissions offsite.

iv. Commence monitoring of mercury concentrations in air using a Jerome 431-X Mercury Vapour Analyzer accurate to 0.003 mg/m^3 (cf the NIOSH time weighted average for mercury vapour is 0.05 mg/ mg/m^3).

v. Commence clearing and drumming of waste and soil with workers equipped with Personal Protective Equipment (PPE) as recommended by NIOSH i.e., rubber boots, hand gloves, full body overalls, eye and hair protection and respirators/dust masks.

not done

vi. The glass waste and soil, excavated down to bedrock, will be placed in open-top 200 litre steel drums and sealed with steel lids.

vii. The sealed drums will be manually loaded onto truck using ramps.

viii. The truck will be lined with HDPE sheeting to contain any potential spills during loading and transport, and secured with tarpaulin cover.

ix. The truck will be driven to the HLL factory site under police escort.

x. On arrival at the factory the drums will be unloaded, weighed, labeled and transferred to a secure storeroom.

xi. The PPE and implements used during the operation will be decontaminated by washing in the factory and the water discharged to the factory effluent treatment plant.

xii. Any springs or seeps of water down slope of the scrapyard should be identified before start of operations and samples collected for mercury analysis. If concentrations exceed 0.0003 mg/l an alternative water supply will be provided by HLL until such time as mercury levels decline to the above criterion.

2.4 Medical Surveillance

The work place atmosphere in the mercury area is monitored using a gold film mercury vapour analyser with a self-calibrating facility. The intention is for the mercury in the atmosphere to be controlled to 0.05 mg/m^3 of air by adopting the following measures:

- Exhaust fans fitted along the length of the Mercury Area in the factory to turnover the air every 45 minutes;
- Provision of vacuum cleaners in the factory to collect broken thermometers when breakage occurs; and
- Scrubbing and washing of the factory floor once a day with water to remove traces of mercury. This water is treated in the effluent treatment plant (ETP) and reused for floor washing.

Operators in the Mercury area are provided with safety masks to filter out mercury vapours. This is backed by an emergency procedure when the mercury vapour exceeds 0.05 mg/m^3 which includes opening all windows and cleaning the entire floor with water after which the water is brushed into the ETP.

Records of mercury vapour levels have been maintained for the period 1983 to 2000. The records for 1994 to 1999 have not been sighted and are currently being traced. During this time there have been instances of readings exceeding the maximum level mainly during the month of May 2000 in the mercury distillation and crusher areas. The maximum spot reading of mercury in air, from the records available, has been 0.480 mg/m^3.

The medical surveillance comprises an annual medical checkup of all employees and monthly monitoring of mercury in urine. The annual medical check up consists of physical examinations with special attention to mouth, gums, skin, teeth, hair and neurological symptoms such as tremors or unsteady gait. The medical tests comprise blood tests (haemoglobin estimation, total white blood cell counts, differential white blood cell counts) and routine urine examinations for albumen, red blood cells, casts, crystals and sugar). Records of these examinations for 130 employees are available from 1988. The medical records of 30 employees who left the company others whose services of were terminated in the recent past are available and are within normal limits.

The monthly urine examinations of all employees are done for mercury and compared to the maximum regulated level of 100 micrograms of mercury per litre of urine. Employees whose mercury levels exceeded this level were re-deployed from the mercury area. In all such cases mercury levels of the re-deployed staff reduced to acceptable limits in the subsequent readings. The monthly urine monitoring was commenced in 1986 and the records since 1988 are available.

Results of the most recent urine examinations conducted in the year 2000 indicate that the mercury concentrations in the urine of all employees, ex-employees and scrap dealers are well below the WHO recommended acceptable upper limit of 100 micrograms per litre. Of the 255 included in the survey, 3% of those surveyed had between 40 and 60 micrograms of mercury per litre of urine, another 3% between 30 and 40 micrograms per litre and the remaining 94% had mercury levels of less than 30 micrograms per litre of urine.

3.1 Description

The most significant anthropogenic activities giving rise to mercury (Hg) discharge to land, water and air are:

- Mining and smelting of copper and zinc ores;
- Burning of fossil fuels, mainly coal;
- Industrial production processes, in particular the mercury cell chlor-alkali process for production of chlorine and caustic soda;
- Consumption related discharges, including waste incineration; and
- Use of agricultural fertilisers, fungicides and seed disinfectants.

All chemical compounds of Hg are toxic to humans although Hg^{o} may have to be oxidised to ionic forms to show toxic effects. Organomercurials, in particular methyl mercury appears to show strong teratogenic effects, and carcinogenic and mutagenic activity have also been implied.

Occupational Health and Safety Guidelines applicable to mercury in the workplace are therefore very strict. The most applicable guidelines are those published by the US Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH). The Kodaikanal Thermometer Factory closely follows the NIOSH guidelines for mercury vapour which include a maximum time weighted average mercury concentration of 0.05 mg/m^3 in air and regular monitoring of mercury levels in urine of all employees.

Handling, storage and transport of glass scrap with residual mercury is also planned to be undertaken under NIOSH guidelines.

3.2 International Guidelines

There exist a number of international guidelines for total inorganic (metallic) mercury and methyl mercury in soil that are relevant to the assessment of potential exposure via incidental contact with soil. Examples are listed below:

Mercury Concentration (mg/kg)

	USEPA Region 9		Canadian	Australian	Dutch Intervention Value
	Total Hg	Methyl Hg			
Residential	23	6.1	6.6	15	10
Commercial			24		
Industrial	610	88	50	75	

Note: The Dutch do not provide a value for industrial land use, the value provided is for both the protection of human health and terrestrial ecosystems. A risk assessment study recommended when values are in excess of 10 mg/kg.

It should be noted that the above guidelines provide a basis for identifying conditions that may warrant further assessment, they do not signify conditions that would represent an unacceptable risk. They have been developed at a generic level to be over protective. Site specific risk assessments normally result in relaxation of these values.

Based on URS Dames & Moore's current understanding of the site conditions, the above guidelines form an appropriate basis for the assessment of risks to human health for both on site workers and the surrounding population.

Regulatory Considerations

The following environmental legislation sets out policies and regulations to control environmental pollution in India:

- The Air (Prevention and Control of Pollution) Act, 1981 and subsidiary Rules;
- The Water (Prevention and Control of Pollution) Act, 1974 and subsidiary Rules;
- The Water (Prevention and Control of Pollution) Cess Act, 1977 and subsidiary Rules; and
- The Environment (Protection) Act, 1986 and subsidiary Rules.

Under the Environment (Protection) Act, all industries requiring a consent under Section 25 of the Water (Prevention and Control of Pollution) Act or under Section 21 of the Air (Prevention and Control of Pollution) Act or both, or requiring authorisation under the Hazardous Wastes (Management and Handling) Rules, 1989, are required to submit an environmental statement for the financial year ending 31 March in Form V to the State Pollution Control Board on or before 30 September every year.

4.1 Air Pollution Control

Air emissions are controlled by The Air (Prevention and Control of Pollution) Act, 1981. The State Pollution Control Boards (formed under Section 3 of The Water Act) are responsible for laying down, in consultation with the Central Board, standards for emissions of air pollutants from industries and any other source. The Environment (Protection) Rules 1986 provide the national standards for emissions and discharges of environmental pollutants from various sources. Since the States have not laid down more stringent standards, the national standards as prescribed in Schedule I of the Rules are applicable.

Prior to its amendment in 1987, The Air Act was enforced through mild court-administered penalties on violators. The 1987 Amendment strengthened enforcement and introduced stiffer penalties. Now, Boards may close down a defaulting industrial plant or may stop its supply of electricity or water. The Boards may also apply in court to restrain emissions that exceed prescribed standards. The Act was extended to include noise as an air pollutant.

The Environment (Protection) Rules of 1986, with amendments up to April 1999, specify the standards of emission and or discharge of environmental pollutants from 80 industries, operations or processes. No standard has been established for mercury.

4.2 Water Pollution Control

The Indian legal system provides four major sources of law for addressing water pollution problems:

- Administrative permit system under the Water (Prevention and Control of Pollution) Act, 1974 and subsequent Rules of 1975 and amendments in 1978
- Provisions under the Environment (Protection) Act and Rules of 1986 relating to water quality standards

- Public nuisance actions
- Common riparian law.

The Water Act empowers the State Pollution Control Boards to:

- Establish and enforce effluent standards for factories discharging pollutants
- Control sewage and industrial effluent by approving, rejecting or conditioning applications for permission to discharge
- Minimise water pollution by advising on appropriate sites for new industry .
- Prescribe standards for the discharge of effluent or quality of receiving waters
- Monitor compliance with permitted effluent discharge standards.

Prior to its amendment in 1988, enforcement under the Water Act was achieved through criminal prosecutions initiated by boards, and through applications to magistrates for injunctions to restrain polluters. The 1988 Amendment strengthened the Act's implementation provisions. Now, the Board may close a defaulting industrial plant or withdraw its supply of power or water by administrative order, penalties are more stringent, and a citizens' suit provision bolsters enforcement machinery.

Effluent standards have been stipulated under the Water (Prevention and Control of Pollution) Act of 1974. The standards for discharge of mercury are as follows:

- Inland surface water--0.01ppm
- Public sewers--0.01ppm
- Marine coastal areas--0.01ppm.

The Water Prevention and Control of Pollution Cess Act of 1977 was passed to help meet the expenses of the Central and State Water Boards. The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay cess (tax) for water consumption. These revenues are used to implement the Water Act.

4.3 Hazardous Substances

The Manufacture, Storage & Import of Hazardous Chemical Rules, 1989, apply to industries that use or store specified hazardous chemicals. These Rules pertain to directives and procedures for:

- Storage of hazardous chemicals;
- Inventory of hazardous chemicals;
- Identification of major hazards posed;

- Preparation of on-site emergency plans;
- Workers' operational safety; and
- Disclosure of product safety information in material data sheets.

Amendments passed in 1987 to the 1948 Factories Act introduced special provisions on hazardous industrial activities. The 1987 Amendment, among other things, empowers states to appoint site appraisal committees to advise on the initial location of factories using hazardous processes. The Act also requires the occupier of a factory to maintain workers' medical records and employ operations and maintenance personnel who are experienced in handling hazardous substances. A Schedule to the Act prescribes permissible limits of exposure to toxic substances and requires the creation of safety committees to consist of workers and managers who are required to review a factory's safety measures periodically.

A review of the list of specified chemicals indicates that mercury, in the forms of alkyl mercury, mercury fulminate, and methyl mercury, are listed under these Rules.

4.4 Hazardous Waste Management

The first comprehensive rules to deal with hazardous wastes were issued in 1989 under the framework of The Environment (Protection) Act of 1986. These rules, The Hazardous Waste (Management and Handling) Rules apply to designated categories of waste generated in quantities exceeding specified limits, and provide for their proper handling, storage and disposal with the requirement for a permit.

Waste Category No. 4 under the rules is mercury bearing waste. Any operation that generates more than a total of 5 kilograms per year (calculated as pure metal) must ensure proper collection, reception, treatment, storage, and disposal of this waste. Rule 3i(b) refers Schedule 2 of the Hazardous Waste Rules and was updated on 6 January 2000. Class A, and specifically Class A6, mercury and mercury compounds, is nominated as Hazardous Waste if the concentration exceeds 50 mg/kg.

4.5 Air Quality

The Indian Occupational Health and Safety Regulations for air quality in the Workplace specifies a maximum time weighted average of 0.05 mg/m^3 of Hg. There are no regulations or guidelines for mercury in air emissions or ambient air.

Site Description

The HLL factory site is located at an elevation of approximately 2,180 m. The site is irregular in shape and occupies an area of approximately 87,250 square meters. The southern boundary of the site slopes steeply into a protected nature sanctuary of the Tamil Nadu government, the Pambar Shola Forest.

Meteorological recrds are available for the six year period 1995 to 2000 and have been used to construct a monthly average rainfall chart (Figure 2) and wind rose (Figure 3). The dominant wind directions are northeast/northnortheast, northwest/northnorthwest and southeast, consistent with the monsoons.

Mercury vapour in air will therefore disperse predominantly to the northwest/northnorthwest, northeast/ northnortheast and to the southeast.

The access road to the site, St. Mary's Road, forms the drainage divide between the factory site and the Pambar River subcatchment to the south and Kodai Lake to the north. Drainage across the site is primarily via a small stream which originates at the northeastern corner of the site and flows in a southwest direction prior to discharging to the precipitous slopes which fall 1,300 m from the southern boundary to the Pambar River. This river is for the most part inaccessible until the Kumbakarrai Falls located about 7 km to the southeast. There is a second smaller drainage traversing the western part of the site and other seepage areas. The topography of the site and its surroundings are provided on Figure 4.

The general land use to the north and east is largely low density private residential properties along St Mary's Road. A few squatter cottages and St Mary's Church are located to the west. A large television broadcast antenna tower is located about 200 meters to the east of the site. The nearest surface water body to the site is the Pambar River (approximately 0.5 km to the south), which flows in a southwest direction to the Kumbakarrai Falls, thence draining eastward across the Tamil Nadu Plain.

The whole site is underlain by shallow Archaean bedrock, mainly granite gneiss and charnockite, which is impermeable apart from limited fracture porosity related to vertical and subhorizontal joints and exfoliation joints in the uppermost weathering profile down to 5 or 6 m depth. Two shallow wells on site are blasted into the rock, but have limited supplies which decline markedly in the summer season. There is also a spring in the central/lower part of the site adjacent to the stream, and this again becomes dry during summer. The soil profile is very thin, and comprise a few centimetres of predominantly sandy material in the upper part of the site grading down into densely vegetated peaty soils in the south. Maximum thickness of soil intersected across the site is 1.5 m. A narrow access path, the Levange Path, is in the Forest Reserve immediately to the south of the site boundary and can be traversed on foot with the approval and presence of the Forestry Department in Kodaikanal. This path lies immediately above the precipitous slopes and is primarily on bedrock with only a thin veneer of soil. There is no easy access to the slopes below the Levange Path. The stream discharging from the site forms a waterfall which has, over time eroded a small shallow basin in the rock along the Levange Path. This shallow pool contains at most approximately 25 to 50 kg of sediment washed down from the factory site. This is termed location DFE and both sediment and water samples have been collected for analysis. There is also some offsite seepage of water and sediment from the soil/rock contact and possibly exfoliation joints which has been sampled at location DFNE.

As part of the environmental investigations and the risk assessment for mercury, URS Dames & Moore has carried out a review of meteorology, topography, drainage, soils, geology and hydrogeology to assess sources and pathways for release of mercury onsite and offsite. The main sources are the Mercury area departments 3 and 4, the distillation plant, the crushing plant, the industrial ETP and the onsite storage areas for glass scrap. These have been examined to evaluate potential sources of mercury release.

This has been followed by a comprehensive sampling programme whereby in excess of 150 samples have been collected for total mercury analysis. This sampling programme is dynamic in that additional samples are collected for analysis as results progressively come to hand. Selected samples have also been tested (or are currently being tested) for methyl mercury. The sampling locations are shown on Figures 5 and 6. Particular emphasis has been placed on following internationally accepted QA/QC protocols for collection and analysis of samples; eg., chain of custody and preservation procedures, duplicate samples and blanks, and storage times. The break down of the samples for which results have been received is as follows; with additional samples of soil, sediment, water and lichen also submitted for analysis but not yet available for review.

Table 1
Summary: Samples Tested for Mercury

	Total Onsite	Total Offsite
Soil	66	13
Sediment	8	7
Water	5	6
Lichen	0	2

Analytical testing of the soil/sediment/lichen samples for total mercury has been primarily conducted at the MGT Environmental Laboratories in Melbourne, Australia.

Testing for methyl mercury is highly specialised and for this study has been conducted at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) laboratory in Sydney, Australia with additional lichen samples submitted to the TNO Laboratory in Holland for total mercury and methyl mercury analysis.

Air quality monitoring data plus medical records (mercury levels in urine and blood) for on site workers have also been examined by URS Dames & Moore.

The Hindustan Lever Research Centre (HLRC) Laboratory in Mumbai has a quick turnaround which is important in a study of this nature and at total mercury concentrations of 10 mg/kg and above has been found to show good correlation with the MGT results. The HLRC total mercury analyses have therefore been very useful in delineating "hotspots" with higher mercury concentrations.

7.1 General

Results of the analytical testing for total mercury are provided in Table 2. Results of the water samples are presented in Table 3 and methyl mercury results are presented in Table 4.

7.2 Mercury Distribution Offsite

The distribution of mercury analyses received to date follows a pattern which is in accordance with the identified sources and pathways. There are slightly elevated concentrations of mercury, up to 2.5 mg/kg, over the whole site and offsite to the immediate north and south. Offsite concentrations in lichen are higher, up to 4.8 mg/kg immediately north of the site. These are attributable to dispersion of metallic mercury vapour by air from the mercury production, distillation and crushing areas. Conservative calculation of air discharges indicate a maximum total discharge to atmosphere over the 18 years of plant operation of approximately 70 kg of mercury.[1] Based on contouring of low level mercury concentrations some 10 kg of this mercury has transferred offsite in air and deposited in the uppermost soil profile to 0.1 m depth, and on lichen and other organic matter, to the north (6 kg) and south (4 kg) of the site. All on site sample locations, those on the private properties located on St. Marys Road to the immediate north of the site and the sample locations along the Levange Path are shown on Figure 5. All the offsite sampling locations on Upper and Lower Shola Roads and Lake Road (to the immediate south of the Kodai Lake) are shown on Figure 6. The sediment sample and the water sample from the Kumbakarrai Falls were collected from the access point marked on Figure 4.

Mercury levels of the surface soils along the Levange Path immediately south of the boundary fence were measured to be between 0.7 and 6 mg/kg. The slightly elevated readings (6 mg/kg) at KP2 and DFNE are related to sediment discharge from the west stream and groundwater seepage. The sediments in the small depression on Levange Path receiving water from the main stream from the site had total mercury concentrations ranging between 26 and 110 mg/kg (at locations LP5 and DFE). These elevated values are within the top 10 to 20 cm of the profile. Mercury levels in the soils/sediments along Upper Shoala and Lower Shoala Roads located about 400m to 500 m north of the site were found to be less than 0.1 mg/kg. Soil samples collected from the southern periphery of the Kodai Lake, 800 m to the northeast also contained mercury levels of less than 0.1 mg/kg. The water sample from the lake contained less than 0.0003 mg/L mercury. Water and sediment samples were also collected and tested from the Kumbakarai Falls understood to be the closest location to the site accessible to humans. This water sample contained less than 0.0003 mg/L of mercury and the sediment sample contained less than 0.1 mg/kg of total mercury.

[1] Maximum Hg concentration in air 0.05 mg/m^3. Air space of mercury area 15,145 m^3. Fan operation 16 hours per day, 310 days per year for 18 years. Air turnover every 45 minutes. Total discharge 70 kg.

7.3 Mercury Distribution On Site

Four 'hotspots' with metallic mercury concentrations in soil in excess of 50 mg/kg have been located within the site. These are illustrated on Figure 5.

Hotspot A (Area A) is adjacent to the mercury distillation unit and industrial ETP immediately south of the Mercury area in the factory. The maximum mercury concentration recorded in this hotspot is 330 mg/kg (location CT1) at a depth of 10 cm, reducing to 47 mg/kg at a depth of 80 cm and 14 mg/kg on bedrock at 1.30 m.

Hotspot B (Area B) is at the old bakery where 3 and 4 glass scrap was stored and also where some glass/steel mercury containers were discarded. Maximum mercury concentration recorded here is 62 mg/kg (location P2) to a depth estimated to be about 40 cm.

Hotspot C (Area C) is located southeast of Area B. Subsequent to the initial sampling at locations FN4 and FN5, 48 additional locations have been sampled and tested. The average concentration of total mercury of these 51 samples is 28.0 mg/kg. Additional sampling is in progress.

Hotspot D (Area D) relates to elevated mercury in sediment along the stream below the distillation room and as far as the Levange Path. The maximum concentration of mercury in the sediment on site is 270 mg/kg (at location DD).

Details of these impacted areas are provided in Table 5.

Additionally an estimated 80 kg of mercury at low levels of concentration is distributed across the site with the primary source considered to be from air discharged from the mercury working areas.

7.4 Methyl Mercury Results

The available methyl mercury results are provided in Table 6. The samples being tested for methyl mercury include those with higher than average total mercury concentrations for on site samples as well as off site locations such as those from the banks of Kodai Lake, the sediments at the main stream discharge on to the Levange Path, the sediments of Kumbakarrai Falls and lichen samples from the Charlemont Property. Additional on-site lichen samples and soil, sediment, water and lichen from the area between the Levange Path and the Kumbakarai Falls have recently been collected.

All methyl mercury analyses indicate concentrations so low that they do not constitute either a health or ecological risk.

Table 2
Total Mercury Levels in Soil/Sediment/Lichen – March/April 2001

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg, (HLRC)	Hg in mg/kg, (MGT)
BE-05	Soil	5		59
BE-1	Soil	10		0.51
BE-2	Soil	10		0.13
BE-3	Soil	10	2.0	0.26
BGE-05	Soil	5		22
BGW-05	Soil	5		2.5
BN-1	Soil	10	33.3	35
BN-1-40	Soil	40	8.4	6.7
BS-1	Soil	10		0.14
BS-2	Soil	10		0.1
BS-3	Soil	10	9.9	6.2
BS-4	Soil	10		2.7
BS-5	Soil	10		0.99
BW-05	Soil	5		9.4
CC-1 (Carlton Compound)	Soil	10		1.1
CD-05	Soil	5		14
CD-50	Soil	50		71
CM-05 (Charlemont Property)	Soil	10		2.2
CM-1 (Charlemont Property)	Soil	10		1.3
CM-2 (Charlemont Property)	Soil	10		0.70
CML (Charlemont Property)	Lichen	From tree trunk		4.5
CML-2 (Charlemont Property)	Lichen	From tree trunk		4.8
CT-1	Soil	10	108.0	330
CT-1-130	Soil	130		14
CT-1-80	Soil	80	5.9	47
DD	Sediment	Surface	73.0	270
DD-40	Soil	40	9.1	25
DFE-05 (Levange Path)	Sediment	Surface		85
DFE-1 (Main Stream Outfall)	Sediment	Surface	26.0	110
DFNE-05 (Levange Path)	Sediment	Surface		6
DP-05	Soil	5		40
DP-1-10	Soil	10	18.8	36
DP-1-40	Soil	40	31.0	155
DP-2	Soil	10	5.3	5.9
DP-3	Soil	10		3.2
DP-4	Soil	10		5.9
DP-4-50	Soil	50		3.8
DP5	Soil	10		40
DP-50	Soil	50		20
DP6	Soil	10		20

Table 2 (cont'd)
Total Mercury Levels in Soil/Sediment/Lichen – March/April 2001

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg, (HLRC)	Hg in mg/kg, (MGT)
FC-1	Soil	10		1.7
FC-2	Soil	10		1.3
FC-3	Soil	10		1.7
FC-4	Soil	10	8.9	16
FC-5	Soil	10		3.2
FN-1	Soil	10		2.5
FN-2	Soil	10		1.0
FN-3	Soil	10		0.75
FN-4	Soil	10	62.8	60
FN-4-80	Soil	80		10
FN-5	Soil	10	171.6	240
HL-1	Soil	10	8.3	7.3
HL-1-80	Soil	80		2.9
LK1 (Kodai Lake Bank)	Soil	10		<0.1
LK2 (Kodai Lake Bank)	Soil	10		<0.1
LK3 (Kodai Lake Bank)	Soil	10		<0.1
LP-2 (Levange Path)	Soil	10		6.0
LP-3 (Levange Path)	Soil	10		2.4
LP-4 (Levange Path)	Soil	10		1.4
LP-5 (Levange Path)	Sediment	Surface	12.6	55
LP-6 (Levange Path)	Soil	10		1.1
LP-7 (Levange Path)	Soil	10		0.63
MD-05	Soil	5		20
MD-50	Soil	10		11
NS-05	Soil	5		4.5
P1-05	Soil	5		20
P1S-10	Soil	10		1.9
P1S-40	Soil	40		0.59
P2-05	Soil	5		62
P2S-10	Soil	10		4.1
P2S-40	Soil	40	17.1	5.3
P3-05	Soil	10		25
P3S-10	Soil	10		4.7
P3S-30	Soil	30		5.7
P4-05	Soil	5		9.4
P4E-10	Soil	10	11.9	20
P4E-80	Soil	80		5.0
P4S	Soil	10	22.9	31
P4SE	Soil	10	6.2	10
PPE-05	Soil	5		4.6

Table 2 (cont'd)
Total Mercury Levels in Soil/Sediment/Lichen – March/April 2001

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg, (HLRC)	Hg in mg/kg, (MGT)
PPS	Soil	10		32
PPS-1	Soil	10		6.7
PPS-2	Soil	10		0.35
PPS-3	Soil	10		3.0
PPW-05	Soil	5		13
SR (Kumbakarai Falls)	Sediment	Surface		<0.1
SS-05	Soil	10		6.6
SS-1	Soil	10		3.5
SS-2	Soil	10		2.6
TB-05	Soil	5		31
TBD	Sediment	Surface	41.9	110
US-1 (Upper Shola Road)	Sediment	Surface		<0.1
US-2 (Upper Shola Road)	Sediment	Surface		<0.1
US-3 (Upper Shola Road)	Sediment	Surface		<0.1
US4 (Upper Shola Road)	Soil	10		<0.1
US5 (Upper Shola Road)	Soil	10		<0.1
US6 (Upper Shola Road)	Soil	10		<0.1
VE-1	Soil	10		1.1

Note: All sample locations are from within the HLL site unless otherwise noted in parenthesis.

Table 3
Total Mercury Levels in Water – March/April 2001

Sample Location	Hg (mg/L)
BRW	0.085
DFE (Main Stream Outfall)	<0.0003
DFE-W1 (Main Stream Outfall)	<0.0003
DFNE (Levange Path)	<0.0003
DW-1 (Main Stream Outfall)	<0.0003
ES	<0.0003
LKW (Kodai Lake)	<0.0003
MDRW	0.31
MSYW (Scrap Yard)	<0.0003
PM (Pambar River)	<0.0003
SRW (Kumbakarrai Falls)	<0.0003
SW	<0.0003
SY (Kodaikanal Scrap Yard)	<0.0003
USW (Upper Shola Road)	<0.0003
WS	<0.0003

Notes: All sample locations are from within the HLL site unless otherwise noted in parenthesis.

Samples BRW and MDRW were slightly silty.

Table 4
Methyl Mercury Levels in Soil/Sediment/Lichen Samples

Sample Location	Sample Depth (cm)	Methyl Mercury (mg/kg)	Total Hg
CM-05 (Charlemont Property)	5	0.0011	2.2
CML (Charlemont Property)	Lichen from tree trunk	0.0019	4.5
CML-2 (Charlemont Property)	Lichen from tree trunk	0.0019	4.8
CT1	10	0.0029	330
CT1-130	130	0.0001	14
CT1-80	80	<0.0001	47
DD	Surface Sediments	0.0026	240
DFE-05 (Levange Path)	5	0.126	85
DFE1(Levange path)	Surface Sediments	0.060	110
DFNE-05 (Levange Path)	5	0.0008	6
DP1-10	10	0.0002	36
DP1-40	40	<0.00005	155
DP5	10	0.0094	40
FN4	10	0.0049	60
FN5	10	0.0026	240
LK1 (Kodai Lake)	10	0.0008	<0.1
LK3 (Kodai Lake)	10	0.0002	<0.1
LP5	Surface Sediments	0.0062	55
MD-05	5	0.0014	20
MD-50	50	0.0005	11
SRA (Kumbakarrai falls)	Surface Sediments	0.0001	<0.1
TBD	Surface Sediments	0.003	110

Table 5
Details of Areas Requiring Remediation

Location	Approx. Area (m^2)	Average Depth (cm)	Volume (m^3)	Approx. Weight (tonnes)	Average Concen-tration (mg/kg)	Approx. Weight of Mercury (kg)
Area A	1200	500	600	1200	45	55
Area B	2400	400	950	1900	27	50
Area C	1600	400	640	1280	28	36
Area D	160	300	50	100	45	5
TOTALS			2240	4480	-	146

A mercury balance has been prepared in order to estimate the total unacounted losses of mercury over the 18 years life of the operation. These unaccounted losses comprise dispersion of airborne mercury to soil and lichen, both onsite and offsite, mercury retained in sludge from the industrial effluent treatment plant, mercury in soil and sediment hotspots derived from accidental spillages, and mercury in suspended sediment discharging offsite southwards to Pambar Shola.

The elements of the mercury balance are:

MI: Mercury imported to site in containers from the USA and Spain. The customs bond register records a total of 125,676 kg and the supplier has a tolerance of +/- 0.0625%.

TE: Mercury exported from site in thermometers. The weight of mercury in each thermometer is dependent on type of thermometer and grading. HLL has made an exhaustive review and collation of the recorded numbers and types of thermometers dispatched from site. The total number of thermometers is 165,078,561 and average mercury content ranges between 0.66819 gm and 0.66666 gm per thermometer, a range of +/- 0.0012%.

GSS and GSO: This represents glass scrap stored onsite (GSS) and glass scrap disposed offsite (GSO). This has been calculated from tabulated records of unrecovered 3 and 4 glass (6% residual mercury), 3 and 4 partially recovered (1% mercury), and 3 and 4 enhanced recovery (0.15% mercury). The figures have been further supported by sampling each batch of unrecovered glass scrap in GSS and measuring mercury recovery. The accuracy of the GSS figure is assumed to be +/- 3% (any larger percentage could result in a potential net gain in the mercury balance, which is clearly not the case). GSO is assumed accurate to +/- 5%.

ST and WIP: Mercury in stock (ST) correct to +/- 0.0625% and work in progress (WIP) correct to 0.0012%.

Therefore the mean figures, in kg of mercury, are as follows:

MI		TE		GSS		GSO		ST		WIP		
125,676	=	110,178	+	9,741	+	284	+	2,983	+	1,931	+	ΔU

Unaccounted losses, ΔU, therefore total 559 kg.

Statistical analysis using two standard deviations gives a range of probability for ΔU of between 43 kg minimum and 1,075 kg maximum.

The unaccounted losses can also be expressed as the following equation:

$$\Delta U = A + SS + ETP + PS$$

where:

A	=	airborne emission of mercury vapour, estimated to be 70 kg.
SS	=	mercury contained in soil and sediment, namely hotspots A, B, C, and D (150 kg) plus widespread low level dispersion (90 kg, of which 70 kg is derived from A). Total SS unrelated to air dispersion is therefore 170 kg.
ETP	=	mercury in stored sludge from the industrial ETP, estimated to be 20 kg.

and

PS	=	discharge offsite to the south to the Pamber Shola.

PS	=	**ΔU**	-	**A**	-	**SS**	-	**ETP**
		559		70		170		20

Therefore estimated offsite discharge to the Pambar Shola is approximately 300 kg.

This figure is considered to be of the correct order of magnitude based on the grassed nature of the site, limited evidence of soil erosion and comparison to the current level of mercury recognised onsite (i.e. 260 kg).

9.1 Potential Exposure Pathways – Human Health

Human exposure to mercury in the environment external to the mercury working areas in the factory may occur via the following mechanisms or pathways:

- Incidental ingestion of soil through hand to mouth contact; ?
- Inhalation of dusts;
- Inhalation of vapours;
- Ingestion of water; and
- Consumption of food grown in contaminated soil, or exposed to mercury vapours, or fish from methyl mercury contaminated waterbodies.

In relation to the site, the following issues are relevant to the assessment of exposure pathways.

- The area, including the site, is heavily vegetated and therefore there exists limited opportunity for the generation of dust through wind erosion.
- The prime source of mercury vapours is via emissions from the factory extractor fans. When in operation, the site workers would represent the population most at risk from inhalation of vapours due to their proximity to the source. The mercury intake of workers has been assessed through a medical monitoring program.
- The potential for exposure to mercury via food consumption is likely to be low for the following reasons:
  - air dispersion from the site is limited due to the location of the extractor fan outlets (ground level) and the occurrence of dense vegetation including moderately sized trees;
  - the surrounding area is not used extensively for food production or fisheries; and
  - metallic mercury, as opposed to methyl mercury, does not bioaccumulate.
- As surface water run off occurs predominantly to the south of the site into the forest, there is limited potential for ingestion of surface water that may be affected by mercury attached to suspended sediment.

On the basis of the above, there are no pathways for human exposure to mercury which are of concern and this is applicable to both on site workers and the off site population.

Consideration of potential exposure to mercury vapours for site workers remains an occupational health safety issue relevant to the management of the site.

9.2 Potential Exposure Pathways - Environment

The available data confirm that elevated concentrations of total mercury relative to expected background concentrations in soil are present within the site boundaries. Slightly elevated mercury concentrations also extend a short distance to the north and south of the site. The available data suggest a background concentration of less than 0.1 mg/kg of total mercury. Whilst there are offsite concentrations greater than the background, the values are generally low and only marginally above apparent background. The mechanisms by which mercury may have migrated beyond the site boundaries are:

- Via sediment in surface water run off principally to the south of the site; and
- Via dispersion in air from the factory extractor fans.

The prime form of mercury released to air from the factory extractor fans was elemental mercury vapour. Mercury vapour may be absorbed by vegetation or disperse into the atmosphere. Given the low water solubility of elemental mercury, there exists limited potential for deposition in rainfall. The apparently elevated concentrations of mercury in the lichen samples near to the site reflect absorption of mercury vapour from the air.

The prime direction for surface water run off is to the south into the Pambar Shola. This area is precipitous and heavily forested and not frequented by humans until a substantial distance downstream.

The mercury balance which has been derived in order to assess the amount of mercury discharged to the Pambar Shola indicates a total of 300 kg, equivalent to about 17 kg/year over the 18 years of factory operation.

Additional soil, sediment, water and lichen samples have been collected below the Levange Path and from the Pambar River upstream of Kumbakarrai Falls. It is considered extremely unlikely, pending receipt of these analyses that the flora and fauna of the Pambar Shola and Pambar River are at risk from the calculated mercury discharges.

Kodai Lake is on a separate drainage catchment to the Factory and receives only infinitesimal mercury input from sediment on the northern margin of St Mary's Road. All soil, sediment and water samples at the Lake return total mercury concentrations below detection level.

10.1 Conclusions

Mercury impacted soil has been identified on the Kodaikanal site. The total estimated volume of impacted soil requiring remediation is 2,240 m^3 equivalent to 4,480 tonnes of soil containing approximately 150 kg of mercury. An estimated 80 kg of mercury has also been deposited across the site to shallow depth, primarily from airborne mercury. There has also been offsite transfer of mercury in air to the north and south, totalling approximately 10 kg and by runoff to the south via the stream which traverses the site, crosses the Levange Path and falls 1,300 m down to the Pambar River. Based on mercury balance calculations and site disposition ie limited evidence of soil erosion on site, the maximum discharge to the Pambar River catchment may be of the order of 300 kg of mercury over a period of 18 years.

The available soil and water data suggests that risk to human health is negligible. The available data and the mechanisms by which mercury is believed to have migrated beyond the site, also suggest a low potential for adverse effects on the environment.

10.2 Recommendations

10.2.1 Priority Actions

The highest priority is to recover the 3 and 4 glass scrap from the dealer's scrapyard in Kodaikanal. This is an exercise that will only occupy two days or so, and should be undertaken as soon as approval is given by the TNPCB. Any delays could result in offsite discharge of mercury to adjacent residential areas during periods of high rainfall. Appropriate occupational health and safety protocols have been detailed.

The second priority action is to prevent discharge of sediment south from the site before the advent of the southwest monsoon. This can be accomplished by installing silt traps and sediment settling ponds along the stream (Area D) which receives stormwater runoff from the three hotspots (Areas A to C) identified on site. A preliminary engineering design has been prepared maximising the use of existing facilities, and also requires the approval of the TNPCB.

Following the installation of silt traps, soil should be excavated from the hotspots (Areas A, B, C and D in Figure 3) and temporarily stored on site in steel drums. Manual excavation is recommended in order to minimise the volume of soil to be excavated and suitable protocols will be developed to ensure full protection of workers. Mercury levels in urine and blood will be tested before and after excavation is completed, PPE will be nominated and monitoring of mercury vapour levels will be undertaken throughout the duration of the works.

In the longer term the soil, together with stored ETP sludge and treated 3 and 4 glass scrap should be transferred to an approved landfill site. Although an approved landfill site does apparently exist in Tamil Nadu it is recommended that HLL either purchase or use an existing HLL industrial site in the lowlands and obtain approval from the TNPCB via the environmental impact process for construction of such a landfill. Allowing for over excavation and some bulking, the area required for landfill is provisionally estimated to be 40 m by 40 m by 3 m deep allowing for 1.5m of clean soil cover.

10.2.2 Clean Up Criteria

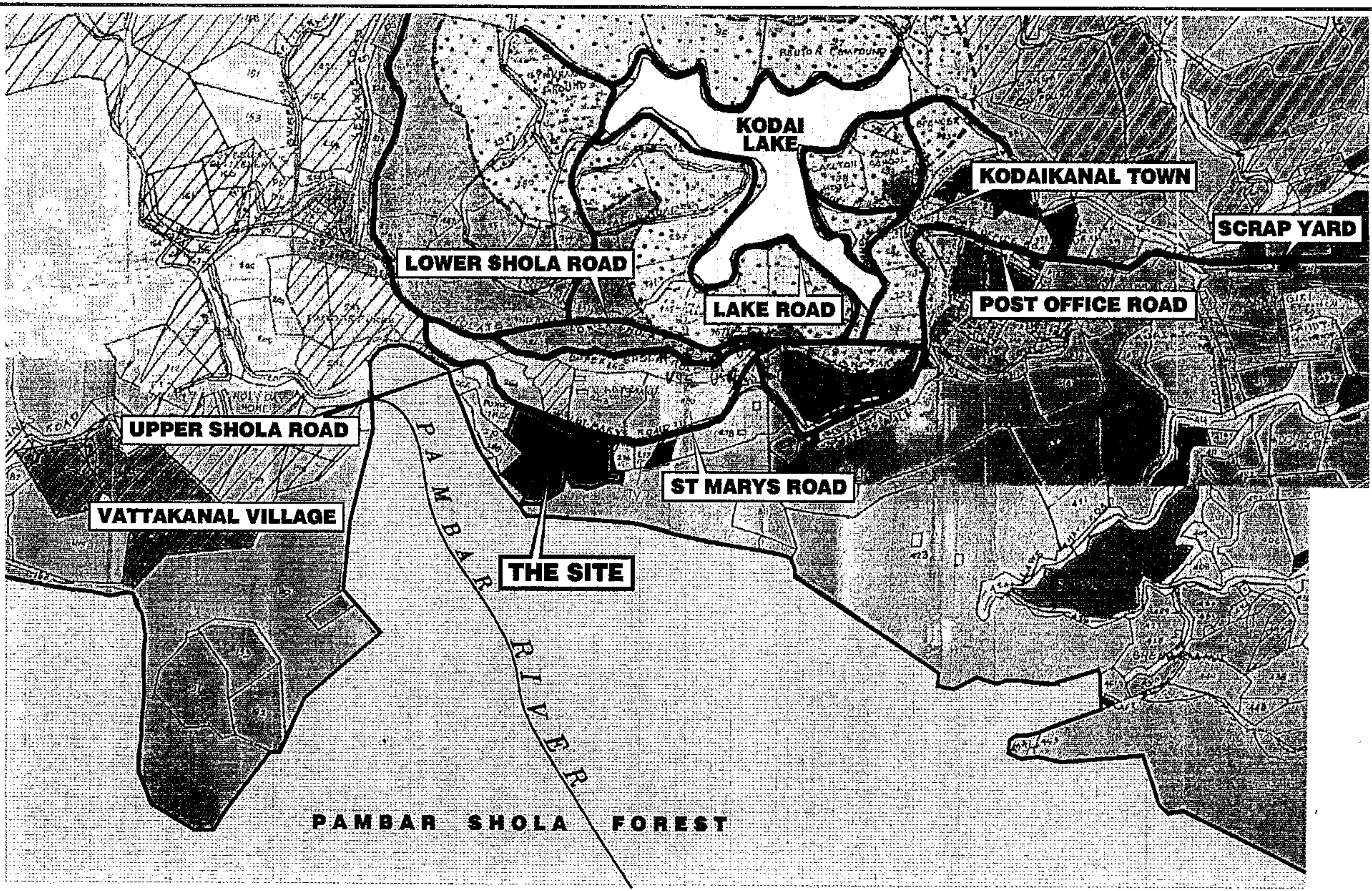
Risk Based Corrective Action (RBCA) is a USEPA accepted system for determining appropriate clean-up levels in soil based on assessment of sources, pathways, receptors and evaluation of health and ecological risk. The Tier 1 RBCA uses Risk Based Screening Levels (RBSLs) derived from published data. Should observed values be elevated above Tier 1, then further analysis can be undertaken using exposure data, human body weight, published toxicological data etc to derive site specific Tier 2 and Tier 3 clean-up criteria. Clean-up criteria are progressively relaxed from Tier 1 through to Tier 3.

The Dutch Intervention value of 10 mg/kg is based on multi-functional use of land over a shallow drinking water aquifer and is therefore very conservative for most sites. It is accepted that if the Intervention Value is exceeded a risk assessment should be undertaken to calculate a site specific value, and at the Kodaikanal Site this would be significantly higher than 10 mg/kg.

However, because of the publicity surrounding this site it is highly recommended by URS Dames & Moore that risk assessment should not be undertaken on this occasion. Rather it is proposed that the conservative Dutch Intervention Value of 10 mg/kg total mercury should be used as the remediation criteria for the Kodaikanal site, on the basis of future residential use.

PAUL WHINCUP
Senior Vice President, Asia
URS Dames & Moore

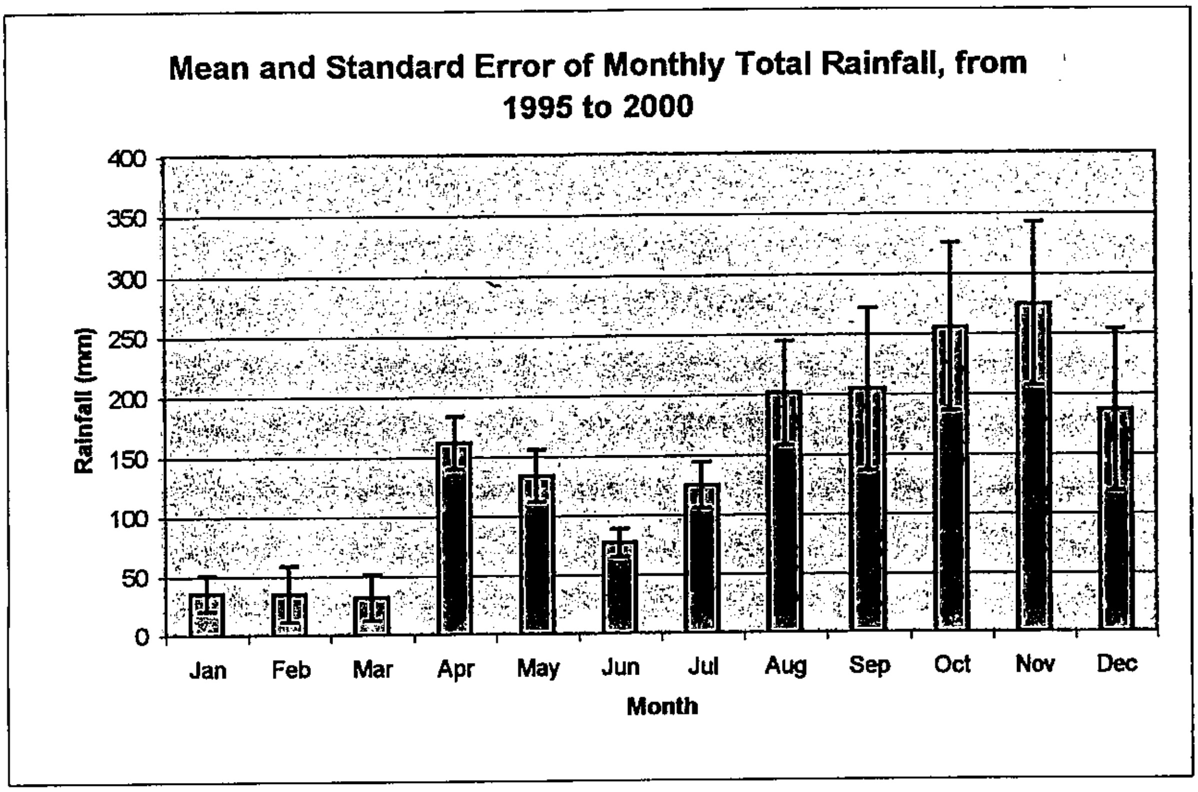
25 May 2001

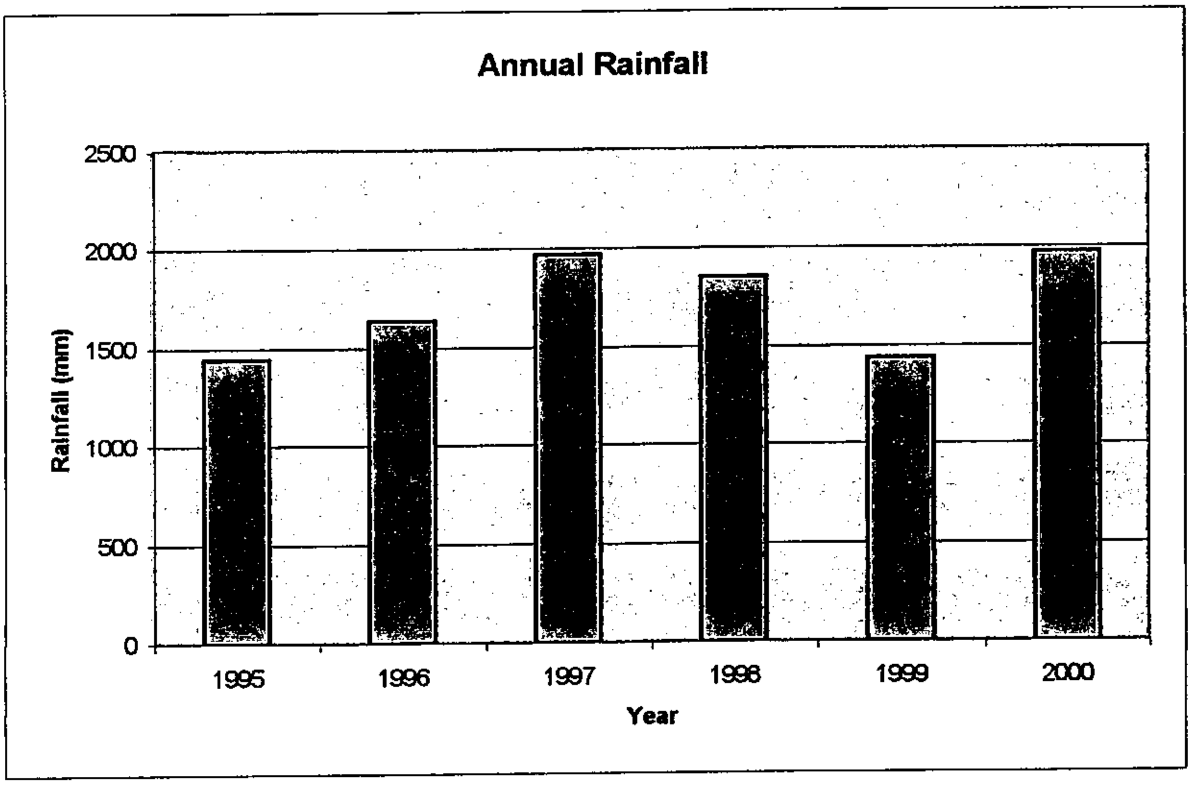


LEGEND

—— ROADS

CLIENT **HINDUSTAN LEVER KODAIKANAL THERMOMETER FACTORY, TAMIL NADU, INDIA** PROJECT **ENVIRONMENTAL SITE AND RISK ASSESSMENT FOR MERCURY**		TITLE **SITE LOCATION MAP**
0 100 200 300 400 500 metres (approx)	DESIGNED: **DSW** APPROVED: DRAWN: **HC** DATE: CHECKED: STATUS: **FINAL**	PROJECT: **49032_002_353** CAD FILE: **49032_002_002** REVISION: **A** A4 — URS — FIGURE **1**





Job No.	49032-002-353		Hindustan Lever Kodaikanal Thermometer Factory, Tamil Nadu, India ENVIRONMENTAL SITE AND RISK ASSESSMENT FOR MERCURY **RAINFALL RECORDED AT KODAIKANAL WEATHER STATION**	**Figure 2**
Prep. By	PW	22 May 01		URS
Chk'd By				
Office	Perth, Western Australia Phone: +61 8 9221 1630			

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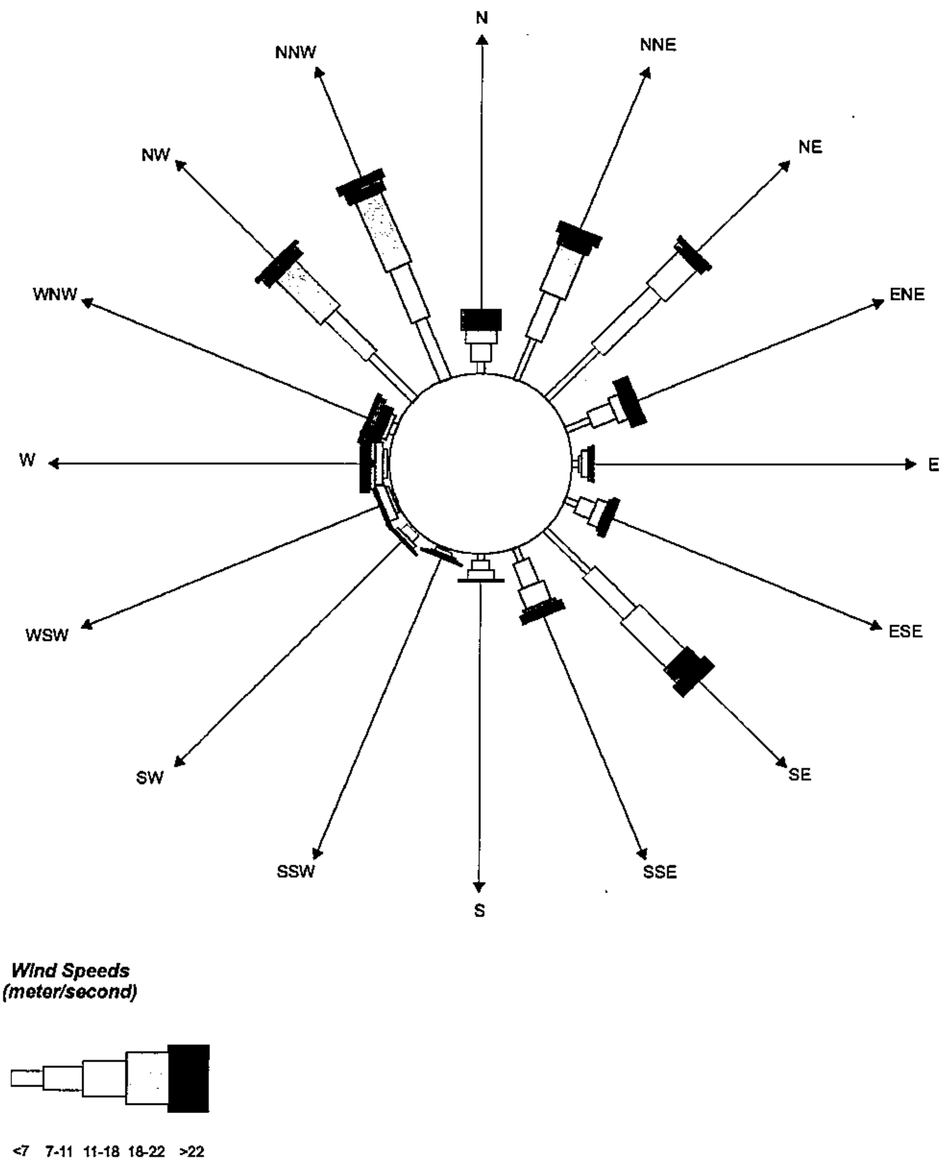
WIND ROSE for 1995 - 2000



Note : The middle circle shows calm wind, is not in the right scale

Job No.	49032-002-353		Hindustan Lever Kodaikanal Thermometer Factory, Tamil Nadu, India ENVIRONMENTAL SITE AND RISK ASSESSMENT FOR MERCURY	Figure 3
Prep. By	PW	22 May 01		
Chk'd By			**WIND DIRECTIONS AND SPEED RECORDED AT KODAIKANAL WEATHER STATION**	**URS**
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Plate 1: Kodaikanal Scrapyard : Measuring mercury concentrations in air at stockpile of 3 & 4 glass scrap. Note granite bedrock near rear

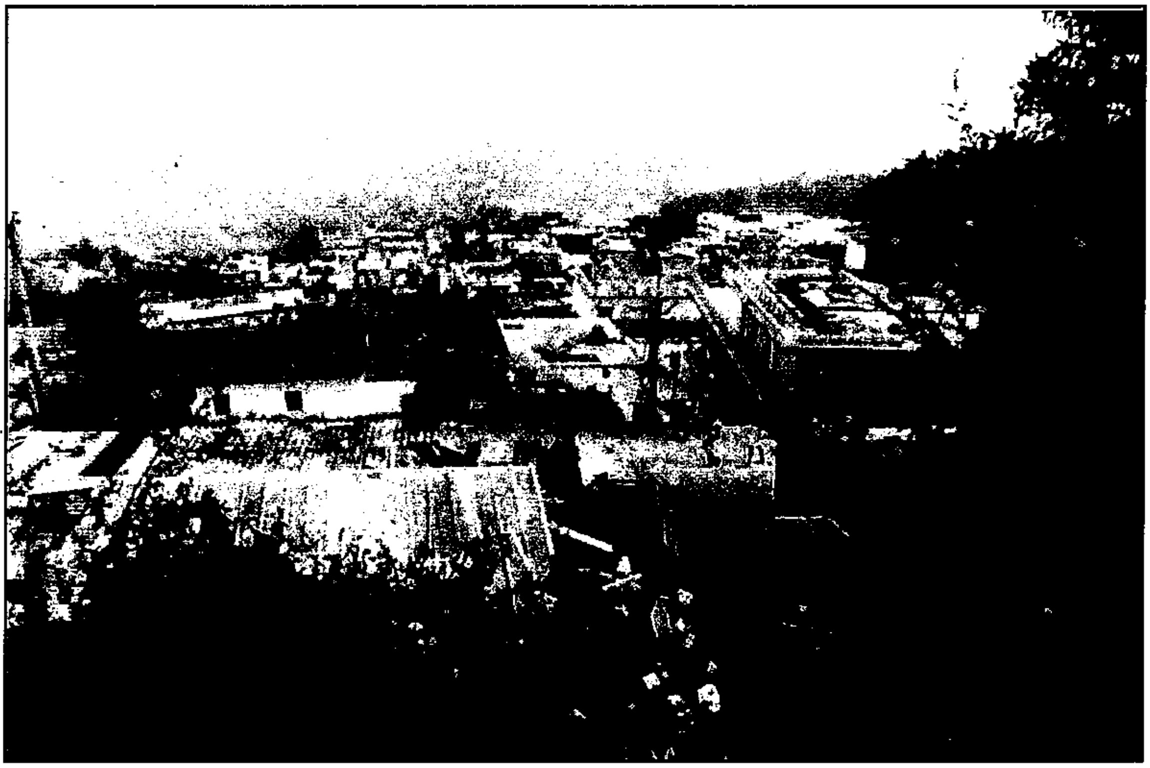

Plate 2: Kodaikanal Scrapyard : View looking down over scrapyard. Truck is parked at second stockpile of 3 & 4 glass scrap

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Thu 24 May 01

Plate 3: Soil erosion in stream adjacent to mercury distillation room Hotspot A

Plate 4: Stream Draining across site. Only limited soil erosion

Plate 5: Grassed area, typical of upper part of site. No evidence of soil erosion

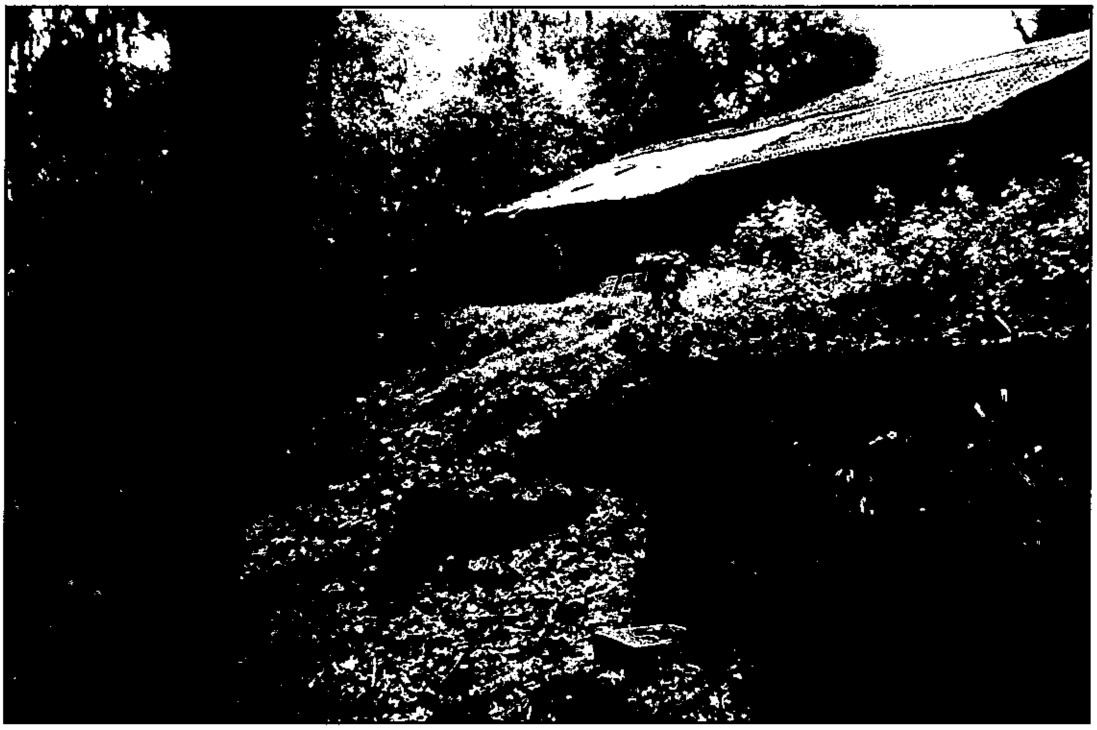

Plate 6: Hotspot B below former glass scrap storage area

Plate 7: Stream draining off site across Levange Path
and to Pambar Shola. Elevated mercury concentrations in pool sediment (DFE)

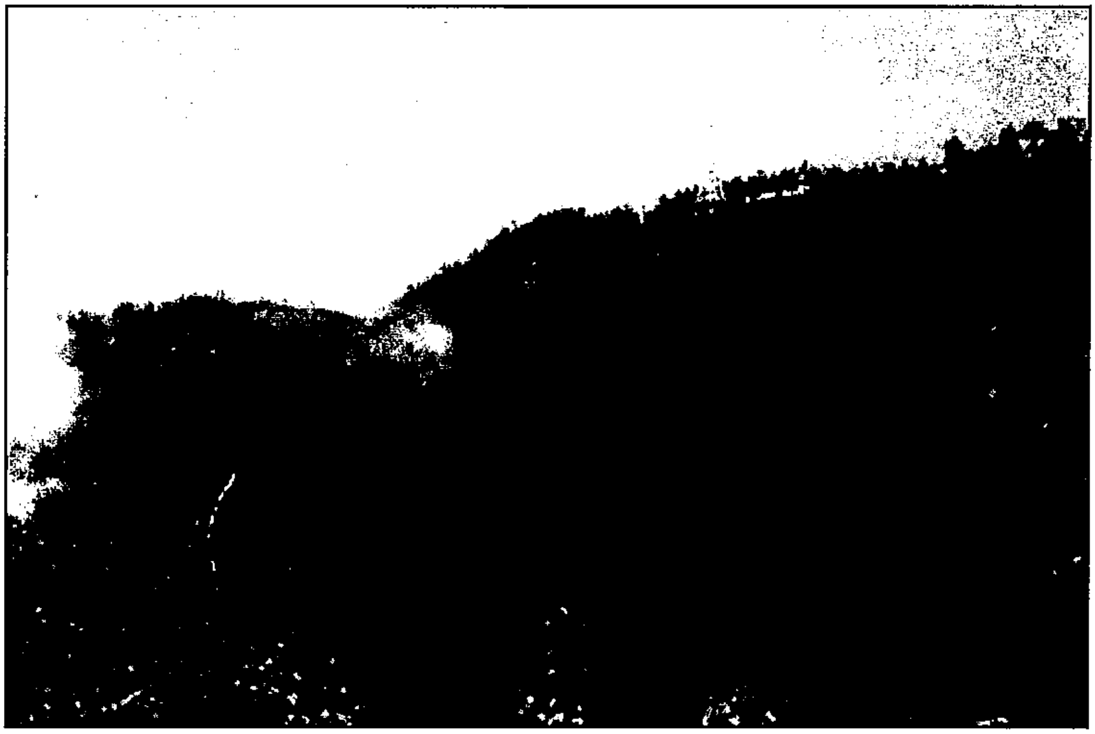

Plate 8: Site perspective headwater of Pambar River (west stream) to west of site

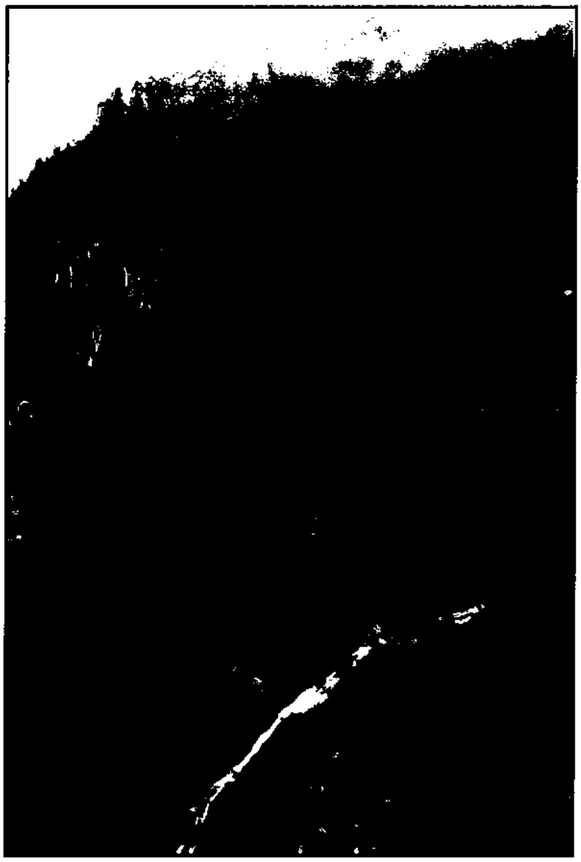

Plate 9: Precipice below Levange path. Waterfall (east stream) above Pambar River, east of site

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Plate 10: Precipice below Levange Path. Note TV aerial directly east of site

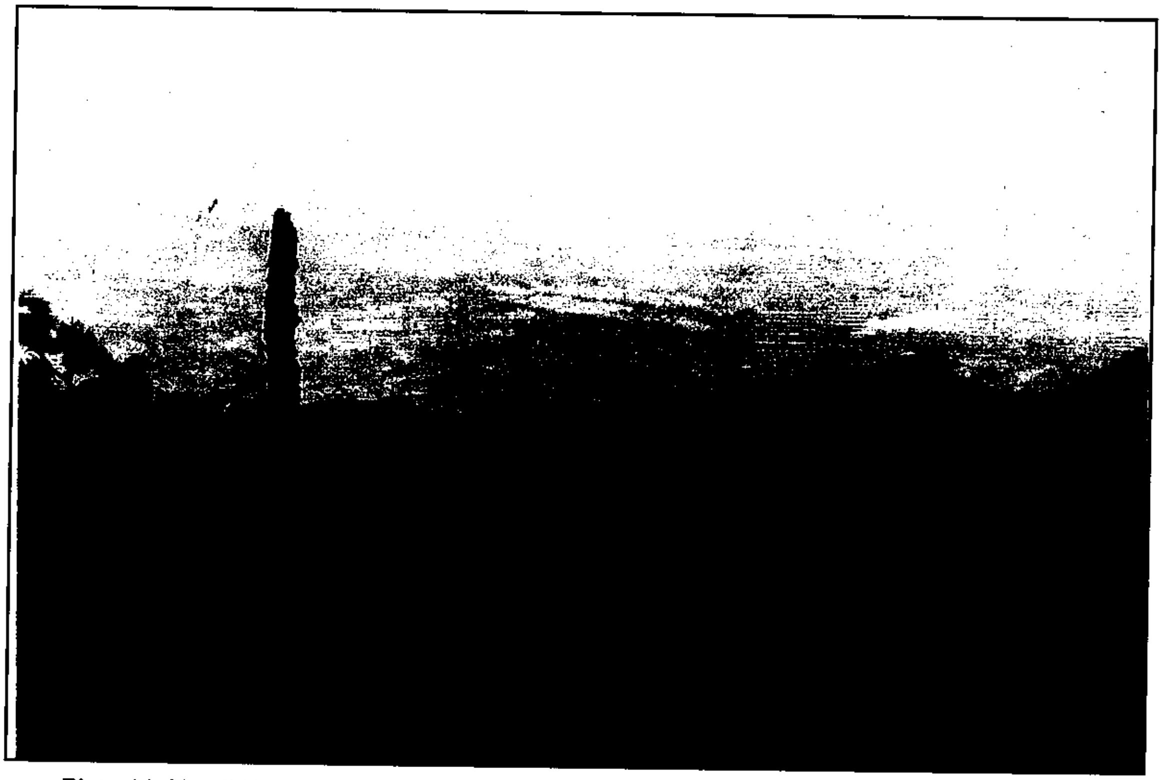

Plate 11: Tamil Nadu Plains below Pambar Shola, approximately 1400m lower elevation

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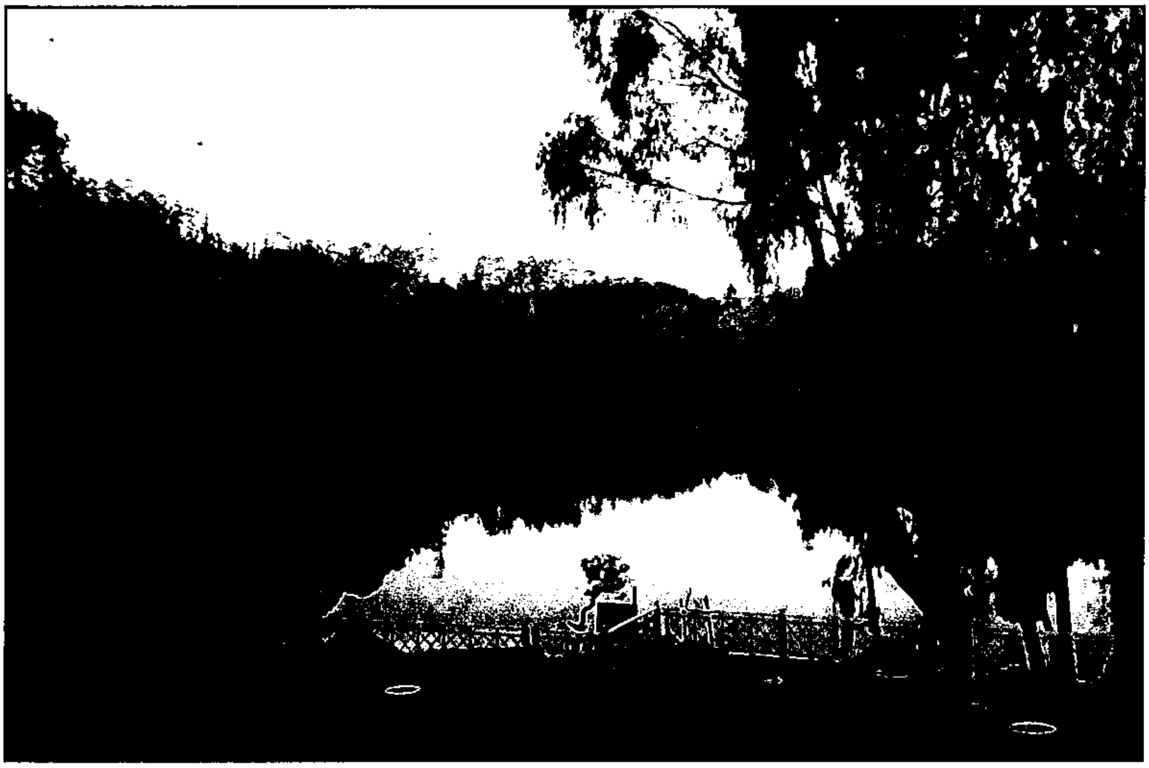

Plate 12: Kodai Lake from Carlton Hotel

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