தமிழ்நாடு

TAMILNADU POLLUTION CONTROL BOARD

From
The Chairman,
Tamil Nadu Pollution Control Board,
76, Mount Salai, Guindy,
Chennai – 600 032.

To
Thiru. Navroz Mody,
Greenpeace. +91 4542 40286
C/o. 92, 3rd Cross,
Thiruvalluvar Nagar,
Besant Nagar, Chennai – 90

Letter. No. T14/TNPCB/F.36448/27568/2015-2, Dated: 18.08.2015

Sir,

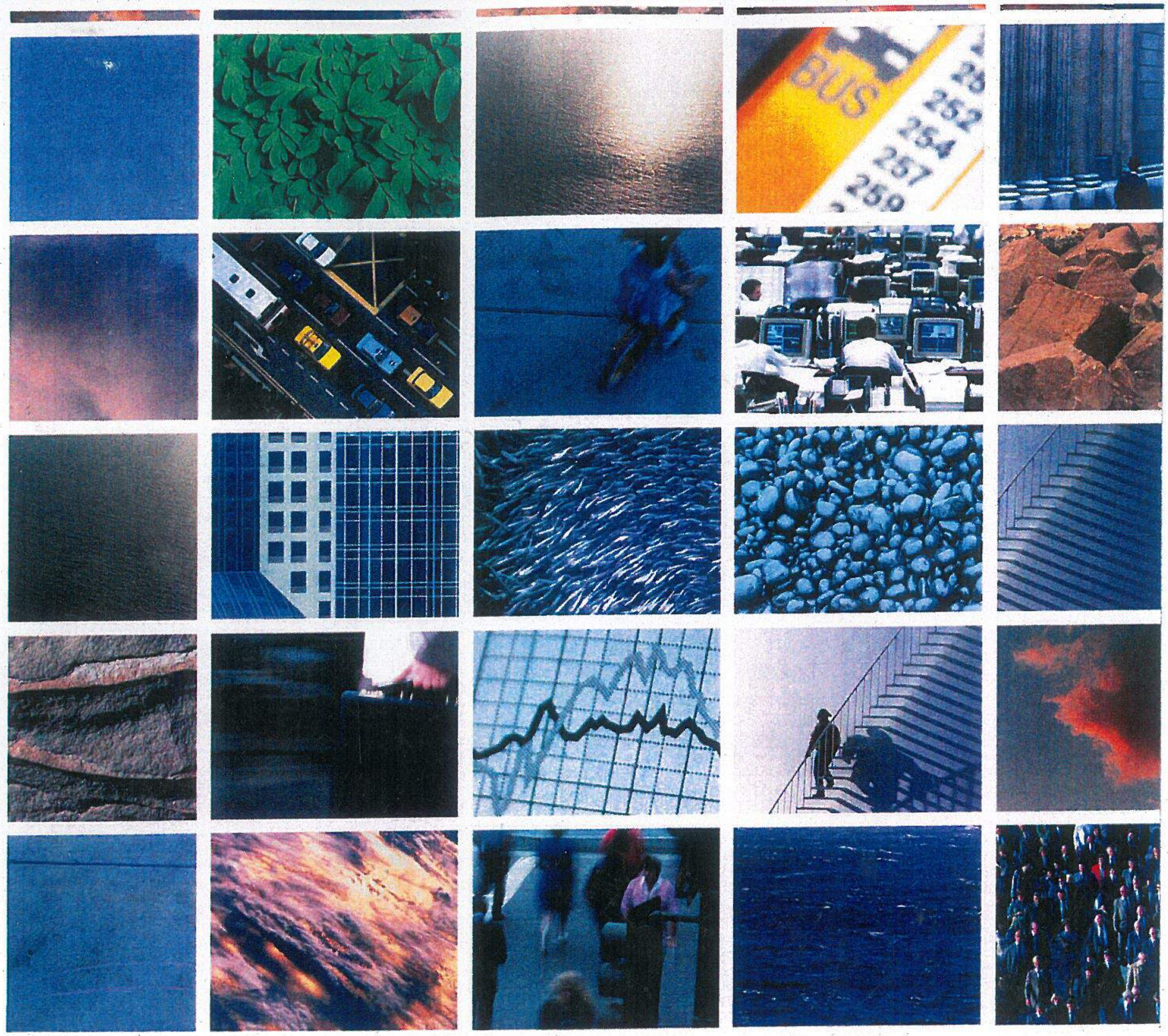
Sub: TNPC Board – HWWM – M/s. Hindustan Unilever Ltd., Kodaikanal – Soil Remediation – Meeting on 28.8.2015, 3.00 PM at TNPCB, Chennai – Intimation – Reg.

Ref:
1. TNPCB E.mail sent to SEC members on 14.7.2015 by communicating the report of 'Community Environmental Monitoring ', June 2015.
2. Detailed Project Report (Final) for Soil Remediation at Kodaikanal HUL (copy enclosed).

A copy of Detailed Project Report for Soil Remediation at Kodaikanal HUL Factory furnished by M/s. Hindustan Unilever Limited is enclosed herewith. It is proposed to have meeting with the Members of Scientific Expert Committee, Local Area Committee and Central Pollution Control Board on the subject matter. The meeting is convened on **28.8.2015, 3.00 PM** in the Conference Hall of TNPCB, Chennai-32. You are requested to make it convenient to attend the meeting.

Encl: A copy of DPR.

18/8/15
For Chairman



Soil Remediation at Kodaikanal HUL Factory site, with offsite disposal of treated soils to Authorised TSDF.

Hindustan Unilever Limited

Detailed Project Report (Final).

Prepared under collaboration and supervision of NEERI.

August 2015

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CONTENTS

1 EXECUTIVE SUMMARY

This project report presents the details on the proposed remediation activities at the former Hindustan Unilever Limited Thermometer factory, located in Kodaikanal, Tamil Nadu. The Detailed Project Report (DPR) is subsequent to the earlier DPR dated May 2008, and incorporates the soil washing/ vacuum retorting treatment followed by offsite disposal to an authorised Treatment, Storage & Disposal Facility (TSDF).

To aid in the development of the remedial action plan, pilot scale studies on soil washing and vacuum retorting of mercury impacted soils were carried out at the site during the month of August, 2007. Results from the pilot scale studies are used to develop the equipment design and manufacture.

This report incorporates the following information to the report, for which additional onsite investigations and assessment have been undertaken at the site:

- Final on-site mercury contamination delineation maps based on the latest detailed investigation undertaken;
- Assessment of alternative options for containment of treated soils in line with TNPCB/ Scientific Expert Committee's recommendation to furnish a proposal for containment of treated soil in a confined/ secured land fill area either onsite or offsite. The secure landfill will be designed as per CPCB guidelines and applicable Hazardous Waste Rules (Please refer to Minutes of Meeting of the Scientific Expert Committee (SEC) on the remediation of mercury contaminated soil at M/s. Hindustan Unilever Limited (HUL), Kodikanal held on 28th May 2015 at TNPCB, Chennai-32).

Soil at some areas of the factory site was previously contaminated with elemental mercury, and a remediation action plan has been proposed that will include excavation of impacted soils, followed by soil washing and vacuum retorting of the impacted soil fractions. The remediation criteria set up by the Tamil Nadu Pollution Control Board on the recommendation of the Scientific Experts Committee constituted by the Supreme Court Monitoring Committee is 20 mg/kg of mercury in soil. It is estimated that approximately 5,200 to 6,900 MT of soil will be remediated. This is only an estimate based on the data that is currently available, and may vary when the actual remedial activities are undertaken.

The report is based on the studies carried out by National Environmental Engineering Research Institute (NEERI), Environmental Resources Management and previous studies carried out at the site.
It also incorporates a

- detailed Health & Safety plan,
- emergency response plan

- preparatory activities that will be carried out at the site prior to and during actual remediation activities.

The soil excavation of impacted areas shall be conducted in phases and excavated soil will be washed and screened in order to concentrate the elemental mercury into the fines fraction. Washed soil retorted fines fractions that meet the soil remediation criteria will be transported and disposed at an authorised Treatment, Storage & Disposal Facility located at Virudhnagar District in Tamil Nadu located approximately 150 km from Kodaikanal. Fresh virgin/ uncontaminated soil (from either outside or within the site) will be used for filling the excavated areas. These soils will be validated to ensure that they are unimpacted.

Once all the impacted areas have been excavated, treated, validated, and filled with virgin/ uncontaminated soils on site, an in depth site validation procedure shall be undertaken before site closure. Post soil remediation monitoring, restoration of backfilled areas, and prevention of erosion will be important phases that will be undertaken at the site.

It is expected that after the remediation process is completed and validated, the site would be safe.

Environmental Resources Management (ERM) was commissioned by Hindustan Unilever Limited (HUL) to prepare a Detailed Project Report (DPR) addressing remediation plans for mercury contaminated soils and buildings at the former Mercury Thermometer Factory situated in Kodaikanal, Tamil Nadu, India. This document describes the Remedial Action Plans that will be used during the full scale remediation phase. The DPR follows *"Protocol for Remediation of Mercury contaminated site at HLL Thermometer Factory, Kodaikanal (February 2007)"*, developed by National Environmental Engineering Research Institute (NEERI), Nagpur and accepted by the Scientific Expert Committee, constituted by the Supreme Court Monitoring Committee (SCMC) and approved by the Tamil Nadu Pollution Control Board (TNPCB). The DPR which has been prepared in collaboration and under the supervision of NEERI, presents the technical details of the proposed remediation activities at the Mercury thermometer factory site of HUL.

The project site of HUL occupies an area of approximately 87,250 square meters. The site is bounded on the North by St. Mary's Road. The southern boundary of the site slopes steeply into a protected nature sanctuary of the Tamil Nadu Government, the Pambar Shola Forest.

ERM understands that URS Dames & Moore (URS) had conducted a detailed soil investigation at the site and identified areas of the site to be remediated. For further details of the findings and recommendations of the study please refer to the report *"Environmental Site Assessment and Risk Assessment for Mercury, Kodaikanal Thermometer Factory, Tamil Nadu, India, (May, 2002)"*.

ERM also understands that the former Kodaikanal Thermometer Factory has areas within the factory boundary where soil has elevated levels of mercury. There is an established need for remediation of contaminated soils to facilitate redevelopment of the site in a way that represents minimal risk to public health or the environment. Off site mercury distribution is insignificant as verified by a series of sampling rounds where soil, water and sediment were analyzed, with the exception of soil & sediment samples located immediately south of the factory, formed due to the outfall of the main stream from the site.

ERM had previously conducted a study titled *"Total Mercury content in sediment, surface water and fish samples drawn from HLL in area surrounding Kodaikanal (June 2005)"*. In September 2006, ERM also conducted a quantitative risk assessment to derive risk based Site Specific Target Levels (SSTL's) to guide remediation of mercury impacted soil at the site. The SSTL's were generated based on the future use of the site. The quantitative risk assessment has resulted in a SSTL of 25 mg/kg total mercury, which is considered to be a health protective remedial criterion for residential development of the site.

NEERI prepared a detailed document *"Protocol for Remediation of Mercury contaminated site at HLL Thermometer Factory, Kodaikanal (February 2007)"*. The protocol was developed by NEERI based on the SSTL derived by NEERI/ ERM and the laboratory and pilot scale studies on selected technologies for soil remediation. The protocol delineated the approach, methodology and technical aspects to be considered during remediation of mercury contaminated areas at the site. The protocol recommended soil washing followed by retorting for treating the contaminated soils. The treated soils that met the remediation criteria of 20 mg/kg, would then be backfilled within the excavated areas. The protocol was submitted by NEERI in February 2007 to TNPCB. The Protocol was reviewed by the Scientific Experts Committee constituted by the SCMC.

Based on the recommendations of the Scientific Experts Committee constituted by the Supreme Court Monitoring Committee, the Tamil Nadu Pollution Control Board (TNPCB) set a remediation criterion of 20 mg/kg for the site with a 95% confidence level to be implemented with none of the treated soils to exceed 25 mg/kg.

The proposed technology for remediation of the impacted and excavated soils consists of soil washing to selectively concentrate elemental mercury into the fines fraction, followed by vacuum retorting of the fines. All concentrations that are mentioned in this report are in units of mg/kg mercury.

The Detailed Project report (May 2008) was presented to the TNPCB incorporating all recommendations and amendments from TNPCB and SEC, and the same was accepted.

Following the approval from TNPCB in May 2009, HUL initiated the start of pre-remedial activities at the Kodaikanal site. During this period the following activities were undertaken at the site:

- Fabrication of the soil washing/ vacuum retort remediation systems/ waste water treatment plant, air handling/ treatment plant, onsite mercury analytical laboratory, site upgradation, detailed onsite mercury contamination delineation.
- Erection of all the above remediation equipment on site along with a High Voltage Electrical system upgrade/ installation.

In 2010, in response to TNPCB directions, HUL further undertook the following studies at the site:

- Validation of the site specific Risk Assessment/ Remediation criteria by an external third party, which was undertaken by IIT, Delhi.
- Study and recommendations on Soil Conservation measures to be undertaken at the site during remediation, which was undertaken by

Central Soil Water Conservation Research and Training Institute: Research Centre (CSWCRTI RC) Udhagamandalam;

- Study and recommendation on Plant protection measures to be undertaken at the site during and post remediation, which was undertaken by National Botanical Research Institute, Lucknow.

It was thereafter decided that the Remediation Criteria for the site be set at 20 mg/kg. In addition, the Central Pollution Control Board (CPCB) also reviewed the various reports and concurred with the site specific risk assessment and remediation targets adopted for the site.

At the last meeting, 28th May 2015, held between TNPCB, the SEC, HUL, NEERI and ERM, further recommendations were provided by the Board, which included assessing alternative means of disposing the treated soils from the site.

The Detailed Project Report has therefore been revised to incorporate the detailed mercury contamination delineation map developed in 2009/10, and also the results of the assessment for alternative means of disposing the treated soils from the site, as suggested by the Board.

2.1 *REPORT STRUCTURE*

The remainder of this report is structured as follows:

- Site description including location, geology, site characterization report and buildings on site
- Soil Remediation technology and remediation criteria
- Health and Safety Plan
- Emergency response plan
- Preparatory activities proposed before actual start of remediation works
- Excavation activities
- Soil remediation
- Post soil remediation
- Building decontamination
- Validation and clearance
- Project summary

2.2 *USES OF THIS REPORT*

This report outlines the actionable items, procedures, checks and balances that will be carried out during the remediation phase. It includes a detailed section on Health & Safety measures to be implemented on site; pre excavation activities in preparation of actual site remediation; excavation phasing and activities; treatment processes; analysis and validation during all stages of the remediation phase; post remediation validation; project management and site closure; and post remediation monitoring of the site.

ERM is not engaged in environmental auditing or reporting for the purpose of advertising, sales promotion, or endorsement of any client interests, including raising investment capital, recommending investment decisions, or other publicity purposes. Client acknowledges this report has been prepared for their use and agrees that ERM reports or correspondence will not be used or reproduced in full or in part for such purposes, and may not be used or relied upon in any prospectus or offering circular. Client also agrees that none of its advertising, sales promotion, or other publicity matter containing information obtained from this report will mention or imply the name of ERM.

Nothing contained in this report shall be construed as a warranty or affirmation by ERM that the site and property described in the report is free of any potential environmental liability.

2.3 *LIMITATIONS*

The report is based upon the application of scientific principles and professional judgement to certain facts with resultant subjective interpretations. Professional judgements expressed herein are based on the facts currently available within the limits of the existing data, scope of work, budget and schedule. To the extent that more definitive conclusions are desired by client than are warranted by the currently available facts, it is specifically ERM's intent that the conclusions and recommendations stated herein will be intended as guidance and not necessarily a firm course of action except where explicitly stated as such. We make no warranties, express or implied, including, without limitation, warranties as to merchantability or fitness for a particular purpose. In addition, the information provided to client in this report is not to be construed as legal advice.

3 SITE DESCRIPTION

3.1 SITE LOCATION

The facility is located at an elevation of approximately 2,180 m in a notified industrial area. Access to the site is via St. Mary's Road, which forms a divide between two catchment areas, one located to the south and the other to the north. The southern catchment area includes the factory and the Pambar River, while the northern catchment area includes Kodai Lake (Please refer to *Figure 1* for the site location map). The Kodai Lake is located approx 1.0 km north of the site, beyond a mount and it is in a different catchment area. The nearest surface water body to the site is the Pambar River (approximately 0.5 km to the south). The Pambar river flows in a southwest direction to the Kumbakarrai Falls about 7 km to the southeast, thence draining eastward across the Tamil Nadu Plain. A narrow access path, the Levange path, is in the Forest Reserve immediately south of the site boundary. This path lies immediately above the precipitous slopes and is primarily on bedrock with only a thin veneer of soil The general land use to the north and east of the site is largely low density private residential properties along St. Mary's Road.

3.2 SITE GEOLOGY

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 sub-horizontal joints and exfoliation joints in the upper most weathering profile. The soil profile is very shallow, and comprises 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 overlying rock across the site varies between 1.5 to 3.0 meters. Two shallow wells on site which are blasted into the rock have limited supplies of water which decline markedly in the summer season.

3.3 SITE CHARACTERIZATION REPORT

Based on the soil investigation undertaken by URS (May 2002), three areas of elevated total mercury concentrations in soil have been identified across the site. These areas have been identified as Area A, Area B, and Area C as shown in *Figure 2*.

Area A surrounds the old Bakery building where mercury contaminated glass scrap was stored. This area is approximately 1,443 m^2 of which the entire area has a concentration range between 20-100 mg/kg, on the assumption that contamination is linearly distributed in the data range 10-30 mg/kg given in the URS Study report.

Area B is located southeast of Area A and immediately south of Ponds Path. This area is approximately 2135 m^2. Approximately 88% of the area has a concentration range between 20 and 100 mg/kg and the balance 12% (approx.) of this area has mercury concentrations above 100 mg/kg.

Area C, consisting of Areas C1 and C2, is located immediately south of the factory building. Area C also contains the mercury distillation and mercury recovery rooms. This area is approximately 6,113 m^2 of which approximately 84% contains mercury concentrations between 20 and 100 mg/ kg and the balance 16% has mercury concentrations above 100 mg/kg..

Table 3.1. lists the mercury distribution across the site , contamination level above 20 mg/kg of mercury, along with volume of soil impacted.

Table 3.1 Impacted areas across the site (Modified from URS Report, 2002)

Area	Size of Area	Volume of contaminated soil
Area A: Around Old Bakery	1,443 m^2	432 m^3
Area B: South of Ponds Path	2,135 m^2	642 m^3
Area C: North of Ponds Path (C1 & C2)	6,113 m^2	1,894 m^3
Total Area for Areas A, B, C and D	9,691 m^2	2,968 m^3

The total estimated volume of soil that will be excavated and treated is estimated to be around 2968 m^3(i.e. approx. 4749 MT of soil considering 1.6 kg as the specific weight of soil) . After the soil washing process, it is estimated that a volumetric reduction of approx. 70% of input contaminated soil shall occur. Therefore the estimated soil that will require vacuum retorting will be approximately 890 m^3 (i.e. 1425 MT of soil).

Based on the detailed delineation investigations conducted at the site in 2009/10, as part of the pre-remedial activities, the soil volumes have been re-estimated to range between 5,200 to 6,900 MT. This is only an estimate based on the data that is currently available, and may vary when the actual remedial activities are undertaken.

Results from the soil washing and vacuum retorting pilot experiments, conclusions and recommendations for full scale design are presented as an *Annex A* to this report.

Mercury levels in the soils along the Upper Shola and Lower Shola Roads, located 400 m to 500m north of the site were found to be less than 0.1 mg/kg (URS Report, 2002). Soil samples collected from the southern periphery of Kodai Lake, 800 m to the northeast also contained mercury levels less than 0.1 mg/kg (URS Report, 2002). Sediment samples from the Pambar River were also found to be less than 0.1 mg/kg (URS Report, 2002).

The main component of soil remediation works will involve excavation of the shallow soils down to depths of 30 cm in Areas A, B and C. If required, further excavation shall proceed at 30 cm depth intervals, until a point where soil mercury concentrations are below 20 mg/kg. Sediment sample at a location off site (south of Levange path) where a shallow basin has formed due to rock erosion reported the presence of mercury. These sediments will be collected and treated on site. The approvals for removal of sediment will be obtained from the Forest department as this location falls under the Forest Department. Impacted soils will be transported to the main plant area where remediation will comprise of soil washing followed by vacuum retorting. Brief descriptions on the technologies being used are described in Section 4.

Pilot studies involving soil washing and vacuum retorting were conducted at the site during the month of August 2007. The results, conclusions and recommendations for full scale design are presented as *Annex A* to this report.

3.4 *BUILDINGS AND STRUCTURES*

The main buildings at the site that have been historically associated with mercury activities are listed below. Please refer to *Figure 3* for a site layout of all buildings and structures located on site.

a) Main plant: Broadly divided into Mercury area and non mercury areas. Activities carried out in the non-mercury area included stem glass cutting, bulb glass cutting, end opening, end cutting, and bulb forming. Mercury was not used in this area at any stage. Operations that were carried out in the mercury area include mercury filling (this operation was done in a separated small room called Fill room within the mercury area); top chambering, annealing, contracting, air passing, test for shake, scale setting, quality assurance and packing.
b) Mercury distillation building (Distillation room): Commercially purchased mercury was triple distilled in this room, prior to its use in the filling operations. Recovered mercury from the recovery room and fill room was also distilled in this room.
c) Recovery room: Glass scrap from the Mercury area was crushed and retorted in the oven to recover mercury.
d) Old Bakery building: Glass scrap from the mercury area prior to and after recovery of mercury in the recovery room was stored in these rooms.
e) Old administration building: Glass scrap from the bakery building was transferred to this building for storage.

Buildings present on site that have not had any mercury activities associated with them are Utilities building and residential quarters.

Other structures present on site are the, Sewage Treatment Plant (STP), water tanks, dug wells, rainwater harvesting tank, storm water drain, water sump, cooling tower water sump, septic tank, electrical earth pits etc.

All buildings across the site have had little or no mercury activities but have been evaluated for the presence of mercury. Details on building evaluation and results obtained are described in section 11.

4 SOIL REMEDIATION TECHNOLOGY AND TARGET CRITERIA

As mentioned previously, based on the SSTL derived by ERM and the technical protocol developed by NEERI on site remediation, a combination of soil washing and vacuum retorting technologies were selected to achieve remediation criteria of 20 mg/kg of total mercury in treated soils. Process water and off gas treatment are included in the entire treatment train in order to address process water and off gas treatment. A brief description of these processes is presented in the following sections and a detailed description is presented in section 9.

4.1 SOIL WASHING & VACUUM RETORTING

SOIL WASHING

Impacted soils will be initially processed using a soil washing technique, where the soils will be mixed with water, agitated, scrubbed, washed and screened into various size fractions. Coarse washed material will be diposed to the offsite TSDF once the site remediation criteria of mercury concentrations < 20 mg/kg have been met. Elemental mercury, by virtue of its specific gravity and relative insolubility in water will concentrate in the fines section of the washed soil. The soil washing process separates the contaminated feed soil into a relatively clean coarse-grained fraction and a fine grained fraction that will be concentrated with elemental mercury. The coarse soil fraction is analyzed and, if the mercury concentration is less than the remediation criteria of 20 mg/kg, will be transported and disposed offsite at the authorized TSDF. If the mercury concentration in the coarse soil is greater than 20 mg/kg, it will be either washed again or thereafter treated in the vacuum retort process. The fine soil fraction, which may contain mercury at concentrations higher than 20 mg/kg, will be treated in the vacuum-retort process. The ultimate goal of the soil washing process is a volumetric reduction of total volume of soil that will be subjected to vacuum retorting

VACUUM RETORTING

The washed fines/ sludge that are concentrated with mercury will be initially dried at low temperatures (~100°C) to remove moisture and then heated at higher temperatures (~ 350-400°C) for a residence time of approximately 30 minutes and pressure (100-150 hectopascals or ~76 mm mercury) in a vacuum retort, forcing elemental mercury into the vapour phase. Mercury vapors removed from the vacuum retort unit enter a multistep condenser unit that condenses the vapors into elemental mercury. The condensed elemental mercury will be collected in a trap to be recycled for industrial uses. Carbon absorption filters, post mercury condensation and trapping, shall be used to remove any fugitive mercury vapours that may be present in the system prior to discharge to ambient atmosphere. The treated soils shall be analysed for residual mercury concentrations.prior to offsite disposal to the authorised TSDF.

Filling of all the excavated areas will be done using virgin/ uncontaminated soils from either onsite or offsite.

PROCESS WATER TREATMENT

Process water from the soil washing treatment will be treated with a flocculation agent and sedimentation to remove the fines fraction. The sludge will be dewatered and then subjected to vacuum retorting. Treated process water will be reused in the soil washing treatment train.

PROCESS AIR TREATMENT

Off gas generated from the retorting process will be passed through a granular activated carbon battery to trap any fugitive mercury vapours that may have escaped the condensing step. Similarly, in the event of dust generation during the soil washing process, appropriate air handling units have been incorporated into the system to handle dust and fugitive mercury vapours which will be trapped by the activated carbon columns. The vacuum retort equipment shall be enclosed in a room under negative atmospheric pressure where all vapours and air are routed through the granular activated carbon traps.

After the soils are treated to the remediation criteria of 20 mg/kg, the treated soil will be transported to the offsite landfill Virudhnagar District, Tamil Nadu. Limited on-site storage (if necessary) for the treated soils are available on site.
The treated soils that are transported to the TSDF will be disposed at the authorised landfill as per CPCB guidelines.

The design of the secure landfill cell will be in accordance with the guidelines for landfill capping components as specified by the Central Pollution Control Board (CPCB) & Ministry of Environment & Forest (MoEF) , for Hazardous Waste Landfills titled *"Criteria for Hazardous Waste Landfills" (February 2001)* and specifications provided by CPCB & MoEF for a Hazardous Waste Landfill Top Cover system titled *"Protocol for Performance Evaluation and Monitoring of the Common Hazardous Waste Treatment Storage and Disposal Facilities" (May 2010 – under section 2.4.1 (iii))* and at a minimum include:

- Base lines provided on the well compacted hard base;
- Base liner system consists of 45 cm compacted clay meeting desired permeability criteria followed by 2mm HDPE liner and 300 mm drainage media duly providing geo textile where ever required as per landfill design; and

- The same thing will be repeated by providing one more clay liner, one more HDPE and drainage media making the landfill as double liner system.

Following the proper and scientific disposal of the treated soils within the offsite landfill, appropriate monitoring and maintenance of the cell will need to be followed by the operator of the TSDF.

4.2 *REMEDIATION TARGET*

Based on the directive of the Supreme Court Monitoring Committee and TNPCB, a Site Based Risk Assessment Study, to decide the Site Specific Target Levels, was constituted by NEERI and ERM. The detailed risk assessment study was carried by Environmental Resource Management Pty Ltd (ERM), Australia in 2006 to arrive at risk based Site-Specific Target Level (SSTL) for remediation of mercury-contaminated soil (*ERM, 2006, "Former HLL Mercury Thermometer Factory, Kodaikanal, Tamil Nadu, India: Site Specific Target Levels")*. The risk assessment study considered a tiered process using a conceptual site model. The linkage between source, pathways and receptors was assessed. The SSTL derived by ERM was based on a probabilistic approach considering the future use of the site for residential and recreational purposes. The receptor of concern was considered to be future child residents who have the potential to be exposed to mercury via vegetable ingestion, dermal contact, indoor dust inhalation, outdoor dust inhalation, and soil ingestion. Under the assumed conditions of the site, a SSTL of 25 mg/kg for child residents and 29 mg/kg for child recreational users were derived by ERM for mercury-contaminated soil at HUL, Kodaikanal site.

The results of the risk assessment were presented to the Tamil Nadu Pollution Control Board (TNPCB) and the SCMC constituted Scientific Expert Committee. Based on the review and recommendations of the Scientific Experts Committee, remediation criteria of 20 mg/kg mercury with a 95% confidence level (with none of the treated soils to exceed 25 mg/kg) was set by TNPCB.

Following further validation of the Risk Assessment and derivation of remediation criteria by IIT Delhi, and reviews by TNPCB, SEC and CPCB recently, the remediation criteria was set at 20 mg/kg for the site

This Health and Safety Plan (HASP) describes the health and safety requirements for project personnel involved in remediation of the HUL Thermometer Factory, St Marys Road, Kodaikanal, Tamil Nadu. The duration of the remediation work is estimated to be 29 months. Approximately 75-100 persons will be employed in the remediation activities at any given time. Work would be generally carried out in the day time throughout the week, Monday through Saturday.

The Project Manager (PM) must assure that the subcontractors are provided with a copy of the HASP, and all their employees are made aware of the plan. The employees will be provided necessary induction and safety training. Subcontractors performing work activities as part of a contract are expected to meet all applicable Government and other relevant Statutory Authority requirements for employee health and safety. Subcontractors are responsible for supervising their employees and maintaining safe working conditions at the work site. Specifically, the Subcontractor will:

- Ensure that health and safety of persons, safety of equipment and personal protective clothing/respirators that are provided are used and maintained by employees; and

- Maintain equipment and plant in a safe operating condition.

A Safety, Health & Environment (SHE) officer responsible for ensuring compliance of Subcontractor personnel with health and safety requirements.

The SHE officer may stop a Subcontractor's operation which presents an imminent hazard to employees or property, the general public, or to the client employees or property.

Standard operating Procedures for equipments and various processes that will be undertaken during remediation shall be in place before work begins. Work instructions for all phases of work will also be written and conveyed to all the workers, during all phases of remediation works.

A list of *Do's and Don't s* with regards to Safety, Health and Environment will be listed and communicated to the employees. All equipments and processes will have safety checklists will be assessed at the start of each day.

Health and Safety Planning for this project is typically based on the following procedure:

- Undertaking a Work Activity Risk Assessment (WARN) before the commencement of remediation activities. Please refer to *Annex B* for an example of ERM's WARN document.
- Preparation of a Health & Safety Plan (HASP) based on the WARN analysis; the HASP includes details of safety equipment and PPE to be used for each task.

- Induction of all subcontracted workers as per the HASP and ensuring provision of all required PPE to them prior to commencing field work;
- Preparation of an Action Plan in consultation with the site management to handle foreseeable emergencies; and,

This Project will be subjected subject to a Work Activity Risk Assessment process (referred to as the WARN process), though which project specific HASP's are developed. Each task is risk assessed using checklists and appropriate measures are included within the HASP to ensure risks are securely managed. Permit to Work (PTW) will be required to be issued for all the critical tasks. A separate PTW and checklist for sub-surface clearance is followed prior to intrusive investigations.

Permit to work (PTW) is required for handling mercury, working at height, electrical work, confined space entry, hot work and maintenance of equipments. These activities will not be carried out without a PTW. The PTW will be issued by the supervisor in charge of the section and authorised by the SHE officer.

5.1 *MEDICAL SURVEILLANCE OF EMPLOYEES INVOLVED IN ON SITE REMEDIATION WORKS*

The site will have a Occupational Health Centre equipped with stretcher, couch, oxygen cylinder, and necessary emergency drugs, including anti snake venom, etc. Pre-employment medical check-up will be conducted by a doctor and only the employees found suitable will be engaged on remediation activities. The SHE officer will work in coordination with the Doctor and maintain the health records (pre-employment medical check-up data, weekly monitoring of urine samples, daily mercury vapour readings, health check-up at the closure of the project) for monitoring workers health condition during the remediation phase. Medical facilities will include a First Aid room, emergency First Aid kits (located at treatment plant floor, close to the excavation areas, and factory gate, eyewash stations, and an emergency vehicle to be available at the site to transport injured employees in case required.

All workers and employees will be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program will include education of employers and workers about work related hazards, early detection of adverse health effects if any, and referral of workers for diagnosis and treatment. To detect and control work related health effects, medical evaluations shall be performed (a) before job placement; (b) on a quarterly basis during the term of employment; and (c) at the time of termination.

Pre – employment medical check-up includes a physical examination and laboratory tests. These will concentrate on the function and integrity of the eyes, skin, respiratory system, central and peripheral nervous systems and kidneys. Serum creatine levels will be analyzed during the pre employment phase on all employees that will be working on site. Weekly urine monitoring at a predetermined time shall be conducted on all workers that are present on site during remediation phase. All workers will be required to bathe before leaving the site. Similarly, all employees will change out their work clothes and safety shoes and have them washed on site, before leaving for the day. Workers will be impressed upon that Safety, Health, and Environment must begin with them for the project to run in a safe and successful manner.

Medical surveillance of all employees during the remediation phase will be carried out for the duration of on site works. Weekly urine monitoring for Mercury will be conducted on the employees.

A comprehensive health check up will also be performed on all employees post remediation works.

Any deviances from the safety norms and allowed permissible levels with respect to mercury, during an employee's employment will entail the termination of his work permit, in consideration of his health.

5.2 *FIRST AID*

The following items will be located on site at all times:

- First aid medicines,
- first-aid kit; and
- Emergency phone list.

All injuries must be reported to the SHE officer. SHE officer will take immediate actions required and report the accident to the Project Manager, who will inform HUL immediately. An Accident Report will be submitted to the Project Manager and HUL for each job-related accident. The PM and HUL will investigate using an investigation team and take the necessary measures. If necessary, the employee will be referred to an emergency room for further treatment.

In the event of serious trauma or unknown chemical exposure, the employee should be stabilised by one group of employees while the emergency phone number list is consulted and an ambulance immediately requested. Workers with suspected back or neck injuries are not to be moved until professional emergency assistance arrives.

5.3 *AIR MONITORING*

The United States Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) is 0.1 mg/ m^3 and the United States National Institute for Occupational Safety and Health (NIOSH)

Recommended Exposure Limit (REL) have been set at 0.05 mg/m^3 for mercury compounds (except (organo) alkyls). For human safety, workplace mercury vapour should not exceed 0.05 mg/m^3 as per Indian Factories Act.

The Jerome Mercury Vapour Analyser (please refer to *Annex C* for further details) will be used throughout the duration of on site work to monitor the surrounding environment. The minimal PPE (Level D) described in the Section 5.4 shall always be worn by all on-site personnel. Should the vapour readings in the breathing zone exceed 0.025 mg/m3, the level of PPE will be upgraded to the next level (Level C) where, half face air purifying respirator with mercury cartridges will be worn. If the mercury vapour level exceeds 0.05 mg/m^3 conditions will be monitored and re-assessed by the SHE officer and appropriate actions undertaken.

All work shall cease should the mercury concentrations remain at elevated concentrations above 0.05 mg/ m^3 for a period longer than 4 hours.

Air monitoring for mercury will be carried out using a Jerome 431-X Mercury Vapour Analyser accurate to 0.003 mg/m^3. Monitoring of air for mercury will be conducted daily at hourly intervals within the excavation areas and within the treatment process area. All data shall be duly logged onto a separate field note book. All site personnel will wear Personnel Protection Equipment (PPE) as required for the different levels of protection based on air monitoring results.

A Mercury environmental Monitoring station (Jerome 451) will be installed at the downgradient fence of the site to monitor any potential fenceline ambient mercury concentrations. The Jerome 451 monitoring system is designed to provide long term monitoring of mercury in all weather conditions. The station also provides wind speed and direction data. It has a linear response throughout the entire range of the sensor. The detection range for the unit is 0.003-0.999 mg/m^3. Please refer to *Annex C* for further information on the Jerome 451 Met Station. All data shall be duly logged onto a separate field note book.

5.4 *PERSONAL PROTECTIVE EQUIPMENT*

The minimal PPE that will be worn by employees and workers at all times are:

- Hard hat
- Dust masks, when mercury vapour readings are less than 0.025 mg/m3. If and when vapour concentrations are above 0.025 mg/m^3, all workers in the immediate area will be issued NIOSH approved half face air purifying respirators (twin filter) fitted with mercury vapour cartridges.
- Safety glasses, where there may be risks to flying dust and objects (e.g., excavation areas, soil washing points, etc)
- Hearing protection in areas where noise decibel exceeds 85 decibels;

- Long sleeved shirts, long pants;
- Orange safety vest, if working in an area where there is machinery or traffic;
- Nitrile Gloves, and heat resistant gloves (Ceramic or Kevlar);
- Foot Protection (appropriate safety shoes are a must);
- Safety harness when working on slopes and at heights greater than 2.0 m, including life-wire, safety belt and safety net etc.

The following activities shall be followed by the employees during remediation activity:

- Upon leaving the exclusion zone at the end of the day, personnel will remove all contaminated protective clothing/equipment;
- Uniforms, safety shoes, gloves and other personal protection equipment will be washed on a regular basis.
- Respirator cartridges and other personal protective equipment shall be replaced when saturated as indicated by a colour change on the indicator strip;
- Contaminated personal protective equipment, i.e., suits, gloves, respirator cartridges, etc., will be placed into plastic bags and/or barrels and prepared for disposal by HUL;
- Wash and rinse waters will be considered contaminated and will be treated in the process water Treatment Plant ;
- Personnel will thoroughly wash their hands before eating, drinking following field activities.
- Smoking is prohibited in the factory premises.
- At the end of the day, all employees shall bathe before leaving the site.

Each worker will be responsible for cleaning, sanitising and storing their own respirator in accordance with manufacturer's guidance (i.e., washing in warm water and detergent or sanitising solution, air drying, and storing in a plastic storage bag). All waste and wash water will be routed to the process water treatment plant. Cartridges will be changed as soon as breakthrough occurs as verified by the change in indicator colour on the cartridge. Respirators will be kept in storage bags or boxes when not in use.

5.5 *DAILY RECORD SHEETS*

The SHE officer will complete Daily Record Sheets (DRS) for the entire duration of the remediation work. The DRS will include the following information as a minimum:

- Weather conditions (including temperature, rainfall and wind directions);
- Urine monitoring data (every employee shall be covered at least once a week)

- Air monitoring results in each area being excavated/ soil treatment plant area;
- Number of crews and number of persons in each crew;
- Areas excavated, soil treated- washed, retorted and filled with virgin/ uncontaminated soils including indicative volume;
- Analysis of washed soil, and retorted soil samples.
- Calibration data of monitoring equipments;
- Incidents of dust and odour and any other unusual observations if any; and
- Any incidents / accidents/ near miss and names of persons involved where relevant.

5.6 *POTENTIAL EXPOSURE TO ELEMENTAL MERCURY AND PREVENTION*

Mercury is a naturally occurring metal, which has metallic, inorganic and organic forms. In its pure metallic form, it is a silver white odourless liquid that can form a vapour at room temperature.

Inhalation and absorption through the skin is an important source of exposure.

Exposure may also occur through inhalation of contaminated soil as dusts or liquid aerosols or through ingestion of contaminated soil. If mercury is present in its elemental form, it may also exist as a vapour, leading to exposure by inhalation of the vapour. Organic and other forms of inorganic mercury (i.e. salts) exist as solids. Mercury has a low solubility in water. Organic and inorganic forms of mercury can be absorbed through intact skin.

The proper use of personal protective equipment and good personal hygiene practices will minimise the hazards posed by skin absorption. All PPE shall be worn by workers to minimize their exposure to mercury during all phases of site work.

5.7 *SAFE HANDLING PROCEDURES FOR MERCURY*

Appropriate health and safety procedures shall be in place in the treatment plant area, besides the issues already discussed under the health and safety section.

The soil washing area will have air handling units interspersed across the length of the treatment train, to handle and collect any dust that may be generated. The vacuum retort equipment will be placed in a separate room within the treatment plant area, and the room will be maintained under a negative pressure. All air from this room will be routed to a separate air handling, dust collection unit followed by a series of activated carbon columns. All personnel entering the room will be required to wear appropriate PPE and half face respirators with the required mercury adsorption cartridges. Air monitoring of the treatment plant areas shall be conducted on a daily routine and records maintained.

Mercury that has been collected from the condenser of the retort equipment shall be transferred into air tight containers. Mercury containers shall have the appropriate labels and stored in a cool and secure place.

In case of accidental mercury spillage, evacuate the people inside the room, ensure proper ventilation, wear PPE including half face mercury respirators, hand gloves etc. and remove mercury from of the spilt area using Vaccupick / Card or stiff board / spoons to push the small mercury beads into a container. Mercury can be handled over a suitable waterbed in a plastic tray. Monitor the mercury vapour in the room and take the necessary corrective steps. Special purpose vacuum cleaners fitted with activated carbon filter shall be used to collect any spilt mercury on the floor. Skin contact with mercury or touching by bare hand should be avoided. All instances of such incidents and measures that were taken shall be documented.

5.8 ACCESS AND ACCESS CONTROL REQUIREMENTS

Only authorised persons will be allowed inside the factory premises. Health and Safety and emergency requirements are to be informed to the persons before entry. All the equipments / tools / accessories are to be tested and before taking inside the premises. All the materials / vehicles in and out of the premises are to be checked before entry /exit.

Only personnel who are essential to the completion of the task will be allowed access to the controlled areas, provided they are wearing the prescribed level of protection. Work area barricades will be used to prevent access by unauthorised persons.

Work zones will be established and communicated to all employees by the SHE officer. The zones include:

- **Exclusion Zone:** Areas where contamination does or could occur. All personnel entering the exclusion zone must wear the prescribed level of protection. The exclusion zone boundary can be made larger or smaller by the SHE officer, based on results of environmental monitoring which has been conducted. Changes must be documented in the daily field log.

- **Support Zone:** Outermost part of the active site which is considered non-contaminated or "clean". Support equipment is located in this zone; contaminated samples and equipment are not located in this zone. The location of this zone depends on factors such as accessibility, wind direction (upwind of work area), and resources (i.e., roads, shelter, utilities).

- **Contamination Reduction Zone:** Links the exclusion and support zone. Zone where decontamination of personnel and equipment takes place. A waste container will be placed at the end of the corridor so contaminated - PPE can be placed inside and covered. Surface/soil contamination in this area should be controlled using plastic sheeting. No personnel or site visitors will be permitted into the Contamination Reduction Zone or Exclusion Zone unless they are in full compliance with the requirements of this HASP.

The **Exclusion Zone** is minimally defined as an area extending at least 2 metres from the work area and will be conspicuously identified through the use of traffic cones, flags, ropes, barricades, caution tape or other suitable means.

Visitors must report to the SHE officer before entering the site. All visitors must also wear protective equipment as specified in the H & S plan, and follow instructions as directed by the SHE officer. As a general rule, visitors will not be permitted to enter areas where respiratory protection devices are required.

The SHE officer will see that all site visitors sign a visitors' log, use PPE's, and follow the HASP.

The SHE officer will provide site hazard and emergency action information to all site visitors before they enter the site; a health and safety briefing will be given to the visitor.

5.9 SAFETY TRAINING OF PERSONNEL

All field subcontractors and their equipment will be vetted before employment to ensure that they can meet HUL's and ERM's requirements. All personnel will be inducted into the H&S program of the site and remediation activities.

HUL and ERM will, as part of the health and safety induction for all personnel working on site, ensure that a full briefing to the risks present on site will be given. HUL and ERM will also ensure that all equipment brought onto the site will be fit for purpose and itself not present additional risk to the subcontractor or any third parties. All Standard Operating Procedures, work instructions, Do's and Don'ts will be communicated to workers prior to initiation of the remediation phase.

5.10 SAFETY WITH RESPECTS TO SITE EQUIPMENT

The equipment used on this project presents potential physical hazards to personnel. Operation of equipment during excavation activities and also during soil processing and treatment presents a potential "run over" or collision hazard, pinch and thermal burn hazards to personnel. Personnel should always be aware of the location of operating equipment and take precautions to avoid getting in the way of its operation. In addition, the following should be complied with:

- traffic safety vests, and other personal protective equipment (PPE) such as steel-toed shoes, safety glasses or goggles, and hard hats are required for personnel working near mobile equipment, such as backhoes, drum handling trucks and other excavators;
- Excavator will be accompanied by a "signals" man, to clear the path in front, behind and on the sides of the excavator at all times
- never walk directly in back of, or to the side of, equipment without the operator's knowledge;
- when an equipment operator must operate in tight quarters, the equipment subcontractor should provide a person to assist in guiding the operator's movements;
- keep all non-essential personnel out of the work area; and
- All equipment that are used in the Exclusion Zone should remain in that zone until its task is completed. Completely decontaminate such equipment as required in the designated equipment decontamination area.
- All process equipment should be handled and maintained only by authorized personnel.
- Lock out/tag out procedures for electrical work will be in place for the major equipments comprising of the soil washing process and vacuum retorting process.
- All hazard points should be appropriately identified and plainly visible
- Fire extinguishers placed at all locations where a fire could break out
- Appropriate main switch for shutting down all power in case of emergency appropriately identified and plainly visible.
- Workers shall be tethered to a safety harness when working on steep grades south of the Bakery building and in Area B. Safety wire nets and life lines shall also be placed downhill of the excavation areas A and B.

Health & Safety precautions will be incorporated into the Project Plan to cover the transportation risks. These include:

- Transportation Safety Plan;
- Road Safety and Spill Prevention/ Control Plans (SPCC);
- Emergency Action & Response Plan during Transportation of treated soils to offsite TSDF;
- Health & Safety Plan for any further treatment (if required) and subsequent landfilling at the TSDF;

Although these Plans are not covered under the current DPR, a detailed Road Transportation Safety Plan will be developed for the project.

At a minimum the transportation of treated soils to the offsite landfill will at a minimum consider the following:

- Follow the hazardous waste and motor vehicle act of 1987 for transportation guidelines for the packing and transportation of the treated soils to disposal facility.
- The transportation carrier must be leak proof.
- The transportation carrier must have a first aid kit, spill control kit, fire extinguisher, PPE'S for driver and helper.
- Truck driver should carry TREM card and filled in Manifest forms.
- There should be prominent label to be fixed to the container / truck as per CPCB guidelines indicating the "Hazardous Waste Carrier".

6 EMERGENCY RESPONSE PLAN

No contingency plan will substitute for sound environmental and safety practice during the remediation works. Accordingly, it is the responsibility of the Site Supervisor to monitor the works at all times and manages all potentially significant activities in a proactive manner. Records of all actions relating to environmental protection measures, contingency events and impacts will be incorporated into the site daily log book completed by the Supervisor.

An assembly point will be located in an upwind area and all employees shall be notified of the area. A horn will be used to signal an evacuation in the event of an emergency. Continuous blasts of the horn will be the signal to immediately stop work and proceed to the emergency assembly point near factory main gate.

Details of possible emergency situations and emergency mitigation procedures are provided in *HUL Kodaikanal site emergency response plan* document. All the personnel working at site and visitors are to be explained about the emergency requirements. Emergency drill will be conducted at least once in a quarter.

6.1 ON SITE EMERGENCY PROCEDURES

Emergency procedures on site will cover actions to be taken if unfortunate events occur. Unfortunate events may include but are not limited to:

- Failure of construction structures.
- Fire.
- High mercury vapours beyond the safe limit.
- Injury from machinery (earth moving, soil washing and retorting)
- Industrial Accident.
- Tripping and falling in the slopes.
- Truck Accident
- Tree falling
- Snake bite
- Land Slide
- Medical emergencies.
- Sudden downpour.
- Failure of silt trap(s).

In order to ensure that the health, safety and environmental impact of unfortunate events is minimised (inclusion of these procedures will form part of the Site Specific Induction Courses), emergency procedures are to be followed. These include:

The first priority is the safety of any persons either workers or others involved in the events. Immediate required actions necessary to protect safety of personnel and property will be taken. The site Emergency response Plan outlines actions to be taken in relation to safety of persons, if these circumstances eventuate.

The second priority is to quickly minimise the environmental damage. All emergency action should take place as soon as possible after the event. Actions to be taken may include:

- The containment of any pollution.
- Re-establishment of the silt fence(s).
- The taking of appropriate samples to assess the extent of the problem and take appropriate actions.

In the event of an emergency situation arising, all possible immediate actions to control the pollution have been taken.

6.2 *EMERGENCY INFORMATION*

Fire Brigade	Phone # 240785
Ambulance (Van Allen Hospital)	Phone # 241273
Police Department	Phone # 240262
Local Electrical Utility	Assistant Engineer,TNEB,Phone # 240300, 240700
Local Telephone Utility	Assistant Engineer Office, Phone # 245605;
Enquiry # 198 & 163	
Local Water/Sewer Utility	Kodaikanal Municipality, Phone # 241253
District Forest Officer	Phone # 240287
Poisons Information Centre	Van Allen Hospital, Phone # 241273
Name of Nearest Hospital	Van Allen Hospital, Phone # 241273

Van Allen Hospital is on St. Mary's Road, approximately one kilometre away from the factory towards the Township.

6.3 *EXCAVATION CONTINGENCY PLANNING*

The table below summarizes conditions that can reasonably be expected and the resulting problems they may cause, and how these problems may be resolved within the context of the excavation program.

Anticipated Problem	Corrective Action
Excessive Rain	Maintain access roads, cover high-traffic areas with gravel; or cover working areas with plastic during offshifts; or shut down operations until runoff is more manageable.
Unmanageable mud in excavation zone	Improve drainage collection system; add geotextile/gravel in problem areas; or strip off mud/slurry materials; or excavate from the top of the fill.
Excessive drainage	Minimise active/contaminated work area; or improve diversion clean run-on; or mobilise additional storage and/or treatment systems as needed.
Excessive dust	Use water sprays; or cease dust-generating activity until better dust control can be achieved, or apply interim capping systems.
Excessively wet materials	Stockpile and dewater onsite.
Equipment failures	Maintain spare equipment or parts; or keep rental options available; or shut down affected operations until repairs are made.
Springs/seeps	Isolate, collect, test, or store/treat (if required).
Release of fuel/oil from machinery	Remove source, use adsorbent booms to remove oil, make any machinery repairs as required.
Silt fence fails	Stop work, repair silt fence, ensure anchoring systems are adequate.
Excessive noise	Identify source and review noise attenuation equipment.

Risks associated with initial sampling and excavation/ transportation of impacted soils, and treatment within the plant area are identified in the table below, along with the minimum mitigation procedures that shall be in place during the entire phase of remediation.

Risks	Mitigation procedures
Excessive dust during initial sampling, and excavation/ transportation of soil	Given the climatic conditions at the site, this is foreseen as a low risk scenario. However, in the case of excessive dust generation, water will be used at a minimum to suppress the dust generation
Injury from equipment	All employees will be inducted in to the stringent H&S procedures that will be in place. Equipment will be handled by only certified equipment handlers. No cross work will be entertained by employees. All hazard points will be adequately labelled in the native language with appropriate signage. Where feasible, points of particular concern on equipment will be shielded against accidental injuries to personnel.
Traffic accidents during transportation/ excavation and treatment	All employees present on site will be issued and be required to wear high visibility vests at all times when present within the site premises. Where required, signal man will be posted to maintain the safe and proper routing of traffic.
Electrical hazards	All electrical points will be shielded from accidental handling. Double earthing will be provided for all equipments. ELCB will be provided in all circuits. Appropriate signage in native language and secondary barriers will be emplaced to minimize accidents. All electrical work will be audited before the trial runs by a certified electrician
Air quality	Air quality monitoring will be in place at all times and all locations where work is being conducted. Ambient air mercury vapour concentration exceedances will be

Risks	Mitigation procedures
	addressed as mentioned in section 5.3.
Equipment failure	All equipment shall be duly maintained on a regular basis, during off days. Log books shall be maintained to ensure that these activities are conducted on a routine basis. Equipment surveys and audits will also be conducted on a regular basis, in order to identify any potential for malfunction at an early preventative stage.
Exhaustion	Employees shall be given appropriate rest periods during work, to minimize exhaustion from work

Offsite emergency plans will need to be developed for the transportation of the treated soils to the secure landfill located at Virudhnagar District, Tamil Nadu.

7 PREPARATORY ACTIVITIES

7.1 PERMITTING REQUIREMENTS

For full scale remediation activities the following permits will be required and therefore applied for, before the start of excavation activities:

Air- A consent to establish (CTE) and Consent to Operate (CTO) will be applied for as per Section 21 of the Air (Prevention & Control of Pollution) Act, 1981.

Water- A consent to Establish (CTE) and Consent to Operate (CTO) will be applied for as per Section 25/26 of the Water (Prevention & Control of Pollution) Act, 1974.

Hazardous wastes that may be generated at the site include mercury, used oil, asbestos cement sheets and mercury bearing materials such as cotton swabs, used PPEs, ETP sludge, and residue from air treatment units. Authorization for collection, storage and transport to a Treatment, Storage and Disposal Facility (TSDF) shall be applied for under Section 5 of the Hazardous Waste (Management and Handling) Rules (HWR), 1989. Permission to be obtained for disposal of mercury to industrial users and used oil to recyclers shall be sought. Also permission from TNPCB for disposal of decontaminated scrap materials to recyclers will be sought.

An application will be filed with the Factories Inspectorate under Tamil Nadu Factory Rules 1950 (Rule 3) under the Factories Act, 1948, for permission to install and operate treatment equipments that shall be required during remediation phases. Licence to engage contract workmen under section 12 (1) of Tamil Nadu Contract Labour Act shall be obtained from the Factories Inspectorate.

The District Collectorate, Kodaikanal Revenue Department and Forest Department shall be informed, and necessary permits obtained, if required, of the soil remediation activity and the possible loss of trees due to excavation / remediation activities. A minimum of two trees shall be planted for every tree lost during the remediation phase.

Electrical permits for the purpose of additional power requirements and bringing in HT power to the site will be applied for with the Tamil Nadu Electricity Board.

Required permits from Local Municipal Administration and Fire Department shall also be obtained.

7.2 ON SITE LABORATORY FOR SOIL ANALYSIS

Two (2) X-Met 3000TXS real-time XRF Soil Analyzers will be used for the initial screening of the impacted areas. The XRF analyzer uses a miniature x-ray tube as the excitation source and a peltier-cooled silicon-PiN diode x-ray detector. The x-rays from the source have the appropriate excitation energy that causes elements in the sample to emit characteristic x-rays. A qualitative elemental analysis is possible from the characteristic energy, or wavelength, of the fluorescent x-rays emitted. A quantitative elemental analysis is possible from the number (intensity) of the x-rays at a given wavelength. The mean method detection limits from field trials conducted under the USEPA SITE program were reported to be between 20-50 mg/kg. Analytical precision of the instrument that was evaluated was reported to be between 5-10 % for mercury. Please refer to *Annex D* for product specifications of the instrument.

For the purpose of on site analysis to determine spatial and vertical extent of contamination above 20 mg/kg during excavation activities, a mobile analytical Mercury Analyzer, (Ohio Lumex RA-915 Zeeman; please refer to *Annex D* for description) will be utilized. This instrument together with confirmatory laboratory analysis will also be used to validate mercury concentrations in treated soils, before offsite disposal.

The RA-915+ Mercury Analyzer is a portable atomic absorption (AA) spectrometer with a 10-meter multipath optical cell and Zeeman background correction. Mercury is detected without preliminary accumulation on a gold trap. Mercury samples are heated to 750-800°C, causing organic materials to be decomposed and mercury to be vaporized in a carrier gas of ambient air. The airflow carries the vaporized mercury to be carried to the analytical cell. The operation of the RA-915+ is based on the principle of differential, Zeeman AA spectrometry combined with high-frequency modulation of polarized light. A mercury lamp is placed in a permanent magnetic field in which the 254-nm resonance line is split into three polarized components, two of which are circularly polarized in the opposite direction. These two components (F- and F+) pass through a polarization modulator, while the third component (B) is removed. One F component passes through the absorption cell; the other F component passes outside of the absorption cell and through the test cell. In the absence of mercury vapours, the intensity of the two F components are equal. When mercury vapour is present in the absorption cell, mercury atoms cause a proportional, concentration-related difference in the intensity of the F components. This difference in intensity is what is measured by the instrument.

The Method Detection Limit for the instrument has been determined to be between 0.0053 mg/kg and 0.042 mg/kg. The weight of the sample is approximately 500 mg. More details on the RA-915+ Mercury Analyzer including accuracy and precision tests verified by the United States Environment Protection Agency (USEPA) are presented in *Annex E*.

All results for mercury analysis will be reported on a dry weight basis. Moisture content on native soils, washed and retorted soils will be performed and appropriate correction factors incorporated to derive the concentrations of mercury on a dry weight basis. Since drying of contaminated soils is not an appropriate option, clean soil from other locations across the site will be run through the washing process to derive an estimated moisture content of the soil. Retorted fractions of soil will be processed similarly to derive the moisture content.

Prior to actual remediation works, results of the RA-915+ analyzer will be validated. For this purpose, verification samples and reference material will be collected and analysed by both the RA-915+ analyzer and off-site laboratory. The results will be analysed to assess the accuracy of the Zeeman analyzer. Samples will also be analysed at an off-site laboratory on regular basis for validation purpose.

Soil samples will be sent to external laboratories (Australian Laboratory Service and NEERI), to maintain QA/QC control on the analytical component of the project. The on site laboratory will use the Zeeman Mercury analyzers for measuring mercury concentrations in soils during pre excavation, excavation, and validation activities. During the delineation studies, 10% of samples collected will be split, with the duplicate samples being sent to ALS. A minimum of ten soil samples per week (collected during the delineation studies) will be sent to NEERI for their in house analysis. This will serve as a second QA/QC check on the field analytical instruments being used at the site for mercury analysis.

Mercury analysis conducted by ALS consists of two analytical components as described below:

- Hot block digest for metals in soils. USEPA Method 200.2
- Analysis of total mercury in soil by Cold Vapor/ Flow Injection Mercury System (CV/FIMS). American Public Health Association (APHA) Method 3112 Hg-B

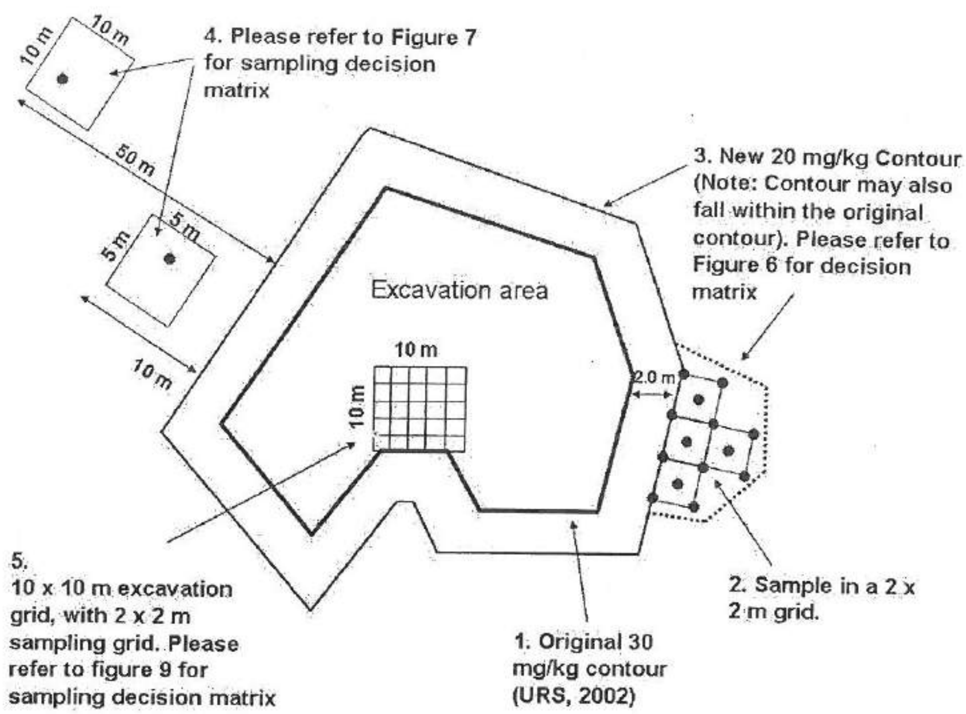
All the analytical instruments that will be used on site during remediation will be duly calibrated on a routine basis. Calibration certificates from the suppliers will also be kept on file at the site office.

7.3 *SOIL SCREENING PRIOR TO EXCAVATION TO ESTABLISH SPATIAL AND VERTICAL LIMITS OF MERCURY PRESENCE ALONG THE PERIMETER OF IDENTIFIED EXCAVATION AREAS*

The last investigation of mercury distribution in soil at the site was performed by URS in 2002 and by NEERI in 2005. It is essential that a thorough sampling plan be developed and conducted prior to excavation works, in order to delineate the present spatial extent of mercury contamination.

An initial soil survey prior to excavation and treatment will be conducted along the perimeter of the excavation areas to evaluate the spatial distribution of mercury. The XMET 3000 XRF will be used for field screening of soil samples. The Ohio Lumex analyzer will be used for on site analysis of soil samples. 10% of soil samples collected during the delineation study will be sent to ALS for QA/ QC purposes. Soil samples shall be collected within a 2 x 2 m grid along the 30 mg/kg contour identified by the URS contour map (*Figure 2*). Please refer to *Figure 4* for a broad schematic description of the pre excavation screening.

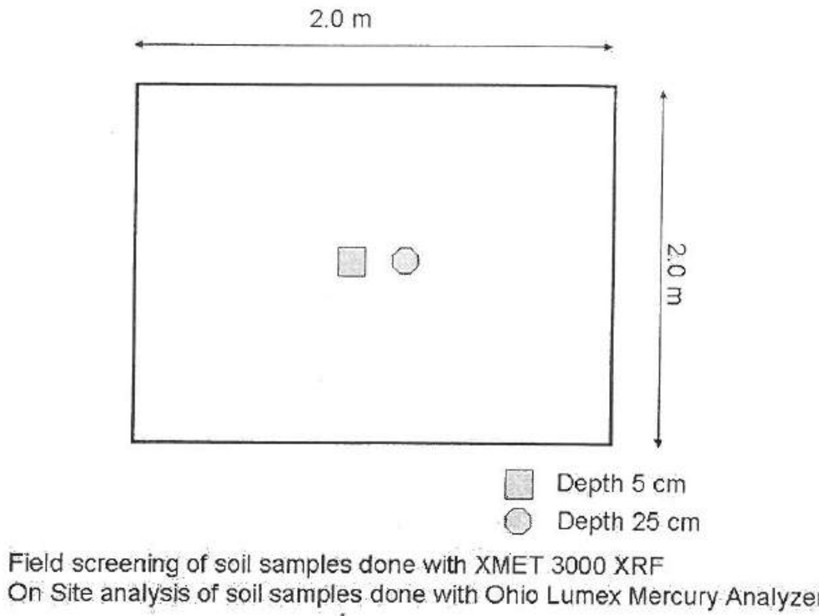
Figure 4. *Pre excavation soil screening and sampling schematic*



Soil sampling and analysis will include development of a sampling grid and plan that ensures a low human health risk associated with the probability of missing a mercury impacted area in soil.

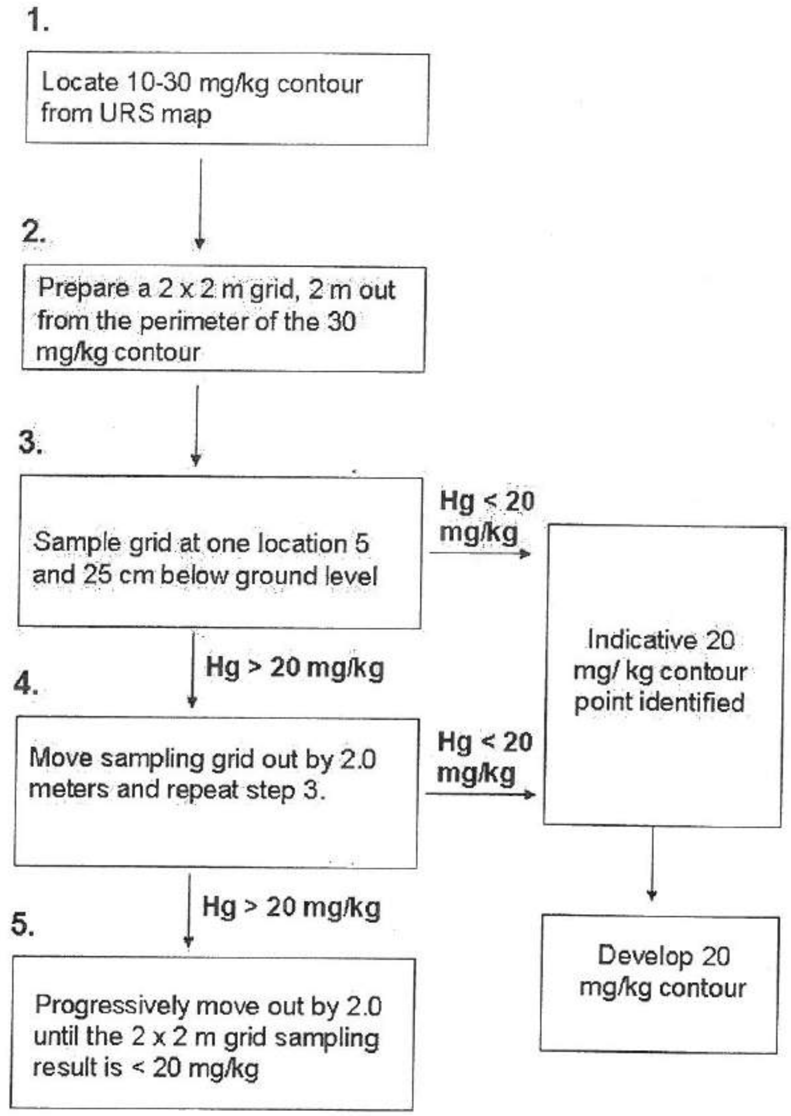
Sampling of soil in a 2m x 2m grid (Please refer to *Figure 5* for a sampling grid schematic) within the contaminated areas provides a reasonable balance between the level of confidence in the delineation of contamination and the time associated with the survey. Generally, soil sampling design has the objective of estimating average concentrations or total amounts in a study area. Elemental mercury is relatively immobile in soil and would tend to remain in the deposition zones, leading to a spatial distribution across the study area that would be very uneven. The sampling grid therefore has to be relatively fine, to ensure that mercury impacted areas will not be missed. There is however a practical limit on the grid spacing.

Figure 5 *Soil sampling grid schematic*



The URS contour map shall be used as a base map from which sampling will begin. Sampling shall be carried out within three areas; (a) along the identified 30 mg/kg contour of excavation area to fix the 20 mg/kg contour; (b) upto a distance of 10 m from the 20 mg/kg contour identified in the new phase of sampling; and (c) upto a distance of 50 m from the 20 mg/kg contour from the new phase of sampling.

Sampling along the perimeter of the identified excavation areas (A, B, C1 & C2) shall proceed as follows (please refer to Figure 6 *for a decision tree schematic on the screening and sampling protocol)Figure 6 Decision matrix for evaluating the spatial and vertical extents of excavation required along the perimeter of contaminated areas*



1. Along the identified 30 mg/kg contour of each excavation area (A, B, C1 and C2), soil sampling and analysis shall be conducted within 2 x 2 m grids.

2. Within each 4 m^2 grid, soil samples shall be collected at one location 5 and 25 cm below ground level.

3. If mercury is detected above the remediation criteria of 20 mg/kg, then the 4 m^2 sampling grid shall be extended out by another 2 meters, until such a point where mercury concentration are less than 20 mg/kg. The 20 mg/kg contour will thereby be established as the new perimeter of each excavation area.

4. Beyond the 20 mg/kg contour (perimeter of excavation area) sample at one location shall be collected randomly within a 25 m^2 area (please refer to *Figure 7* for decision matrix). Samples will be collected at 5.0 and 25 cm depths. This random sampling shall be conducted upto a maximum distance of 10 m from the 20 mg/kg contour line established in step 3.

5. Within a distance of 50 m from the 20 mg/kg contour, one (1) location shall be sampled at two depths (5.0 and 25 cm bgl) within a 100 m^2 area. Please refer to *Figure 7* for the decision matrix.

6. Some screening samples shall be collected at two depths at random across the rest of the site.

7. Sampling will always be biased towards previous historical presence of mercury impacted areas, and also past use of mercury at certain areas within the sites.

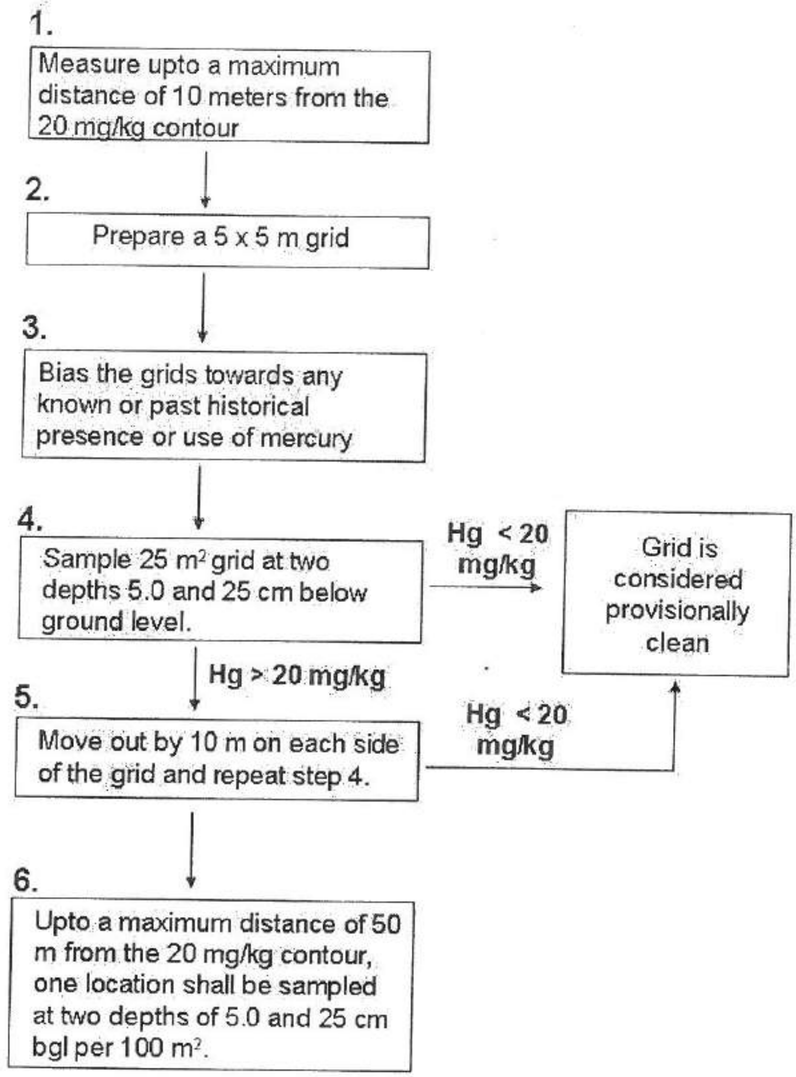
8. When the sampling location within a grid indicates mercury concentration below 20 mg/kg, the area can be certified as "provisionally uncontaminated".

9. Revisions to the remediation areas to be excavated will be made based on the results obtained.

10. The XMET 3000 XRF units will be utilized on for quick field screening of soil samples

11. The Zeeman mercury analyzer will be calibrated against the standard laboratory analytical procedures followed by ALS Laboratory Service and NEERI, by analyzing split samples and also reference material obtained from a certified supplier.

Figure 7 *Screening and sampling outside the 20 mg/kg contour line*



Soil samples for field screening and on site laboratory as well as off site laboratory analysis will be collected as per the protocol given below:

- Remove organic substances such as grass, stones and dry leaves from the location where the soil sample will be taken;
- With a duly decontaminated hand auger, advance the boring to the desired depth;
- Using Nitrile gloves collect the soil sample and transfer to the appropriate cleaned sampling bottle or zip lock bag;
- Close the sampling jar or zip lock bag well and avoid any void space where vapours may accumulate;

- Mark the soil sample location identification code, date of sampling, time of sampling, and analysis required with a permanent marker;
- Make the same field notes on the appropriate soil sampling log book;
- If samples are to be shipped to Australia for analysis, prepare the required chain of custody form, along with all the other required paper work for shipment of samples;
- If soil samples are to be analysed on site, move the samples to the on site laboratory so that they are analyzed on the same day; and
- Make sure that the excess soil cuttings from the sampled location are collected and stored in a drum, for soil washing/ retorting at a later stage.

The mercury delineation map, that was based on the detailed investigations carried out in 2009/10, as per the above approved plan are annexed to this report as *Annex A2*.

7.4 *BUILDING DEMOLITION*

Within the identified excavation areas, three buildings, i.e. the mercury recovery room, distillation room and old bakery shall be demolished prior to excavation activities beginning. Based on the evaluation of mercury concentrations these building are contaminated with mercury, as shown in the building evaluation maps (*Figure 23 A-E*). Therefore the paint, plaster, and concrete up to the brick layer shall be scraped off the interior walls, collected in steel drums and then retorted after the facility is installed. These buildings will then be demolished and the rubble used for upgrading existing pathways , building retainer walls, fillings and construction of compound wall etc. The building debris will be tested before usage on site. More details on building demolition is presented in Section 10.

7.5 *BARK AND LICHEN ANALYSIS*

Mercury concentrations were analysed in bark and lichen samples by URS and NEERI in 2002 and 2007, respectively. The elevated levels of mercury in the bark and lichen samples in the first round of sampling in 2002 was probably due to the absorption of mercury vapours from the atmospheric discharge during the operation of the plant over the years. Since the plant is shut and the sources are eliminated, the accumulated mercury in the bark and lichen continues to come down due to growth and decay as can be seen from the results obtained by NEERI validation study (2007) which was carried out after ~3 years of the URS study. Moreover the elevated levels found in barks and lichens will have no impact, as they are not likely to get in to the food chain.

Nevertheless, random bark and lichen samples shall be collected and analyzed for total mercury across the site. Analysis of bark and lichen samples for total mercury will be according to the analytical methods described in section 7.2.

Any bark and lichen that have been reported to exceed 20 mg/kg will be removed in that area and drummed and stored to be disposed of in a TSDF.

8 EXCAVATION ACTIVITIES

Excavation in each of the Areas A, B, C1 and C2 will proceed in a phased sequence, commencing with areas where mercury concentrations are reported above 100 mg/kg, based on the new round of spatial and vertical extents of contamination. These impacted areas located within each area shall be excavated first and treated. Following the excavation of any identified mercury impacted soils within an excavation area, the entire area will be excavated. The phasing of excavation will begin with areas A, B, C1 and ultimately C2. Excavation will be conducted in 10 m x 10 m grids. The excavated area will be filled with virgin/ uncontaminated soils.

With the exception of Area B and the southern section of Area A, where the terrain is steep, all other excavation activities will be carried out with a mechanized excavator (JCB or equivalent). Excavation at Area B and some portion of A will be carried out manually.

8.1 SITE PREPARATION AND STAGING

8.1.1 Development and demarcation of on site work area

Prior to initiation of excavation, the areas identified will have to be developed in order to allow for easy access of equipment and to allow for phased excavation and transport of impacted soils. Safety measures shall also be in place in areas of steep slopes. Sediment retaining fences, wire mesh/ safety net shall be installed down slope of manual excavation areas. During manual excavation of Area B and southern section of Area A, soil shall be conveyed to the to the Ponds pathway using a mechanized conveyor. To the extent possible, manual carrying of soil along steep grades shall not be allowed. From this point, excavated soil shall be transported to the treatment area via tractor, trolley. Other activities will include indicative boundary staking, construction of access roads, identification of decontamination zones for each of the excavation areas, removal of bushes and shrubs.

Along the perimeter of each area that is to be excavated, seven foot barriers will be erected to minimize unwanted traffic across the active excavation area, minimize soil erosion, and maintain effective access control mechanisms during the active phase of excavation. Areas that are undergoing active excavation will have the appropriate hazard signs and warning tape.

Existing pathways/ driveways will be upgraded to allow for safe movement of material and equipment (excavator, tractors, and trailers). Where access roads do not exist to access the excavation area, the same will be laid on a temporary basis. Driveways and pathways will be upgraded or built in such a manner, so as to provide a rational and logistical manner for which material can be moved to the treatment area and back to the excavated area post treatment. This is done in order to have proper material movement to the plant area where remediation of excavated soil will be carried out.

8.1.2 *Barriers for prevention of cross contamination and soil erosion including drainage re-orientation and control*

During the excavation phase there is potential for soil erosion and surface water runoff during rain events. In order to prevent soil erosion and surface water runoff that could potentially lead to cross contamination in non contaminated areas, the following measures will be implemented:

- Cut off drains and/or berms will be installed upslope of excavation areas to prevent storm water runoff from outside entering areas being excavated.
- All existing storm water drains shall be clearly identified, cleared, desilted and upgraded prior to any excavation works commencihg on site. In areas where current drainage pathways are affected by excavation works, temporary diversions (taking into account the local contours) will be constructed to allow the system to function satisfactorily. Please refer to *Figure 8* for an indicative schematic on re-orientation of drainage channels affected by excavation activities.
- Straw bales or other sediment retaining control structures will be placed around the perimeter of the excavated area to minimize the potential for both run-on and run-off from surface water and sediment during rain events.
- In order to minimize surface runoff in the excavated areas, high density polyethylene (HDPE) sheets will be used to cover the exposed soil surface allowing water to drain from the area without causing soil runoff during rain.
- The existing silt traps will be cleaned prior to excavation works, and thereafter routine maintenance and cleaning will be conducted.
- Sediment retaining traps will be erected around excavation areas to prevent silt contaminated water leaving these areas. Sediment control structures in the form of silt fences/diversion drains/bund shall be installed in the catchments zones of each of the four major excavation areas prior to any excavation commencing.
- No surface drain or excavation dewatering drain will discharge directly into any off site permanent watercourse without having first been diverted through a sediment control measure.
- Routine monitoring of collected silts from traps and storm water for mercury shall be carried out on a weekly basis.

In areas where there is a steep grade and excavation is planned, soil erosion prevention mechanisms will be put in place. The initial site inspection identified two locations which might require special soil erosion prevention measures; one on the southern edge of the bakery building, and the second on the southern end of Area B. A temporary drain will also be provided at these two locations to collect any surface runoff from the excavation area and route it to the main drain situated on site.

It is essential that the erosion and sediment control measures be frequently inspected and have any repairs implemented if any is required. The Project Manager is responsible for ensuring that this inspection and maintenance is conducted frequently/adequately.

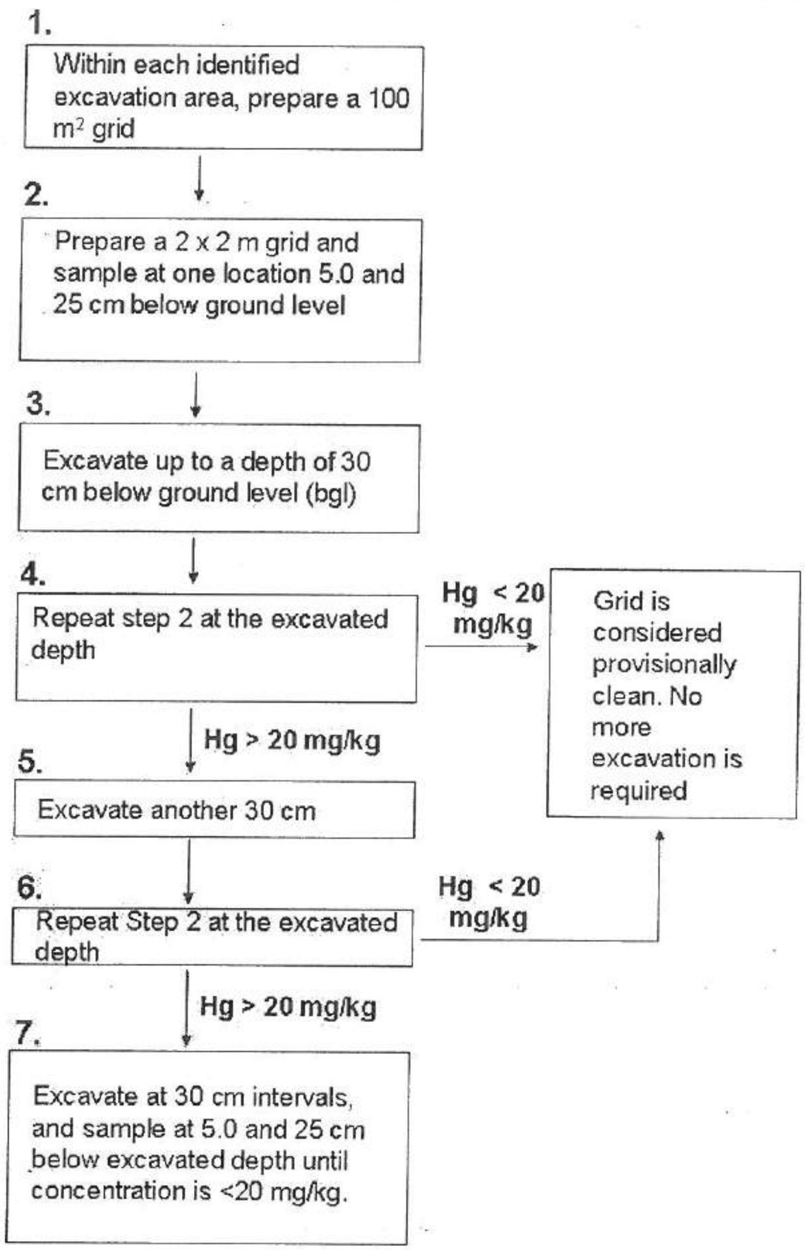
All existing drainage and erosion control facilities will be inspected regularly, or after each rain event, and cleaned or repaired, as required.

Soil samples from non contaminated areas within the site will be analysed during the pre remediation activities for biological parameters, including total bacterial counts, enzymatic activity, organic carbon content, moisture, pH, essential nutrients including carbon (C), nitrogen (N), phosphorous (P), and potassium(K) amongst others. This will be done in order to establish a baseline of soil quality at non contaminated areas across the site.

8.2 *SOIL SCREENING DURING AND AFTER EXCAVATION TO TEST WHETHER REMEDIATION CRITERIA HAVE BEEN ACHIEVED*

Within each identified area, excavation shall proceed in 10 x 10 m grids (please refer to *Figure 9* for decision matrix). Initially, 30 cm of soil shall be excavated, with the identified contaminated areas being removed first. Once the depth has been excavated, a second round of soil sampling and screening shall be undertaken. Soil samples shall be collected at a depth of 5 and 25 cm below the excavated depth, within the previously described 2 x 2m grid. If the mercury concentrations are below 20 mg/kg, then the grid can be reported as provisionally clean and shall not require further excavation and treatment. If, however, mercury concentrations are still above 20 mg/ kg, then the soil shall be excavated up to 60 cm below ground level. Once this depth has been excavated, then screening and analysis of soil for mercury at 5and 25 cm below the excavated depth shall be undertaken. This process of excavation and screening/validation shall be continued until such a point where in all the sampling points within the $4m^2$ grid report mercury concentrations below 20 mg/kg. In case basement rock is encountered, then excavation shall be ceased.

Figure 9 *Decision matrix for sampling/ validation in excavation areas.*



Note: Areas where mercury concentrations > 20 mg/kg shall be excavated first

8.3 *PHASED AND CONTROLLED EXCAVATION*

8.3.1 *Dust and vapour control measures*

Activities carried out on site will be such as to ensure that all equipment used are designed and operated to control the emission of smoke, dust, fumes and other objectionable matter into the atmosphere. If necessary, water spraying will be undertaken to minimise any airborne dust caused by the remediation works.

Equipment / Vehicles will be properly maintained to ensure exhaust emissions are within limits. The soil washing treatment train will have special air handling units to control any dust generated during the process. Air from the vacuum retort room, will be handled separately by passing the air through activated carbon units.

The following dust and mercury vapour control procedures will be strictly adhered to:

- Air handling units shall be placed across the soil washing treatment train, in order to collect any fugitive vapours or dust that may be generated from sieving action. The use of water during the washing process will suppress dust and mercury vapour generation, however as a redundancy, these air handling units will route the air through activated carbon filters.
- The entire vacuum retort assembly, including drying and cooling, shall be conducted in a separate room, which is under a constant negative pressure. All vapours and air will be routed through activated carbon units in order to trap any fugitive vapours that may be generated from the retorting process.
- Vapours that may be not be condensed in the condenser unit, shall also be routed through the activated carbon columns.
- Water sprays may be used across the excavation area to suppress dust if necessary. The water will be applied by water sprinklers across ground surfaces whenever the surface has dried out and has the potential to generate visible levels of dust either by the operation of equipment over the surface or by wind.
- Seeding/grassing of validated areas.

Mercury concentration in air will be monitored using a Jerome 431- X Mercury Vapour Analyser (the NIOSH time weighted average for mercury vapour is 0.05 mg / m^3). Vapour monitoring will be conducted within the plant area and also where active excavation activities are ongoing.

8.3.2 *Soil handling and Internal transport*

Most of the excavation work will be carried out with a back hoe excavator (JCB or equivalent), with the exception of Area B and south of Area A (Old bakery building), due to the steep grade. During heavy periods of rain, all excavation pits shall be covered with HDPE sheets, and excavation activity ceased until a time when surface water runoff has ceased across the excavation area. Surface water runoff from the HDPE sheets will be routed to the drains that contain silt traps.

One excavator (*"Bobcat" or equivalent*) shall be used to excavate the soil within the designated grid. Soil will be excavated nominally up to a depth of 30 cm, unless otherwise reported by the on site field screening results. After the required depth has been excavated, further soil sampling and analysis shall be conducted to validate whether mercury concentrations are less than 20 mg/kg. If concentrations are reported to be higher than 20 mg/kg, another 30 cm shall be excavated until a depth is reached where mercury concentrations are less than the remediation criteria of 20 mg/kg.

Excavated soil will be transported to the main plant for treatment by use of a tractor with a self unloading trailer. It is estimated that on an average, approximately 10-15 tons of soil per day will be hauled to the main plant for processing. As discussed earlier, drive paths will be constructed in each area undergoing excavation, which link to the main drive path to and from the main plant area.

It is envisaged that excavation, transport of excavated soils, and backfilling of virgin/ uncontaminated soil be carried out simultaneously at different places. One or two tractors are envisaged for transporting the soil from/ to excavated areas. It is anticipated that in this manner, material balance will be maintained with minimal need of stockpiling of soil. Please refer to *Figure 10 & 11* for a schematic plan map of material flow from the point of excavation to backfilling.

8.4 *TEMPORARY STOCKPILING OF MATERIAL*

Excavated or treated soil stockpiling will be kept at a minimum. There shall be no stockpiling of more than one days supply of material within the process treatment area and excavation areas. The need for temporary stockpiling is required in case of equipment failure or maintenance or process requirement. Also it may be required to stockpile the treated soil prior to offsite disposal. It is anticipated that stockpiling will be done within the main plant area where washed soil / retorted soil shall be stored in 200 litre steel drums, for QC clearance / further treatment. If stockpiling is required, it shall be under the following conditions:

- Soils will be stockpiled in a designated area, with containment berms surrounding it.
- Soil piles (excavated soil and treated soil) will be in a covered factory shed or covered with a HDPE sheet.
- Excavated soil shall not exceed more than the processing capacity of one day.

8.5 *PRESERVATION OF TREES*

Wherever trees are encountered during excavation, a 1.0 meter radius around the tree will be maintained where manual excavation will proceed to the required depth. Backfilling and provision of adequate soil cover after manual excavation will ensure that minimal stress will be subjected to trees. If support structure can prevent tree falling, the same will be provided to protect the trees. In cases where the stability of trees is known to be poor and pose danger to safety, it may be necessary to remove such trees, thereby ensuring safety. For each tree that is felled or that falls down, two trees will be replanted on site.

9 SOIL REMEDIATION

9.1 SOIL WASHING

9.1.1 Process:

The soil washing process will be a continuous, water-based, screening process that is based on two mechanisms:

1. Removal of mercury from coarse-grained soils.
2. Separation of the washed coarse-grained soils from fine-grained soils with the preferential concentration of mercury in the fines fraction.

Results from the soil washing pilot experiments, conclusions and recommendations for full scale design are presented reporting *Annex A* of the report.

Elemental mercury will tend to physically adhere to the fine-grained soil fraction (silts and clays) due to the greater surface area and high cation exchange capacity of this fraction. The silts and clays, in turn, tend to adhere to coarser sand and gravel particles. The soil washing process results in a coarse-grained fraction that contains residual mercury at low concentrations, and a fine-grained fraction that contains mercury at high concentrations, due to beneficiation and concentration of mercury into that fraction. The soil washing process thereby reduces the volume of soil that needs to be retorted in order to reduce mercury concentrations below remediation criteria.

The soil washing process involves the sieving of excavated soil to a particle size less than 30 mm with the larger size fraction having been washed; mixing this soil with recycled process water in a screw washer; and separating the soil into a relatively clean coarse fraction, and a contaminated fine fraction). Please refer to *Figures 13, 14 and 15* for a flowchart, layout and plan elevation of the soil washing equipment train, respectively.

The soil washing process will be carried out in individual horizontal screen separators that each have a single sieve mesh. Each vibratory sieve has a single mesh size and is powered by two vibratory motors, one of which provides a horizontal vibratory action, whereas the second provides a vertical vibratory action resulting in a 45° angle sieving action. Each vibratory screen will be approximately 3 m in length. Forced water or water jets will be used to wash the input soil along the first half of the screen; while the second section is for the purposes of dewatering the washed soil to the maximum extent possibly. Each oversize fraction from the respective sieves will be collected in steel drums, to be analyzed and verified whether the remediation criteria have been achieved.

Washing of material with grain size larger than 30 mm

The following are the steps that will be used for washing of soil with grain size larger than 30 mm and vegetation;

Initially, the excavated soil will be mechanically sieved in a vibratory sizer to less than 30 mm in size. Plants and vegetation will be cut at the root level, with the roots and adhering soil being washed in a separate unit, whereas the remaining biomass will be stored separately and analyzed. Materials greater than 30 mm in size will predominantly consist of rocks, gravel, biomass and vegetation collected during the excavation. This oversize fraction (> 30 mm) is sent to an agitator containing water to remove any adhering soil particles from rocks and vegetation. Through a separator, this washed soil is separated from the rocks and vegetation and routed to a screw washer, whereas the rocks, biomass and vegetation are collected separately as a washed fraction. The washed vegetation and rock that have been washed will then be air dried and analyzed for total mercury content. If mercury concentrations in the washed vegetation are higher than 20 mg/kg, the washed and dried matter shall be stored in HDPE bags in drums. This material will be transported and disposed at the authorised TSDF.

Washing of material with grain size less than 30 mm

The following stages and equipment will be used for washing of soil with grain size less than 30 mm;

screw washer; 1st stage screening; 2nd stage screening; slurry making chamber; 3rd stage screening; 4th stage screening; 5th stage screening; 6th stage screening; 1st stage hydro cyclone; 2nd stage hydro cyclone.

After the initial screening, the soil will be transported via an encapsulated conveyor to the highest point of the treatment facility and is transferred downward by gravity and series of conveyors through the various washing and separation steps.

First, the soil is fed continuously to a screw washer unit where it will be mixed with water at a rate of one cubic meter of water per metric ton of soil. Feed water to the screw washer will be treated process water. A constant feed rate of contaminated soil will be maintained by a feed control system.

The soil/water slurry exiting the screw washer unit will be transferred to two separate stages of screening consisting of a single screen of 6 mm mesh size (3 m length; half the length under forced water and second half for dewatering) and a second single screen of 2 mm mesh size of similar dimension as mentioned above. All oversize material will be analyzed for mercury concentrations.

After this the soil fraction consisting of grain size less than 2 mm is introduced into a slurry producing chamber. From here the slurry is passed through the next four stages of screening with screens of 1 mm mesh size, 0.6 mm mesh size, 0.3 mm mesh size and finally through a 0.1 mm mesh size. At all these stages forced water will be used as described above to wash the fractions. All oversize material will be analyzed for mercury concentrations before being routed to a blender, or back to the treatment train, in case remediation criteria have not been achieved.

The soil fraction that has a grain size < 0.1 mm along with process water will be passed through the first set of hydrocyclones. Here, it is anticipated that the fines with grain size ranging between 0.03 mm and 0.1 mm will get settled out along with mercury.

The process water from the first set of hydrocyclones is passed through a second set of hydrocyclones, where the very fine particle size (< 0.03 mm) will be settled out with mercury. The fines, in the form of a sludge (and concentrated mercury) that are collected from these two hydrocyclone sets will subsequently be transferred into the vacuum distillation/ retort/ condensing unit for the recovery of elemental mercury.

All soil fractions that have been washed at the various stages, collected and found to contain mercury concentrations < 20 mg/kg, will be disposed to the authorized offsite TSDF.

9.1.2 *Equipment including capacity*

All the soil washing equipment modules are designed to handle a throughput of 2 tons/hour of soil.

Please refer to *Figure 14* for a detailed schematic of the individual pieces of equipment that are listed below:

- Vibrosizer (30 mm mesh);
- Stone washing unit and
- Vegetation/biomass washing unit;
- Screw washer (6 m length);
- Six vibrating screens, 3 m length each, forced water jets for 1.5 meters length of screen, dewatering for the remaining 1.5 m length (6 mm, 2 mm, 1 mm, 0.6 mm, 0.3 mm, and 0.1 mm mesh size);
- Slurry making chamber;
- Collection bins for washed fractions;
- Two hydrocyclone batteries containing ten of each;
- screw conveyors;

9.1.3 *Process water treatment*

The following two streams of process waters will be generated from the washing activities:

- Process water from the soil washing activities approximately 5 m^3/hour for a 8 hour operational shift; and
- Process water from the rock, gravel and vegetation washing activities approximately 1 m^3/hour for a 8 hour operational shift.

The Process water from the rock, gravel and vegetation washing activities will be pre-treated through screens and grit chamber to remove the floating solids and coarse solids. The resultant process water stream shall be mixed with the process water from the soil washing activities and collected in an equalization tank. The retention period of the equalization tank will dampen the flow fluctuations as well as provide sufficient holding time in case of any process disruption. All water that is derived from the plant floor washing during regular housekeeping and maintenance shall be pumped into the process water treatment plant. The representative flow chart of the process water treatment train is provided in *Figure 16*. The sectional elevation and plan map of the above ground water treatment facility is provided in *Figure 17*.

The process water will be discharged to a mixing tank where flocculants and other settling agents will be added. The mixing tank will be provided with a flash mixer for adequate mixing of the flocculants. The process waters will be then passed through a primary clarifier tank in order to settle the suspended solids. The treated effluents will be stored in a treated water tank. The treated process waters will be further treated through a pressurized sand filter and an activated carbon filter and stored in storage tanks. The treated water will reused for the soil washing process, dust suppression on site and also for watering seeded grass at backfilled areas.

The sludge generated from the grit chamber, equalization tank and the primary clarifier will be collected. The effluents from the filter press will be rerouted back to the equalization tank while the dewatered sludge will be treated in the vacuum retort chamber to remove any residual mercury.

Periodic testing of process water including prior to treatment and post treatment shall be undertaken on a weekly basis to ensure that the treatment process is effective and monitor mercury levels in treated process water and sludge.

The entire process water treatment shall be constructed outside the treatment process area, in above ground structures. Treated process water shall be released on a regular basis for dust prevention measures, and for watering the new vegetation on backfilled areas. This is done in order to maintain the quality of water during soil washing and prevent the buildup of dissolved organic matter that is derived from the soil itself, in the process water. Before release, the treated process water shall be analyzed for Biological Oxygen Demand, Chemical Oxygen Demand, and Total Mercury to confirm to discharge standards. In the initial stages of treatment, the process water shall also be analyzed for total suite of chemicals to evaluate the quality of treated process water.

9.1.4 *Equipment including capacity*

All equipment will be sized to handle a minimum process flow of 6-7.5 m^3/hr. Equipment includes:

- Equalization tank;
- Dosing tank;
- Clarifier;
- Pressurized sand filter
- Filter press;
- Activated carbon columns; and
- Treated water storage tank;

9.2 *VACUUM RETORTING*

9.2.1 *Process*

Results from the vacuum retorting pilot experiments, conclusions and recommendations for full scale design is presented reporting *Annex A* of the report.

The fine grained), highly contaminated fraction, i.e., not meeting the remediation criteria of <20 mg/kg of soil that is generated by the soil washing process is transferred as a slurry/ sludge to the vacuum-distillation unit. The vacuum-distillation process involves heating the contaminated fine fraction soil to a temperature high enough to volatilize mercury. Vacuum retorting will be conducted at $1/10^{th}$ of atmospheric pressure, and at a temperature of approximately 400°C. Residence time of soil within the vacuum retort will be between 30 minutes to an hour. Mercury vapours that are generated will be condensed and collected in an appropriate vessel that is under vacuum. Activated carbons units will be placed post collection vessel in order to trap any fugitive vapours that may escape condensation.

The vacuum-distillation process consists of four primary units (Please refer to *Figure 19, 20 and 21* for a flowchart, cross sectional view and cross sectional elevation diagram of the vacuum distillation process and equipment).

The dryer, the vacuum-distillation unit, and the cooler each will have an outside diameter of 0.75 meters (m), an overall length of 10 m, and will rotate at 1 revolution per minute. The maximum throughput of the vacuum-distillation unit will be approximately 300 kg per hour.

The fines/ solids will be fed to a dryer that is heated indirectly by hot air to approximately 100° C. The hot air will be produced in a non contact heat exchanger using excess thermal energy from the cooler of the vacuum-distillation unit. The residence time of the soil in the dryer is approximately 30 minutes. Soil exiting the dryer will have a residual moisture content of less than 1 percent by weight. The air from this drying step will be treated in the process air treatment process. Solids exiting the dryer will be fed through a double chamber vacuum lock via a screw-conveyor to the vacuum-distillation unit, a cylindrical vacuum retort. Under vacuum conditions and an average temperature of 400°C, mercury will be volatilized from the soil.

Mercury vapours will be transported under a vacuum to a double stage condenser, where under low temperatures, the vapours will be condensed in a collection vessel. Any fugitive vapours that may escape the condensation stage will be trapped onto granular activated carbon units.

After passing the vacuum-distillation unit, the soil is transported via a screw conveyor to a cooler. The cooler is a water-cooled rotating drum. The cooled soil (temperature less than 50°C) passes a dual chamber vacuum lock and enters the mixer via a conveyor belt and a vertical discharge pipe.

The washed and retorted soils that meet the 20 mg/kg criteria will be then transported and disposed to the authorised TSDF located in Virudhnagar Distrcit, Tamil Nadu. Fresh virgin/ uncontaminated soils will be used for filling the excavated areas.

9.2.2 *Offsite Disposal*

An appropriate staging area will be set up on site for the loading of treated soils prior to transportation to the authorised offsite TSDF. All treated soils meeting the 20 mg/kg criteria will be stockpiled in this area. Adequate protection and dust control measures will be in place to manage this stockpile.

Dedicated/ TNPCB approved Hazardous waste trucks with appropriate signage, Manifest management Systems, TREM cards and other applicable regulations and rules will be employed for the transportation of the treated soils to the offsite TSDF.

Transportation related risks and Emergency Response Plans have been covered briefly under the Health & Safety Plan section and a detailed Plan will have to be developed.

Virgin/ uncontaminated soil from outside the subject site which is not contaminated will be also bought in.

9.2.3 *Equipment including capacity*

All the vacuum distillation equipment modules are designed to handle a throughput of 0.3 tons/hour of contaminated soil.

Equipment include

- Filter press;
- Hopper;
- drying chamber;
- vacuum retort;
- double stage condenser;
- mercury collection vessel;
- heat exchanger; and
- cooling chamber.

9.2.4 *Off gas treatment*

The entire vacuum retort system will be enclosed within a closed room in the main plant area. The entire room will be under negative pressure, to ensure that no fugitive vapors are emitted to the main floor. All air from this area will be routed through a pair of activated carbon columns.

Air handling units will also be placed at locations across the soil washing train, in order trap any dust and fugitive vapors that may be generated.

The activated carbon columns shall be replaced before breakthrough occurs. Daily monitoring of the process water from the carbon traps shall be conducted.

9.2.5 *Equipment*

Equipment include

- Air handling units
- Dust collection units
- Activated carbon columns for the Retort room and air handling units
- Activated carbon columns for the retort equipment/condenser unit

9.2.6 *Equipment design and manufacture*

All equipment shall be sourced for design, manufacture and commissioning to a reputed companies located within Tamil Nadu. The equipment drawings / flow diagrams attached to this report under Section 9 are subject to revision while final design and manufacture for improving the performance.

The following is a list of the engineering diagrams that have been provided as an addendum to this report. Modifications, if required, to the equipment may be done, during the equipment manufacture.

- Soil washing system
- Retort System
- Process Water Treatment System
- Off gas treatment
- Stone Washing System
- Vegetation Washing System
- Plant layout

If required the treatment equipments will be operated in two shifts after sufficient experience is gained if the total throughput volume needs to be increased. Retorting capacity is very critical to complete the remediation within the scheduled time. Therefore the retort may have to be operated in shifts. However, soil excavation work will be carried only in the day shift.

9.3 *MONITORING FRAMEWORK*

During the remediation activities at the site, the stakeholders will be engaged in the monitoring of the project as per the TNCPB Letter No. T14/YTNPCB/F.27566/HUL/DGL/2009/Dt 12.02.09

10 POST SOIL REMEDIATION

10.1 SAMPLING AND ANALYSIS OF TREATED SOIL FOR MERCURY AND PHYSICAL, CHEMICAL AND BIOLOGICAL PARAMETERS

Screening and sampling for mercury concentrations in soils before and during excavation are described in Section 6.3 and 7.2, respectively.

Each soil fraction that has been passed through various soil washing and retorting will be analyzed prior offsite disposal. There will be two types of treated soil derived across the various treatment processes; washed soil of different particle size and retorted soil. These various fractions shall be collected in 200 liter drums, at various points along the soil washing treatment train.

- For the washed soil fractions, one samples shall be collected per drum of treated soil. If the analysis shows that remediation criteria of 20 mg/kg have been achieved, the soils shall be sent for offsite disposal.
- If the analysis shows otherwise, where concentrations are above 20 mg/kg, then the samples shall be rerouted back into the soil washing treatment train or testing.
- Retorted soils shall be analyzed at a frequency of 5 samples per ton of treated soil. Acceptance criteria shall be similar to those mentioned above
- All soil fractions that have met the remediation criteria will be disposed to the offsite TSDF. Prior to sending the treated soils offsite, samples shall be collected and analyzed at a frequency of 5 samples per ton of treated soil.

10.2 GRADING AND LANDSCAPING

Grading of backfilled soil be done using excavators and heavy rollers, in order to compact the soil and reduce the potential for erosion. Compaction of soil will be done in layers, to the extent that the natural porosity is not altered, thereby making hindering the vegetation to grow. The backfilled areas will be covered with a jute fabric and seeded with local vegetation to minimize erosion and help in the restoration of the site. A landscaping master plan for the site will also be prepared before the backfilling activities with virgin/ uncontaminated soil starts. Only virgin/ uncontaminated soils that meet all cleanup criteria will be used on-site to fill the excavated areas.
Once the excavated areas are filled with virgin/ uncontaminated soils, commercially available biodegradable geo-fabrics or carpet grass (grass turf) will be placed on the soil to prevent it from eroding. In addition, every effort will be made to limit the time between excavation and backfilling. All backfilled areas of the site will be grass seeded and, or protected with jute

mesh or equivalent to stabilise the surface soils and inhibit generation of dust in these areas. There are various commercial geo textiles available that help in stabilizing and revegetation of sites where steep grades may cause instability. These geo fabrics also aid in retaining minerals and organic matter, maintain moisture content, provide a physical substrate for root penetration and gradually biodegrade, leaving a self sustaining erosion control system in place.

10.3 *EROSION CONTROL MECHANISMS*

The backfill area shall be graded to provide stable slopes and to allow for adequate surface water drainage. Various erosion prevention measures shall be undertaken during this activity. The grade of the backfilled slope shall not exceed that of the present site conditions. Retaining bunds shall be erected at regular intervals to help in the stabilization period of backfilled soils. Backfilling procedures will include: placing the material in a uniformly spread loose lift of the proper thickness suited to the compaction equipment; applying the necessary compaction effort to obtain the required densities; ensuring that compaction if of a nature that aeration to the root zone of surrounding trees is maintained. Proper bond shall be provided between each lift and also between the backfill and the sides of the excavation. Natural grade of the site shall be maintained with special attention given to the prevention of water logging and maintenance of a slope where soil erosion does not occur.

10.4 *REVEGETATION PLANS*

Trees shall be planted at a density distribution that allows for maximum potential for growth. As mentioned earlier in the report, for every tree that requires to be felled during the excavation phase, two trees shall be replanted at the site. The trees shall be of the local variety and preferably fast growing. Maintenance of trees and re vegetation shall remain under the purview of ERM during the post remediation monitoring period. However, after this period, maintenance shall revert back to the owners of the property.

10.5 *FILLING AND GRADING OF EXCAVATED AREAS*

Virgin/ uncontaminated soils from outside the site, will be used on-site as backfill.

Once the virgin/ non contaminated soils have been backfilled, commercially available biodegradable geotextiles or carpet grass (grass turf) will be placed on the soil to prevent it from eroding. In addition, every effort will be made to limit the time between excavation and backfilling. All backfilled areas of the site will be grass seeded and, or protected with jute mesh or equivalent to stabilise the surface soils and inhibit generation of dust in these areas. There are various commercial geo textiles available that help in stabilizing and revegetation of sites where steep grades may cause instability. These geo fabrics also aid in retaining minerals and organic matter, maintain moisture content, provide a physical substrate for root penetration and gradually biodegrade, leaving a self sustaining erosion control system in place.

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Natural grade of the site shall be maintained with special attention given to the prevention of water logging and maintenance of a slope where soil erosion does not occur.

11 BUILDING DECONTAMINATION

11.1 CLASSIFICATION OF BUILDINGS AND STRUCTURES BASED ON EVALUATION

Building samples have been collected and analyzed for mercury based on the past historical usage of mercury at each building. Buildings that have not had any mercury history have also been evaluated. Please refer to *Annex G* for a tabulation of the results of mercury analysis from samples taken from the buildings.

During the building evaluation studies, samples were collected from the interior and exterior walls and along the floors of building by chipping away ½ inch of plaster, concrete and brick layers. Care was taken to scrape away the paint before collection of building material.

Building material including plaster, brick cuttings, and concrete floor cuttings were collected and shipped for analysis to Australian Laboratory Services Pty Ltd, in Sydney, Australia. Please refer to *Figure 23 (A-E)* for a plan map of the sampling locations for each building and the results obtained from analysis.

Based on the results the following approach is proposed. Prior to soil remediation commences (i.e. prior to excavation) it has been proposed that the following buildings be demolished:

1) Distillation room;
2) Mercury recovery and extension room; and
3) Old bakery room

The interior wall surface of the above buildings has been found to be contaminated with elemental mercury at levels above 20 mg/kg.

Also the structures in the contaminated area such as old ETP structure, sewage treatment plant (STP), Rain water collection tank, Structure around the natural spring, Well, Unused earth pits, Unused water sump, Cooling tower sump, Incinerator structure etc are to be demolished.

When post remediation activities have been completed and the site has been validated , the main plant building shall be demolished The remaining buildings on site which include the utilities building and old administration building shall also be demolished after the soil remediation phase. Also, all other remaining structures such as ETP, STP, etc. at the site will be demolished. The slit traps and retaining walls etc will not be demolished.

The procedure to be adopted are : scrapping the contaminated interior wall surface and filling into steel drums for retorting , testing the wall / structure after scrapping , demolishing the building structure ensuring safety and utilization of residual building debris and materials.

Based on the results of mercury analysis from the building surfaces, rubble from the demolition will be segregated into contaminated and non contaminated material. The paint, plaster and concrete layers from affected structures will be scrapped up to the brick layer and retorted. Building surfaces that have been classified as contaminated (mercury concentrations > 20 mg/kg) from the evaluation studies will be. The total estimated volume of building material in the form of concrete and plaster that will be retorted will range between 20-25 m^3 (i.e. approximately 50 MT of contaminated building wall scrapings and debris are to be retorted). All other building material that has been classified as non contaminated will be utilized on site for construction of retainer walls, pathways, filling materials for landscape and other constructions.

Prior to demolition, the interior walls of the contaminated building will be scraped off up to a depth of 25 mm. The material from these activities will either be sent for retorting or drummed and classified as hazardous / contaminated material, to be disposed off at an appropriate Treatment Storage and Disposal Facility after checking the leachability.

Asbestos cement sheets will be collected prior to building demolition, bundled in plastic sheets and classified as hazardous material to be disposed off at a Treatment Storage and Disposal Facility.

The rubble from non contaminated building material will be used on site for upgrading existing pathways, building retaining walls, filling materials for landscape and other constructions.

There are other materials such as Wood, Steel structures, Glass, Electrical cables, Electrical fittings, Plastics, GI sheets, GI pipes, Ceramic tiles, Ceramic fittings etc will be generated. These materials will be decontaminated using the Decontamination Protocol (please refer to *Annex F*) which was approved and followed by HUL during Plant & Machinery and Materials. The decontaminated scrap will be tested in test chamber and disposed of as scrap to scrap recyclers.

12 VALIDATION AND CLEARANCE

12.1 DECONTAMINATION OF TOOLS, EQUIPMENTS, AND DISPOSAL OF RESIDUAL MATERIAL

At the termination of remediation works, all equipment will be decontaminated prior to being moved off site. Personal Protective Equipment that is contaminated with mercury (e.g., uniform, face masks, gloves, shoes etc) will be drummed and classified as hazardous material to be disposed of in a TSDF. Excavation and transporting equipment such as JCB, Tractor etc. will be duly decontaminated by cleaning with Sodium hypochlorite solution before moving off site. All other small-medium sized equipment and tools that may be potentially contaminated with mercury will also be decontaminated and tested in the Test Chamber facility before removing out of the site. The decontamination protocol will be followed. This protocol was approved for decontamination of plant & machinery and materials at HUL site. Please refer to *Annex F* for a detailed description of equipment decontamination procedures.

Large equipment that has been used in the treatment process will be washed and thoroughly decontaminated. It is proposed that the washing solution be of hypochlorite and following the steps of the decontamination protocol including a stabilizing solution that will bind any residual mercury as sulfides if required. The decontaminated equipment will be thoroughly inspected before moving off site.

12.2 DISPOSAL OF RESIDUAL MATERIAL

It is anticipated that residual material after the remediation phase ,other than the treated soils, is estimated to be 250 MT. The following is a list of the residual material that will be disposed off to a TSDF. Any pre treatment of material prior to transportation to the TSDF is also provided:

- Spent activated carbon will be mixed with Portland cement in order to immobilize the mercury impregnated carbon. Immobilized carbon will be subjected to leachability tests prior to removal of the activated carbon to the Treatment, Storage, and Disposal Facility.
- Bark and Lichen that are shown to contain mercury concentrations greater than 20 mg/kg, will be appropriately bagged, weighed and drummed prior to transportation to the TSDF.
- Mercury cartridges and other PPE will also be bagged, weighed and drummed prior to transportation to the TSDF.
- Asbestos cement sheets
- Other PPE
- Other residual material

12.3 *SITE VALIDATION PROCEDURE*

After the completion of excavation, treatment and filling of excavated areas with virgin/ uncontaminated soils, a thorough site validation procedure shall be implemented. The National Environmental Engineering Research Institute, Nagpur, will be the focal agency undertaking this operation.

The 95% percent upper confidence limit (UCL) for mercury in across the remediated area will be calculated using the mercury concentration data obtained. As per USEPA standards, a sample size of less than 10, will not yield a statistical valid interpretation of the mean concentration of treated soils. Therefore, it is proposed that for each 100 m² of the remediated area (in different depths), a minimum of 14 measurements will be made to estimate the concentration of mercury in the remediated area. Random samples will be drawn across the site. The sampling plan, number of samples and the location will be finalized by NEERI for site validation. One such model for validation is as follows:

$$UCL_{t,95\%} = x + (ts/\sqrt{n})$$

Where:

x = Treated soil arithmetic mean mercury concentration normalized to moisture content (see equation below)
t = Student's t-test for a one tail test at the 95% confidence level
s = sample standard deviation
n = sample size (number of measurements)

$$x = (C_t)(Z)$$

Where:

C_t = Mercury concentration in treated soil (mg/ kg)
Z = Normalization factor

The normalization factor is calculated as follows:

$$Z = \frac{1-M_u}{1-M_t}$$

Where:

Z = Normalization factor
M_u = Arithmetic mean moisture content of untreated soil (g/g)
M_t = Arithmetic mean moisture content of treated soil (g/ g)

The following activities will encompass the site validation procedure:

- Soil survey spread randomly across the remediated areas to determine that soil mercury concentrations are below the remediation criteria.

- Also random soil sample survey across the site other than remediated area.
- Building materials and debris testing and certification.
- Review of material that has been classified as hazardous and duly transported off site to a TSDF.
- Review of all decontamination procedures carried out on site, to determine that all standards and practices have been carried out before sending decontaminated material off site.

12.4 *SITE MANAGEMENT AND POST REMEDIATION MONITORING PROGRAM*

A post remediation monitoring program will be required to monitor the effectiveness of soil remediation. This monitoring program will also evaluate the remediated area with regards to the fertility and vegetative regeneration at those areas. Evaluation of soil erosion prevention measures will also be undertaken regularly. Geo fabrics that have been installed will be checked and replaced on a regular basis, if it is found that they are not effective at preventing soil erosion.

A quarterly monitoring program is proposed wherein soil sampling and analysis for mercury shall be undertaken within the treated soil area , and silt traps, and down gradient locations shall be undertaken to monitor whether any mercury is encountered on and off site post remediation. Silt traps shall be sampled along with all locations downhill of the backfilled areas, including Levange Path. Soil shall also be tested for the major nutrients (Phosphorous, nitrogen and carbon), organic carbon content, and biological activity of the treated and backfilled soil. An inventory and general health assessment of all trees that have been planted on site will also be conducted. If required add manure to facilitate rehabilitation of soil.

13 PROJECT SUMMARY

13.1 ACTIVITIES PHASING

Figure 24 describes the tentative anticipated phasing of activities once the appropriate permits have been received:

Remediation activities include amongst others, soil washing, vacuum retorting, process water treatment, air treatment, offsite transportation and disposal to offsite authorized TSDF, .

The entire project schedule can be indicatively be divided into three phases:
- 3 month of trial runs including upgradation and optimization;
- 24 months of actual remediation activities; and
- 2 months validation, post remediation.

The total project duration is estimated to take 29 months.

Activity will be suspended during monsoon season by the Project Manager and will resume only after ensuring the appropriate measures are in place considering people safety and environment care. Therefore it is anticipated that in a year two to four months may be lost due to the monsoon season.

13.2 RESOURCE AND UTILITIES REQUIREMENT

Equipments and Estimated manpower present on site during remediation phase

Activity/ Phase/ Process	Machinery/ Equipment	Manager/ Engineer/ Supervisors	Skilled Labour
Excavation/ soil transporting/ filling of excavated areas	One Excavator (inclusive of Driver & Signals man) Two tractors (inclusive of driver). Mechanized conveyor soil handing from the excavated area. Water sprayer Soil ramming equipments	3	34
Soil treatment process	Soil washing equipment Vacuum retorting equipment Process water treatment Off gas treatment Drum Handling truck (3) Stones washing chamber.	4	21

Activity/ Phase/ Process	Machinery/ Equipment	Manager/ Engineer/ Supervisors	Skilled Labour
	Vegetation / Roots washing chamber.		
On site Laboratory and Field sampling crew	Zeeman Mercury analyzer (5) , Sampling augers (3), XMET XRF (2), Jerome Monitoring station (1), Jerome Mercury Analyzers (2)	8	6
Health & Safety	Medical equipments, Urine analyzer (2), Jerome Mercury Vapour Analyser (2), Personal Protective Equipments.	3	1
Support Services		3	5
Project Management		2	
Approximate Total manpower		23	67

The manpower requirement is an indicative one; the actual manning will be decided by the project manager depending on the workload. In addition to the above it is necessary security personnel to be engaged for access control and security.

The total power requirement for the soil washing and vacuum retorting equipment and other activities on site is estimated to be between 350-400 kW. A high tension power line will be required for the treatment and accessories will be required.

The total water requirements for the soil washing and other activities onsite is estimated to be around 75 m^3 per day, of which approximately 90% will be used in the soil washing process. Approximately 10-12 m^3 per day fresh water addition will be required every other day to replenish water that may be removed from the process via washing and retorting. Process water will be treated and reused in the soil washing operations. Fresh water will be added on a routine basis, to cater to the total.

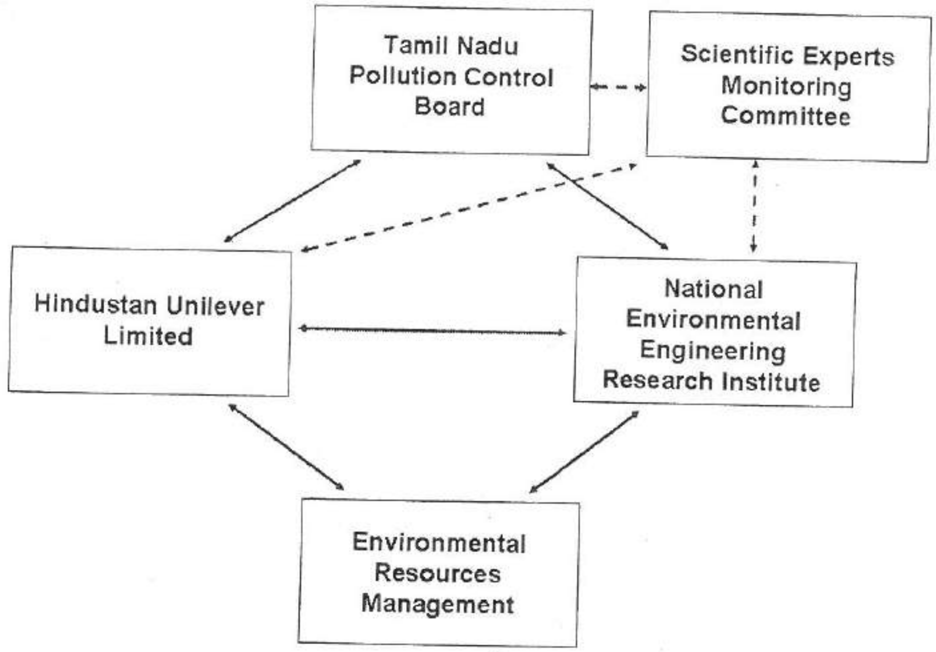
13.3 PROJECT MANAGEMENT

The following organizations, committees and companies are involved in the soil remediation project at HUL , Kodaikanal, Tamil Nadu:

1) Tamil Nadu Pollution Control Board;
2) Supreme Court Monitoring Committee constituted Scientific Experts Committee;
3) National Environmental Engineering Research Institute;
4) Hindustan Unilever Limited; and
5) Environmental Resources Management.

Please refer to *Figure 25* for a representation of the project stakeholders.

Figure 25 *Soil Remediation - Stakeholders*



In order to monitor progress of the project, the following are proposed:

A monthly report shall be prepared by ERM and submitted to HUL, to be forwarded to all stakeholders involved in the project. Deliverables to be included are

- Key performance indicators that have been achieved for the month including area remediated, quantity of treated soil, mercury level in treated soil.
- Progress of activities against the schedule
- Plan for the next months work
- Issues that may have come up during the excavation, treatment and backfilling and analysis phase of remediation and how they shall be addressed.

Any minor change in operational procedures due to on site conditions will be carried out after discussing with TNPCB official. Major variations in any operational procedures given in the DPR will be discussed with all stakeholders involved.

13.4 ROLES AND RESPONSIBILITIES

13.4.1 *National Environmental Engineering Research Institute (NEERI) - Project Management Consultant.*

1) Reviewing and finalizing the Detailed Project Report for site remediation, prepared based on NEERI's technical protocol.

2) Providing clarifications on soil remediation project to TNPCB , SCMC and Scientific Experts Committee during project submission , commencing, execution , closure and post closure stages of the remediation project.

3) Providing technical guidance on soil remediation project.

4) Monitoring on site soil remediation work with periodic site visits by senior personnel.

5) Validation of site remediation through sampling and analysis field samples.

6) Site monitoring during the post remediation phase.

13.4.2 *Hindustan Unilever Limited/ ERM*

1) Undertaking remediation work by engaging remediation contractor.

2) Obtaining required permits

3) Providing access to remediation contractor and crew.

4) Overall control on site remediation activities

5) Ensure strict compliance to Occupational Health & Safety and Environment Care systems and procedures by conducting regular inspections and audits.

6) Project closure activities including disposal of materials.

7) Remediation project execution

8) Sourcing of equipment and setup

9) Occupational Health & safety and environment care

10) Managing daily remediation activities

11) Managing subcontractors including analytical services

12) Project progress reporting

13) Verification of remediation criteria

14) Remediation work closure activities

Annex A1:

Soil Washing and Vacuum Retort result

1 PILOT SCALE EXPERIMENTS & RESULTS

1.1 SOIL WASHING TRIALS

Soil washing experiments were conducted at the HUL, Kodaikanal site to establish design parameters for full scale equipment design during the month of August, 2007.

The pilot plant consisted of a vibro-sieve shaker (20 mm mesh size) followed by a mixing vessel where undersize 20 mm soil was mixed with water in a 1:4 soil to water ratio. Thereafter the slurry was passed through various single circular sieves ranging from 1.18 mm, 300 μ, 150 μ, and 75 μ mesh size. Sieve mesh size was the only variable tested. Different concentration range soils were chosen for the studies. Washed oversize soil fractions were collected and analyzed for total mercury. The results from the soil washing experiments are listed below in the table:

Table 1 ***Soil washing experiments results.***

Sr. No	Trial Batch No.	Sieve mesh size (75 μ common)	Input (mg/kg mercury)	Oversize 1.18 mm (mg/kg)	Oversize 600 μ (mg/kg)	Oversize 300 μ (mg/kg)	Oversize 150 μ (mg/kg)	Undersize 150 μ (mg/kg)
1	32	1180+300+150	13.6	3.8		10.2	63.3	81.9
2	37	1180+600+150	17.4	6.0	25.8		61.3	314
3	42	1180+300+150	20.2	5.0		16.5	18.8	56.2
4	31	1180+300+150	22.3	2.8		7.2	42.6	60.1
5	43	1180+600+300	22.9	4.2	15.2	17.6		71.7
6	19	1180+600+150	23.0	1.8	7.1		21.3	127
7	33	1180+300+150	23.9	4.2		11.5	25.5	72.8
8	7	1180+600+300	25.2	31.2	15.8	20.2		143
9	44	1180+600+300	29.8	2.7	24.0	21.6		66.0
10	26	1180+600+300	31.8	4.0	14.9	15.1		50.4
11	24	1180+300+150	42.7	5.5		22.2	142	107
12	27	1180+600+300	44.1	4.3	13.8	15.2		78.5
13	23	1180+300+150	46.1	6.1		40.6	52.7	159
14	38	1180+600+150	56.8	7.8	17.3		34.3	98.7
15	22	1180+300+150	59.2	3.7		11.3	32.2	93.1
16	48	1180+600+150	64.4	9.6	19.9		67.4	179
17	46	1180+600+150	66.8	6.0	36.1		4.3	199
18	20	1180+600+150	72.6	7.1	27.4		66.8	2.6
19	54	1180+600+300	91.8	50.1	40.7	42.8		242
20	53	1180+600+300	94.2	25.6	50.9	61.3		260
21	47	1180+600+150	110	11.5	32.7		69.2	310
22	25	1180+600+300	138	18	56.7	121		160
23	52	1180+600+300	140	8.1	39.6	63.3		264
24	34	1180+600+300	161	36.2	51.3	104		393
25	50	1180+300+150	198	61.3		125	232	333
26	29	1180+600+150	224	51.8	156		253	526
27	36	1180+600+300	231	22.2	74.3	139		322
28	21	1180+600+150	252	40.1	162		213	398
29	49	1180+300+150	293	59.4		304	277	636

Sr. No	Trial Batch No.	Sieve mesh size (75 µ common)	Input (mg/kg mercury)	Oversize 1.18 mm (mg/kg)	Oversize 600 µ (mg/kg)	Oversize 300 µ (mg/kg)	Oversize 150 µ (mg/kg)	Undersize 150 µ (mg/kg)
30	51	1180+300+150	341	93.5		214	315	370
31	30	1180+600+150	529	96.9	199		250	849

Table 2 *Grain size distribution after soil washing*

Fraction	Sieve mesh size (1180+600+150+75 µ)	Sieve mesh size (1180+300+150+75 µ)	Sieve mesh size (1180+600+300+75 µ)
Input soil	35 Kg	35 Kg	35 Kg
A (Oversize 20 mm)	9.0%	2.0%	3.5%
X (Dead vegetation)	0.1%	0.07%	0.15%
B (Oversize 1180 µ)	41%	34%	49%
C (Oversize 600 µ)	10%		12%
D (Oversize 300 µ)		18%	7.4%
E (Oversize (150 µ)	14%	9.0%	
F (Undersize 150 µ)	13%	16%	20%

1.1.1 *Conclusions and recommendations*

Soil washing experiments showed that mercury is preferentially concentrated in the fines fraction of 150 µ and less. The current sieve design did not wash or beneficiate mercury at higher input concentrations into the fines fractions, although there was a reduction observed (e.g., an 80% removal of mercury is reported for the trial 31, where the input mercury concentration of 529 mg/kg is reduced to 97 mg/kg in the coarse fraction). It can also be observed that Mercury is concentrating in the fines fractions.

Dead vegetation was also analyzed for total mercury and with the exception of one sample dead vegetation with adhering soil which reported 688 mg/kg of mercury, all other fractions reported mercury concentrations less than 20 mg/kg. Therefore the washed vegetation fraction and stones will also be routinely analyzed and verified that remediation criteria have been met. In case, the criteria have not been met, then that particular batch shall be dried and stored to be disposed off in a TSDF.

Large stones and material greater than 20 mm were not processed in the wash trials, and therefore were not analyzed for mercury content. However, it is anticipated that in the washing and agitator step during full scale treatment, all mercury adhering to the large particles will be washed off.

The process water from the soil washing experiments was also analyzed for total dissolved mercury. Mercury concentrations were reported to range between 0.0001 mg/L and 0.0035 mg/L

The current sieve design was circular with vibratory shaker mechanism, with a single wash step at the first sieve. The residence time of the soils within each sieve is also small. Proper washing was not happening in the 2nd, 3rd and 4th sieves.

The following recommendations will be incorporated into the final design and manufacture of equipment:

- Individual horizontal vibro sieve shakers, 3 meters in length
- Two motors for horizontal and vertical movement, resulting in a 45° angle resultant soil particle motion across the screen length
- Forced jets for water washing along the first 1.5 meters, followed by dewatering across the remaining sieve length
- Increase residence time of soil particles across each individual sieve, by keeping the angle of depression at a minimum
- Handle big stones / soil particles bigger than 30 mm size and vegetation on a separate treatment/ equipment, to minimize damage or clogging of sieves
- Use a battery of hydrocyclones to continuously remove the sludge and mercury from the fines fractions, thereby reducing the load on process water treatment
- Minimize manual handling of soils during treatment process, by using hoppers, conveyors and chutes in the treatment train.
- For soil less than less than 100 mg/kg of mercury, soil washing will result ~ 70% of cleaned coarse soil meeting the remediation criteria. The balance 30% of fine soil is to be retorted.
- For soil with higher than 100 mg/kg of soil, double washing and retorting is recommended.

1.2 *VACUUM RETORTING TRIALS*

Vacuum retort experiments were conducted at the HUL site, Kodaikanal site to establish design parameters for full scale equipment design during the month of August, 2007.

Various fractions of raw and washed soils, contaminated building materials, Effluent Treatment Plant sludge were sampled and subsequently retorted at temperatures of 400 °C, and approximately 76 mm Hg vacuum (1/10 of atmospheric pressure). Vapours were condensed in a condenser collected in a vessel and any fugitive vapours were trapped into activated carbon columns.

Table 3 ***Vacuum retort experiment results***

Sample Description	Input concentration (mg/kg mercury)	Output concentration (mg/kg mercury)
F 30 (Washed fraction; Undersize of 75 µ)	849	1.6
F43 (Washed fraction; Undersize 0f 75 µ)	72.0	0.6
S50 (Raw soil)	285	0.3
E49 (Washed fraction; Oversize of 150 µ)	277	0.5
E24 (Washed fraction; Oversize of 150 µ)	142	1.1
E23 (Washed fraction; Oversize of 150 µ)	53.0	1.0

Sample Description	Input concentration (mg/kg mercury)	Output concentration (mg/kg mercury)
Drain Debris	34,300	95.4
Fill room wall debris	353	3.8
Soil from GS 0 (Visible mercury observed)	45,000	83.2
ETP sludge	64,900	23

1.2.1 *Conclusions and recommendations*

The retort experiments show that mercury concentrations are efficiently removed for washed soil fractions or other materials. However, it has been observed that the retorted fractions of samples that had very high concentrations of mercury were not treated to levels below the remediation criteria. It may be necessary to submit these kinds of samples, with elevated mercury concentration, through a second round of vacuum retorting.

The following recommendations will be incorporated into the final design and manufacture of equipment:

- The vacuum retort will be designed and manufactured either on a continuous or semi-batch process.
- Soil that is to be retorted will be continuously tumbled within the equipment to increase efficiency of mercury removal
- A filter press shall be incorporate before the retort in order to remove as much as water from the sludge, before it is taken to the heating stage.
- A heating (100-150 °C) pre treatment and cooling post treatment step shall be incorporated within the design and manufacture
- There shall be a minimum of dead spaces within the retort to prevent any preferential accumulation of mercury vapours within these spaces.
- The vacuum suction end shall be large enough and strategically located in order for efficient transfer of vapours to the condenser unit

Annex A2:

2008 Soil Delineation Maps

Annex B

Work Activity Risk Assessment form

Task Hazard Analysis Worksheet

In assessing the potential hazards, determine if one task description/ analysis is sufficient. If not, then develop additional task assessments with their own steps.

Task Description (Sequence of Steps):

1.
2.
3.
4.
5.
6.

Check Applicable Task Hazard	Check the Planned or Recommended Hazard Control (write in others)
☐ Asphyxiation	☐ Ventilation ☐ Supplied Air ☐ Air monitoring
☐ Chemical Exposure	☐ Isolation, Lockout/Tagout ☐ PPE ☐ Respiratory Protection ☐ Decontamination/ eyewash/ shower
☐ Harmful Dust	☐ Dust Suppression ☐ PPE
☐ Thermal Burns ☐ Hot Surface	☐ Splash Guard ☐ Isolation, Lockout/Tagout ☐ PPE ☐ Equipment Covers ☐ Barricades
☐ Slips, Wet Surface	☐ Clean Surface ☐ Barricade ☐ Walk Carefully/ Eyes on Path ☐ Use alternate route
☐ Trips	☐ Relocate the trip hazards ☐ Barricade ☐ Use alternate path
☐ Falls ☐ More than 4 feet	☐ Fall restraint, guardrails, barricades, short lanyard
☐ Electrical shock	☐ Isolation, LOTO ☐ Testing ☐ Grounding ☐ Shielding on equipment ☐ PPE ☐ Ground Fault Interruption on electrical cords ☐ Electrical expertise on project team
☐ Airborne/Flying material	☐ Cover/Shield source ☐ PPE, Eye & Face ☐ PPE, Arms & Body ☐ Positioning
☐ Fire/ Explosion	☐ Isolation/LOTO ☐ Air testing/monitoring ☐ Control sources of ignition ☐ Implement a "Hot Work" process ☐ PPE ☐ The correct fire extinguisher is available
☐ Heat/Cold Stress	☐ Ventilation ☐ Cooling vests, etc. ☐ Task rotation, Shared tasks ☐ Work/Rest regimen ☐ Planned place for sheltering
☐ High Noise	☐ Hearing Protection ☐ Relocate Work ☐ Muffle Source
☐ Poor Visibility	☐ Illumination is adequate for task ☐ Nighttime considerations if the job *could* extend past daylight hours
☐ Lifting, pulling, pushing	☐ A plan is in place (people, devices, carts) ☐ Handling equipment is designed for the job ☐ Proper technique known/ discussed ☐ Smaller, lighter loads? ☐ Prepared for "unexpected release"
☐ Repetitive motion	☐ Proper technique known/ discussed ☐ Proper tools, rather than manual ☐ Get help, take breaks ☐ Seek advice
☐ Rotating equipment	☐ Isolation, LOTO ☐ Guarding, Barricading ☐ No loose clothing ☐ Positioning
☐ Pinch Points	☐ Guarding ☐ Positioning
☐ Sharp objects	☐ Guarding ☐ Gloves, safety shoes or boots ☐ Substitute safe cutter for blade
☐ Falling objects	☐ Secure objects ☐ Guarding, covers ☐ Hard Hat ☐ Barricading
☐ Hazards from others working in vicinity (particularly heavy equipment)	☐ Communication ☐ Barricading ☐ Shielding
☐ Hazards to other working in vicinity	☐ Communication ☐ Barricading ☐ Shielding
☐ Environmental Spill	☐ Containment ☐ Waste Plan ☐ Waste Containers ☐ Other
☐ Chemical Storage	☐ Container labeling and MSDSs ☐ Incompatibles (acids/bases, flammables/oxidizers) considered ☐ Control physical damage to containers
☐ Drowning	☐ Personal Floatation Device ☐ Barricading ☐ Working with a partner ☐ Alerting Devices
☐ Ionizing Radiation	☐ Exposure Monitoring ☐ PPE ☐ Distance and/or shielding
☐ Nearby Road Traffic	☐ Bright colored work vests ☐ Planned avoidance of traffic areas ☐ Signs and lights to alert drivers
☐ Hazards not listed	List of Hazard Controls:

	YES	NO	N/A
Is a permit (Hot Work, Confined Space Entry, Process Line Breaking, LOTO) required for this ERM work task?			
If so is the client's procedure/policy supplied?			
Do you have the proper tools and/or equipment in good condition			
Have you planned an escape route?			
Was this Hazard Analysis reviewed with the project team performing this task?			

Developed By (Individual or Team Members)
Names:______________________________

Date Developed:____________

Reviewed with the Following Project Employees:

____

____

____

Annex C

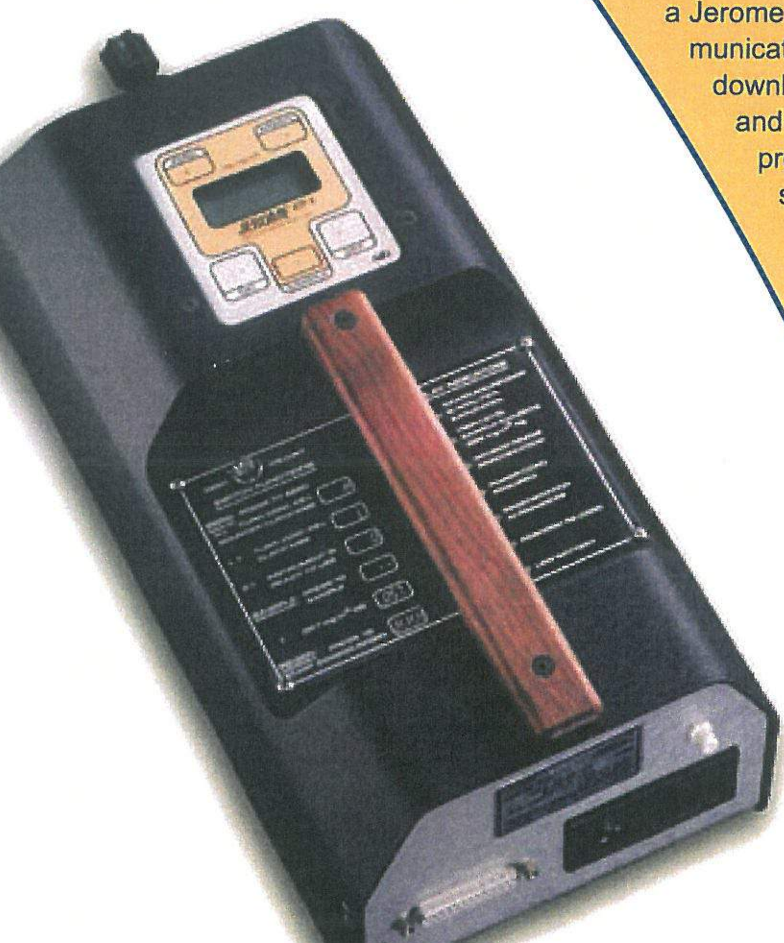
Jerome 431-X Mercury Vapour Analyzer spec sheet

Arizona Instrument LLC
800-528-7411
602-470-1414
www.azic.com

Jerome® 431-X
Mercury Vapor Analyzer

The Jerome 431-X mercury vapor analyzer uses a patented gold film sensor for accurate detection and measurement of toxic mercury concerns for applications such as industrial hygiene monitoring, mercury spill clean up and mercury exclusion testing. Simple, push-button operation allows users to measure mercury levels from 0.003 to 0.999 mg/m³ in just seconds.

The gold film sensor is inherently stable and selective to mercury, eliminating interferences common to ultraviolet analyzers, such as water vapor and hydrocarbons. When the sample cycle is activated, the internal pump in the 431-X draws a precise volume of air over the sensor. Mercury in the sample is absorbed and integrated by the sensor, registering it as proportional change in electrical resistance. The instrument computes the concentration of mercury in milligrams per cubic meter or nanograms, and displays the final result in the LCD readout. An improved film regeneration circuit in the 431-X makes the sensor last even longer than earlier models.



Additional accessories are available to customize the Jerome 431-X to meet individual application needs. An optional communications configuration allows data logging, computer interface, and dosimeter analysis capabilities. For data acquisition during portable surveys, a Jerome data logger plugs into the 431-X. Using Jerome Communications Software (JCS), the analyzer and data logger download recorded data to a computer for analysis, printout, and permanent record storage. The software can also program the instrument for stand-alone monitoring. If the sensor becomes saturated while the 431-X is attached to the data logger or computer, the analyzer automatically regenerates the sensor and then resumes sampling. Jerome gold coil dosimeters, used in conjunction with a low-flow pump and a communications-configured 431-X, provide time-weighted averages for personal mercury exposure. Analysis is quickly performed in-house with these reusable dosimeters. They can also be used as collection devices for applications such as gas stream analysis. An available internal option board allows auto-zeroing, DC power operation, timed regeneration, and timed sampling during prolonged, unattended sampling periods. The option board also allows external fresh air solenoid support and 4-20 mA or 0-2 V analog output. A molded hard carrying case or soft field case give added versatility and organized storage for the instrument and its accessories.

Jerome® 431-X

Mercury Vapor Analyzer

Arizona Instrument LLC
800-528-7411
602-470-1414
www.azic.com

Features:

Rugged and easy operate
Inherently stable gold film sensor
Pressure sensitive membrane switch operation
Accurate analysis of mercury vapor in seconds
Rechargeable internal battery pack for portability
Wide detection range allows for multiple applications
Automatic LCD backlight during low light conditions
Survey mode for rapid source detection of mercury vapor concentrations
Microprocessor ensures a linear response throughout the entire range of the sensor

Specifications:

Resolution	0.001 mg/m^3
Detection Range	0.003-0.999 mg/m^3
Precision	5% Relative Standard Deviation at 0.100 mg/m^3
Accuracy	±5% at 0.100 mg/m^3
Response Time	13 seconds in Sample Mode; 4 seconds in Survey Mode
Flow Rate	750 cc/min
Environmental Range	0-40°C, noncondensing, nonexplosive
Interface	RS-232 port using Jerome Communications Software
Dimensions	431-X: 6" W x 13" L x 4" H/ 16 cm W x 33 cm L x 10 cm H 431-XE: 7" W x 14" L x 7" H / 18 cm W x 35 cm L x 18 cm H
Weight	431-X: 7 lbs / 3 kg 431-XE: 8 lbs / 3.5 kg
Internal Battery Pack	Rechargeable nickel-cadmium
Power Requirements	100-120 V~, 50/60 Hz, 1 A or 220-240 V~, 50/60 Hz, 1 A
Warranty	1 year, factory parts and labor
Marks	European Communities (CE) for 220-240 V~ 431-XE model only

Options:

Data Logger to record field monitoring information
Maintenance Kit for routine maintenance and upkeep
Functional Test Kit for sensor operation verification in the field
Hard or Soft Field Carrying Case for versatile handling and additional storage
Jerome Communications Software Kit for downloading information from the data logger to a PC or for unattended, fixed-point sampling
Dosimeters to provide time-weighted averages for personal mercury exposure or gas steam analysis (reusable)
Option Board for external fresh air solenoid support, auto-zeroing, DC power operation, timed regeneration, 4-20 mA or 0-2 V analog output, and timed sampling
Calibration Check to verify low-level detection limits at 0.010 mg/m^3 and 0.025 mg/m^3

Applications:

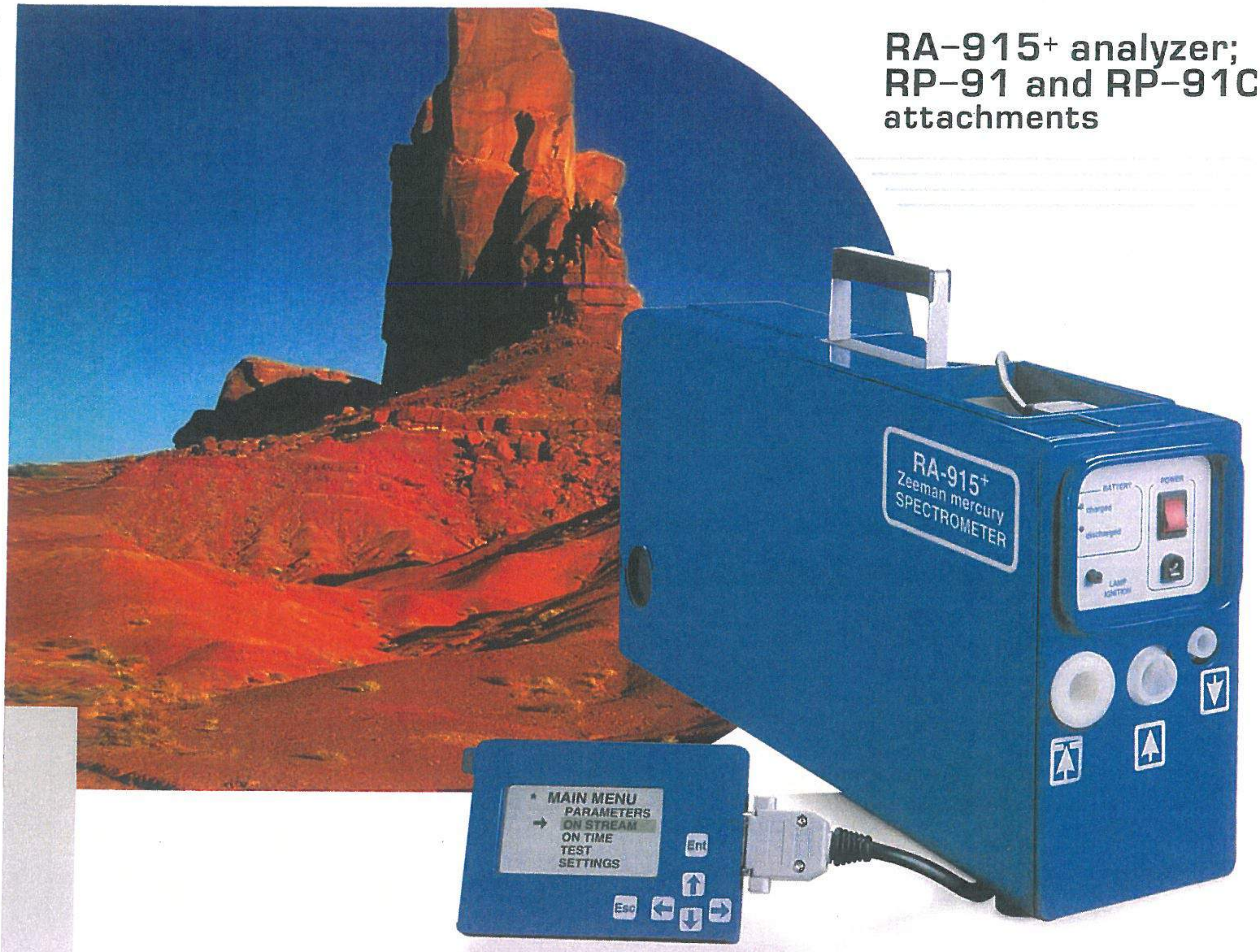
Mercury Surveys and Soil Screening
Spill Response
Worker Safety
Hazardous Waste Sites
Research Projects for Stack, Flue and Natural Gas
Mercury Exclusion Tests
Monitor Disposal and Recycling of Fluorescent Lamps
Exhaust Duct Analysis

Annex D

Ohio Lumex RA-915+ Zeeman Portable Mercury Analyzer

PORTABLE ZEEMAN MERCURY ANALYZER

RA–915+ analyzer; RP–91 and RP–91C attachments



METHOD

Atomic absorption spectrometry

PRINCIPLE OF OPERATION

Is based on the absorption of the 254–nm resonance radiation by mercury atoms using Zeeman correction for background absorption.

FEATURES AND BENEFITS

- Direct detection of mercury without its preliminary accumulation on a gold sorbent
- Ultralow mercury detection limit in air (2 ng/m^3) in real–time operation mode
- Wide dynamic measuring range (more than three orders of magnitude)
- Mercury determination in complex samples without sample preparation
- Operation in the field from a biult–in battery for performance of atmospheric air and industrial gases measurements
- Control by a keypad or by a computer
- State–of–the art software

Annex E

USEPA verification report on field measurement technology for mercury in soils and sediments

United States
Environmental Protection
Agency

Office of Research and
Development
Washington DC 20460

EPA/600-R-03/147
May 2004

EPA

Innovative Technology Verification Report

Field Measurement Technology for Mercury in Soil and Sediment

Ohio Lumex's RA-915/RP-91C Mercury Analyzer - May 2004

SITE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Office of Research and Development
Washington, DC 20460

MEASUREMENT AND MONITORING TECHNOLOGY PROGRAM VERIFICATION STATEMENT

TECHNOLOGY TYPE: **Field Measurement Device**

APPLICATION: **Measurement for Mercury**

TECHNOLOGY NAME: **Ohio Lumex Co.'s RA-915+/RP-91C Mercury Analyzer**

COMPANY: **Ohio Lumex Co.**
ADDRESS: **9263 Ravenna Rd., Unit A-3**
Twinsburg, OH 44087

WEB SITE: http://www.ohiolumex.com

TELEPHONE: **(888) 876-2611**

VERIFICATION PROGRAM DESCRIPTION

The U.S. Environmental Protection Agency (EPA) created the Superfund Innovative Technology Evaluation (SITE) and Measurement and Monitoring Technology (MMT) Programs to facilitate deployment of innovative technologies through performance verification and information dissemination. The goal of these programs is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. These programs assist and inform those involved in design, distribution, permitting, and purchase of environmental technologies. This document summarizes results of a dem onstration of the RA-915+/RP-91C Mercury Analyzer developed by Ohio Lumex Co.

PROGRAM OPERATION

Under the SITE and MMT Programs, with the full participation of the technology developers, the EPA evaluates and documents the performance of innovative technologies by developing demonstration plans, conducting field tests, collecting and analyzing demonstration data, and preparing reports. The technologies are evaluated under rigorous quality assurance (QA) protocols to produce well-documented data of known quality. The EPA National Exposure Research Laboratory, which demonstrates field sampling, m onitoring, and m easurement technologies, selected Science Applications International Corporation as the verification organization to assist in field testing five field measurement devices for mercury in soil and sediment. This demonstration was funded by the SITE Program.

DEMONSTRATION DESCRIPTION

In May 2003, the EPA conducted a field demonstration of the RA-915+/RP-91C and four other field measurement devices for mercury in soil and sediment. This verification statement focuses on the RA-915+/RP-91C; a similar statement has been prepared for each of the other four devices. The performance of the RA-915+/RP-91C was compared to that of an off-site laboratory using the reference method, "Test Methods for Evaluating Solid Waste" (SW-846) Method 7471B (modified). To verify a wide range of perform ance attributes, the demonstration had both primary and secondary objectives. The primary objectives were:

(1) Determining the instrument sensitivity with respect to the Method Detection Limit (MDL) and Practical Quantitation Limit (PQL);
(2) Determining the analytical accuracy associated with the field measurement technologies;
(3) Evaluating the precision of the field measurement technologies;
(4) Measuring the amount of time required for mobilization and setup, initial calibration, daily calibration, sample analysis, and demobilization; and
(5) Estimating the costs associated with mercury measurements for the following four categories: capital, labor, supplies, and investigation-derived waste (IDW).

Secondary objectives for the demonstration included:

(1) Documenting the ease of use, as well as skills and training required to properly operate the device;
(2) Documenting potential health and safety concerns associated with operating the device;
(3) Documenting the portability of the device;
(4) Evaluating the device durability based on its materials of construction and engineering design; and

(5) Documenting the availability of the device and associated spare parts.

The RA-915+/RP-91C analyzed 56 field soil samples, 26 field sediment samples, 42 spiked field samples, and 73 performance evaluation (PE) standard reference material (SRM) sam ples in the demonstration. The field sam ples were collected in four areas contam inated with mercury, the spiked samples were from these same locations, and the PE samples were obtained from a commercial provider.

Collectively, the environmental and PE samples provided the different m atrix types and the different concentrations of mercury needed to perform a comprehensive evaluation of the RA-915+/RP-91C. A complete description of the demonstration and a summary of the results are available in the Innovative Technology Verification Report: "Field Measurement Technology for Mercury in Soil and Sediment—Ohio Lum ex Co.'s RA-915+/RP-91C Mercury Analyzer" (EPA/600/R-03/147).

TECHNOLOGY DESCRIPTION

The RA-915+ Mercury Analyzer is a portable AA spectrometer with a 10-meter (m) multipath optical cell and Zeeman background correction. Mercury is detected without preliminary accumulation on a gold trap. Mercury samples are heated to 750-800°C, causing organic materials to be decomposed and mercury to be vaporized in a carrier gas of ambient air. The airflow carries the vaporized mercury to be carried to the analytical cell . The RA-915+ includes a builtin test cell for field performance verification. The operation of the RA-915+ is based on the principle of differential, Zeeman AA spectrometry combined with high-frequency modulation of polarized light. This combination eliminates interferences and provides the highest sensitivity. A mercury lamp is placed in a permanent magnetic field in which the 254-nm resonance line is split into three polarized components, two of which are circularly polarized in the opposite direction. These two components (F- and F+) pass through a polarization modulator, while the third component (B) is removed. One F component passes through the absorption cell; the other F component passes outside of the absorption cell and through the test cell. In the absence of mercury vapors, the intensity of the two F components are equal. When mercury vapor is present in the absorption cell, mercury atoms cause a proportional, concentration-related difference in the intensity of the F components. This difference in intensity is what is measured by the instrument. The unit can be used with the optional RP-91C for an ultra-low mercury detection limit in water samples using the "cold vapor" technique. For direct mercury determination in complex matrices without sample pretreatment, including liquids, soils and sediments, the instrument will be operated with the optional RP-91C accessory, as was done during the demonstration.

During the demonstration, no extraction or sample digestion was required. Individual samples were mixed manually using a quartz injection spoon. This same spoon was used to transfer the sample directly to the RP-91C sample injection port after the sample was weighed on a digital balance. The sample weight was manually recorded. The sample was analyzed, and the device displayed the mercury concentration in parts per million, which is equivalent to a soil concentration in milligrams per kilogram.

ACTION LIMITS

Action limits and concentrations of interest vary and are project specific. There are, however, action limits which can be considered as potential reference points. The EPA Region IX Preliminary Remedial Goals for mercury are 23 mg/kg in residential soil and 310 m g/k g in industrial soil.

VERIFICATION OF PERFORMANCE

To ensure data usability, data quality indicators for accuracy, precision, representativeness, completeness, comparability, and sensitivity were assessed for the reference method based on project-specific QA objectives. Key demonstration findings are summarized below for the primary objectives.

Sensitivity: The two primary sensitivity evaluations performed for this demonstration were the MDL and PQL. Both will vary dependent upon whether the matrix is a soil, waste, or aqueous solution. Only soils/sediments were tested during this demonstration, and therefore, MDL calculations and PQL determinations for this evaluation are limited to those matrices. By definition, values measured below the PQL should not be considered accurate or precise and those below the MDL are not distinguishable from background noise.

Method Detection Limit - The evaluation of an MDL requires seven different measurements of a low concentration standard or sample following the procedures established in the 40 Code of Federal Regulations (CFR) Part 136. The MDL is estimated between 0.0053 and 0.042 mg/kg. The equivalent MDL for the referee laboratory is 0.0026 mg/kg.

Practical Quantitation Limit - The low standard calculations using MDL values suggest that a PQL for the Ohio Lumex field instrument may be as low as 0.027mg/k g (5 times the lowest calculated MDL). The %D for the average Ohio Lumex result for a tested sample with a referee laboratory value of 0.06 mg/k g is 0.072 mg/k g, with a %D of 20%. This was the lowest sample concentration tested during the demonstration that is close to but not below, the calculated PQL noted above. The referee laboratory PQL confirmed during the demonstration is 0.005 mg/kg with a %D <10%.

Accuracy: The results from the RA-915+/RP-91C were compared to the 95% prediction interval for the SRM materials and to the referee laboratory results (Method 7471B). The Ohio Lumex data were within SRM 95% prediction intervals 93% of the time, which suggests significant equivalence to certified standards. The comparison between the Ohio Lumex field data and the referee laboratory results suggest that the two data sets are not the same. When a unified hypothesis test is performed (which accounts for laboratory bias), this result is confirmed. Ohio Lumex data were found to be both above and below referee laboratory concentrations, therefore there is no implied or suggested bias. The number of Ohio Lumex average values less than 30% different from the referee laboratory results or SRM reference values was significant – 19 of 33 different sample lots. Ohio Lumex results therefore, provide accurate estimates for field determination. Because the Ohio Lumex data compare favorably to the SRM values, the differences between Ohio Lumex and the referee laboratory are likely the result of reasons beyond the scope of this study.

Precision: The precision of the Ohio Lumex field instrument is better than the referee laboratory precision. The overall average RSD, is 22.3% for the referee laboratory compared to the Ohio Lumex average RSD of 16.1%. This is primarily because of the better precision obtained for the SRM analyses by Ohio Lumex. Both the laboratory precision and the Ohio Lumex precision goals of 25% overall RSD were achieved.

Measurement Time: From the time of sample receipt, Ohio Lumex required approximately 21 hours, 15 minutes, to prepare a draft data package containing mercury results for 197 samples. One technician performed half of the equipment setup and demobilization, most of the sample preparation, and all of the analyses. Individual analyses took 1 minute each, but the total time per analysis averaged 8.1 minutes per sample (based upon 1.25 analysts) when all field activities and data package preparation were included in the calculation because the vendor chose to analyze replicates of virtually every analysis.

Measurement Costs: The cost per analyses based upon 197 samples, when renting the RA-915+/RP-91C, is $23.44 per sample. The cost per analyses for the 197 samples, excluding rental fee, is $15.82 per sample. Based on a 3-day field demonstration, the total cost for equipment rental and necessary supplies is estimated at $4,617. The cost by category is: capital costs, 32.5%; supplies, 10.8%; support equipment, 6.0%; labor, 19.5%; and IDW, 31.2%.

Key demonstration findings are summarized below for the secondary objectives.

Ease of Use: Based on observations made during the demonstration, the RA-915+/RP-91C is reasonably easy to operate; however, lack of automation somewhat impairs the ease of use. Operation requires one field technician with a basic knowledge of chemistry acquired on the job or in a university and training on the instrument.

Potential Health and Safety Concerns: No significant health and safety concerns were noted during the demonstration. The only potential health and safety concerns identified were the generation of mercury vapors and the potential for burns with careless handling of hot quartz sample boats. The vendor provides a mercury filter as standard equipment; exercising caution and good laboratory practices can mitigate the potential for burns.

Portability: The RA-915+ air analyzer was easily portable, although the device, even when carried in the canvas sling, was not considered light-weight. The addition of the RP-91C and associated pump unit preclude this from being a truly field portable instrument. The device and attachments can be transported in carrying cases by two people, but must then be set up in a stationary location. It was easy to set up, but the combined instrument is better characterized as mobile rather than field portable.

Durability: The RA-915+/RP-91C was well designed and constructed for durability. The outside of the RA-915+ is constructed of sturdy aluminum and the exterior of the RP-91C furnace is stainless steel.

Availability of the Device: The RA-915+/RP-91C is readily available for rental, lease, or purchase. Spare parts and consumable supplies can be added to the original instrument order, or can be received within 24 to 48 hours of order placement. Standards are readily available from laboratory supply firms or can be acquired through Ohio Lumex.

PERFORMANCE SUMMARY

In summary, during the demonstration, the RA-915+/RP-91C exhibited the following desirable characteristics of a field mercury measurement device: (1) good accuracy compared to SRMs, (2) good precision, (3) good sensitivity, (4) high sample throughput, (5) low measurement costs, and (6) ease of use. During the demonstration the RA-915+/RP-91C was found to have the following limitations: (1) lack of automation and (2) non-portable due to the instrument size and weight. The demonstration findings collectively indicated that the RA-915+/RP-91C is a reliable field measurement device for mercury in soil and sediment.

Annex F

Protocol for decontamination of machinery and equipment in Kodaikanal Thermometer Factory

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Annexure F

Protocol for Decontamination of Machinery and Equipment in Kodaikanal Thermometer Factory

Background

Production of thermometers at the Hindustan Lever factory at Kodaikanal was stopped on the 8th March 2001. However, there are machinery and equipment and materials, including stem glass, which are still stored on-site. As first part of remediation of the site, materials including (i) Glass cullets generated from the manufacturing process of mercury-in-glass thermometers including the work-in-progress and finished goods stock, (ii) Virgin elemental mercury and (iii) ETP sludge have been exported to M/s Bethlehem Apparatus Inc., USA which has the US-EPA approved facility to recover mercury. This has been done after receiving due approvals from the MoEF and TNPCB.

As part of the remediation plan it is now proposed to dispose off the machinery/equipment and materials, which is installed/stored on-site. The entire machinery/equipment and materials has been divided into i) mercury free *i.e* non-contaminated and ii) mercury contaminated (these equipment/materials were used in the mercury sections of the factory). While it is intended to dispose of the non-contaminated equipment/machines and materials as scrap without cleaning (after ascertaining that these are free of any mercury), the Protocol below describes the procedure for decontamination of the equipment/machines and materials which are likely to be contaminated.

The Proposed Protocol for Decontamination

The protocol for decontamination of mercury (if any) on the surfaces of machinery/equipment from the mercury area, distillation and recovery rooms, empty mercury containers, and spare parts used in mercury area has been proposed and described below. It is recognized here that removal of elemental mercury is a challenge and must be undertaken with utmost thoroughness.

Equipment- and work-surfaces could have fine droplets of mercury in certain spaces and areas and in the cracks, corners, slits, holes as well as in-between small spaces of the machines/equipment components. To decontaminate the machinery/equipment procedures have been articulated. As marked in the logic diagram for the proposed clean-up (described in **Figure 1**), the following SIX procedures shall be been employed to achieve the desired level of decontamination.

Procedure 1 Use a flashlight to look around the area of spill. The light will reflect off shiny mercury beads and make it easier to see them. Collect the spilled mercury in zip top plastic bag or plastic container while transferring the mercury to bag or container; work over the box lined with plastic wrap. Use a card or stiff paper to push the small mercury beads on to a plastic dustpan. Mercury can be handled over a suitable waterbed in a plastic tray. Skin contact with mercury should be avoided. One should wash hands thoroughly after handling mercury.

Procedure 2 Mercury can be removed by wiping it with a NaOCl solution swab. Then NaOCl solution dipped swab should be placed in an airtight container or in sealed plastic bag.

Procedure 3 **"Clearance Procedure"** At the conclusion of the decontamination routine, the Mercury Decontamination Site Supervisor will complete a "clearance survey" using the Jerome Mercury Vapour Analyser and/or mercury indicator paper. Background air quality readings for mercury vapour will also be collected. All readings will be recorded in the logbook.

The cleaned machinery parts and components will be placed in a "Test Room" for four hours while the Chamber temperature will be raised to 35^0C. Mercury (if any) present in hidden corners and cracks will volatilise and accumulate in the atmospheric space in the Room. Testing of the air in Room will be undertaken by using the Jerome Mercury Vapour Analyser. If the clearance testing indicates mercury vapour levels above 0.05 mg/m3; the machine parts and components will be re-cleaned in accordance with the procedure described in the logic diagram until the mercury vapour levels drop below 0.05 mg/m3.

Procedure 4 Equipment- and work-surfaces, where fine droplets of mercury could be potentially present, will be treated with a slurry composed of equal parts of calcium hydroxide and flowers of sulphur mixed with enough water to make a yellow wash. The slurry shall be left for 24 to 48 hours after which it is cleaned carefully with dustpan and brush to remove traces of mercury.

Procedure 5 **Clearance Certification** All surfaces successfully decontaminated will be marked as "CLEARED". This marking will include a date and signature of the Decontamination Site Supervisor. Marking may be through the use of tags or signage. Individual pieces of equipment should be marked with impermeable marker used on affixed tags. The statement "CLEARED", with the data and signature of the Mercury Decontamination Site Supervisor, will constitute the clearance for mercury.

Procedure 6 After the initial vacuuming, the NaOCl solution can be applied via a pressure spray (the amount of water used as a decontamination tool should be minimised).

PLAN FOR MINIMIZING RISK TO PERSONNEL AND ENVIRONMENT

It is recognized that the personal safeguards for eliminating exposure to mercury must be strictly adhered to. The proposed protocol cannot be effectively implemented unless the issues associated with several practical aspects are properly addressed including the access and barriers, clearance survey, respirator requirements, health checks as well as health and safety plan. All those issues have been categorically addressed below:

A Access and Barriers

A designated area will be erected for undertaking the decontamination process.

1. Barriers and temporary enclosure will be erected
2. Barriers will be fire retardant
3. An impermeable floor and perimeter bunting will be constructed
4. The area will be ventilated
5. Signs will be posted at each entry point to the decontamination works area
6. Prior to initiation of the decontamination activities, the area will be cleared of all non-essential personnel
7. The Mercury Decontamination Site Supervisor, will be responsible for entry protocol.

B Respirator Requirements

Any time the mercury vapour levels in the breathing zone exceed 0.025 mg/m^3 a half face air purifying respirator with mercury cartridges will be worn. If the mercury vapour level exceeds 0.10 mg/m^3 conditions will be monitored and re-assessed by the Mercury Decontamination Site Supervisor and appropriate actions undertaken.

- ➔ Mercury levels between 0.025 mg/m^3 and 0.1 mg/m^3 will require the use of a MSA half face mask facepiece with "Mersorb-H" cartridges. These cartridges have end of service life indicators that visually indicate when the filters must be changed. This is the only commercially available air-filtering respirator approved by NIOSH for Mercury.

- ➔ No work shall be conducted if the mercury vapour level exceeds 0.1 mg/m^3, unless a full face-piece NIOSH approved positive pressure mode supplied air respirator is being used.

C ***Health and Safety Plan***

All activities of workers involved in the cleaning up exercise will be governed by a Health and safety Plan, which will be strictly implemented during the whole process. Hindustan Lever's Site Manager will be fully responsible for the implementation of the Health and Safety Plan. Requirements with regard to the use of the appropriate respirators depending on the level of mercury vapour in the atmosphere, other Personal Protective Equipment (PPE) and procedures for the health and safety checks of all employees engaged in the cleaning up activities will be covered by the Health and Safety Plan. All workers will undergo a Site Health and Safety Induction prior to being involved in any clean up activities. First-aid kit and eye wash bottle facility is to be made available near the work area.

Personal Protective Equipment (PPE) for the mercury vapour level below 0.025 mg/m^3 *i.e.* Level - D

This level requires the following protective clothing and equipment to be available for all the personnel engaged in the above said activities.

1. Full body overalls
2. Hard hat with wide brim
3. Safety goggles
4. Dust mask
5. Cotton gloves
6. Safety Shoe.

Personal Protective Equipment (PPE) for the mercury vapour level between 0.025 and 0.1 mg/m^3 *i.e.* Level - C

This level requires the following protective clothing and equipment to be available for all the personnel engaged in the above said activities.

1. Full body overalls
2. Hard hat with wide brim
3. Safety goggles
4. Half-face air purifying respirator with mercury cartridges approved by NIOSH
5. Cotton gloves
6. Safety Shoe

Personal Protective Equipment (PPE) for the mercury vapour level above 0.1 mg/m^3 *i.e.* Level – C

This level requires the following protective clothing and equipment to be available for all the personnel engaged in the above said activities.

1. Full body overalls
2. Hard hat with wide brim
3. Safety goggles
4. Full-face piece NIOSH approved positive pressure mode supplied air respirator.
5. Cotton gloves
6. Safety shoe

Health Check All persons directly engaged in decontamination process are to be medically checked prior to engaging and after completing the work by a medical practitioner. Daily urine samples are to be taken from the workmen personnel engaged daily at the end of the day and to be analysed for mercury content using the urine analyser. Max individual mercury in urine body burden is 100 mg/m^3 and the group mean is 50 mg/m^3.

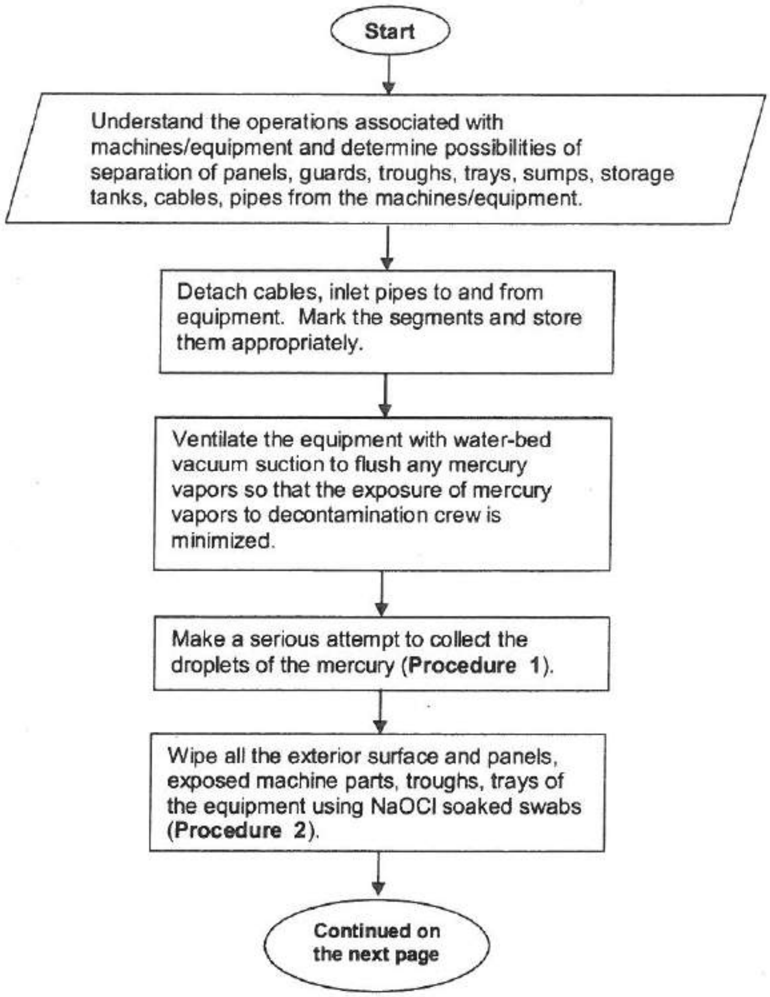

Figure 1 continued

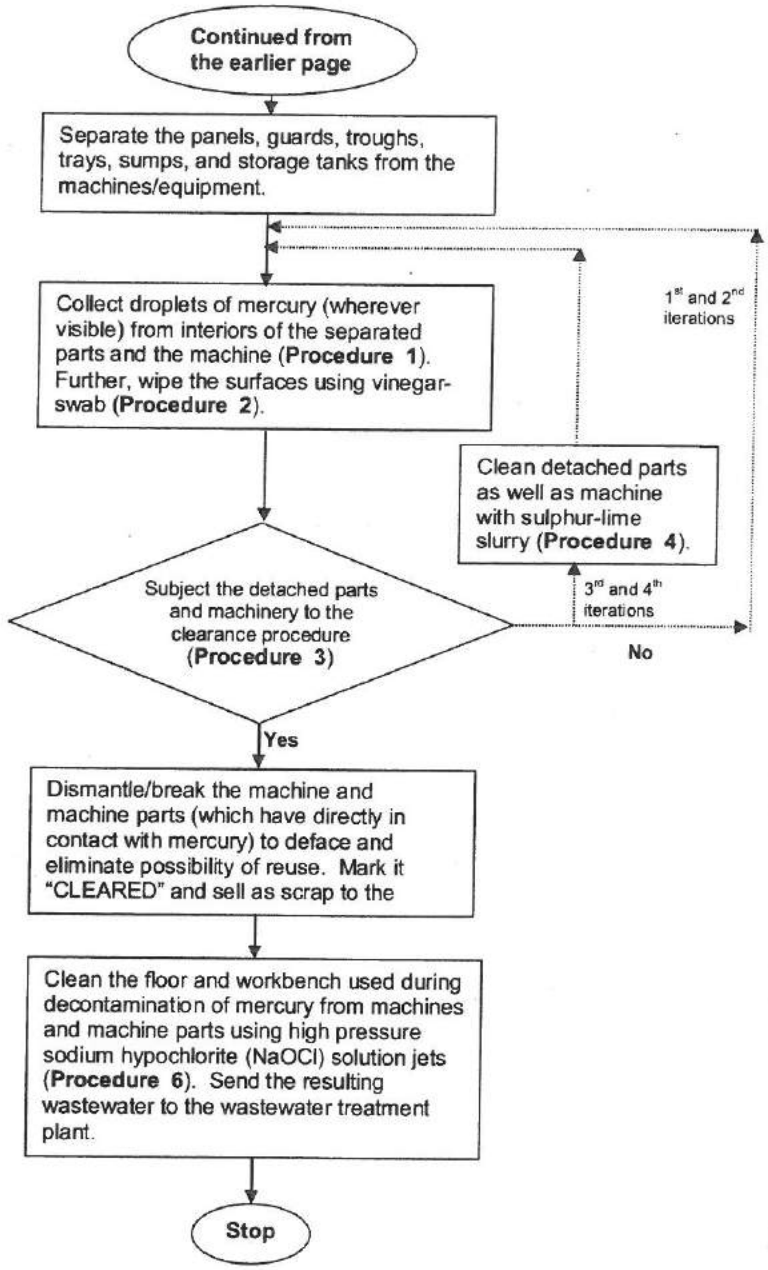

Figure 1 The logic diagram for the proposed mercury decontamination protocol

Annex G

Building evaluation results for Mercury Contamination

Annex G: Building Evaluation Results

S.No.	Sample ID	Hg (mg/kg)	Location
1	1 FR-0	156	FILL ROOM
2	1 FR-1	11.6	
3	1 FR-2	15.6	
4	2 FR-0	825	
5	2 FR-1	30.6	
6	2 FR-2	8.2	
7	3 FR-0	28.5	
8	3 FR-1	4.3	
9	3 FR-2	5.1	
10	4 FR-0	433	
11	4 FR-1	489	
12	4 FR-2	11.2	
13	5 FR-1	120	
14	5 FR-2	6.3	
15	6 FR-1	18.1	
16	6 FR-2	8	
17	6 FR-3	136	
18	7 FR-0	103	
19	7 FR-1	10.9	
20	7 FR-2	22.1	
21	8 FR-0	1440	
22	8 FR-1	1440	
23	8 FR-2	109	
24	9 FR-0	1060	
25	9 FR-1	44.4	
26	9 FR-2	15.8	
27	10 FR-0	5.4	
28	10 FR-1	10.7	
29	10 FR-2	4.8	
30	1 MR-0	11	MERCURY RECOVERY ROOM
31	1 MR-1	9.6	
32	1 MR-2	22.3	
33	2 MR-0	14.3	
34	2 MR-1	12.9	
35	2 MR-2	12.3	
36	3 MR-0	14.6	
37	3 MR-1	10.5	
38	3 MR-2	11.7	
48	7 MR-0	22.0	
49	7 MR-1	9.40	
50	7 MR-2	7.90	
51	8 MR-0	3.20	
52	8 MR-1	3.20	
53	8 MR-3	4.10	

S.No.	Sample ID	Hg (mg/kg)	Location
66	5 MRE-0	2.70	MERCURY RECOVERY EXTENTION
67	5 MRE-1	3.20	
68	5 MRE-2	16.20	
69	6 MRE-0	8.60	
70	6 MRE-1	15.10	
71	6 MRE-2	11.20	
72	7 MRE-0	37.30	
73	7 MRE-1	5.70	
74	7 MRE-2	12.00	
75	8 MRE-0	1.20	
76	8 MRE-1	0.70	
77	8 MRE-3	0.80	
78	9 MRE-0	2.20	
79	9 MRE-1	2.20	
80	9 MRE-2	2.40	
81	DD-1	11,700	DRAIN DEBRIS
82	DD-2	23,500	
83	DD-3	20,800	
84	BR-1	41.8	BRICKS
85	BR-2	18.0	
86	1 DR-0	25.5	DISTILLATION ROOM
87	1 DR-1	13.9	
88	1 DR-2	14.2	
89	2 DR-0	45.9	
90	2 DR-1	6.5	
91	2 DR-2	10.3	
92	3 DR-0	5.2	
93	3 DR-1	15.7	
94	3 DR-2	18.1	
95	4 DR-0	42.3	
96	4 DR-1	8.8	
97	4 DR-2	10.5	
98	5 DR-0	6.5	
99	5 DR-1	5.7	
100	5 DR-2	7.8	
101	6 DR-0	7.2	
102	6 DR-1	13.7	
103	6 DR-2	17.8	
104	7 DR-0	5.50	
105	7 DR-1	22.1	
106	7 DR-3	0.80	
107	8 DR-0	23.1	
108	8 DR-1	6.60	
109	8 DR-3	2.50	
110	9 DR-0	4.00	
111	9 DR-1	4.70	
112	9 DR-2	2.70	
113	1 G1-0	1.10	

S.No.	Sample ID	Hg (mg/kg)	Location
114	1 G1-1	46.00	OLD BUILDING - GROUND FLOOR
115	1 G1-2	0.50	
116	1 G2-0	2.50	
117	1 G2-1	182.00	
118	1 G2-2	1.40	
119	1 G3-0	1.80	
120	1 G3-1	1.60	
121	1 G3-2	1.60	
122	1 G4-0	2.70	
123	1 G4-1	2.00	
124	1 G4-2	2.80	
125	1 G5-0	5.50	
126	1 G5-1	0.60	
127	1 G5-2	368.00	
130	1 G6-2	10.50	
132	1 G7-1	1.90	
133	1 G7-2	2.60	
136	1 G8-2	2.20	
138	1 G9-1	1.50	
139	1 G9-2	2.40	
143	1 G11-0	5.50	
144	1 G11-1	7.50	
145	1 G11-2	10.70	
146	1 G12-0	2.70	
147	1 G12-1	4.90	
150	1 G13-1	23.30	
151	1 G13-2	36.30	
154	1 G14-2	49.50	
155	1 G15-0	5.40	
156	1 G15-1	9.50	
158	1 G16-0	25.70	
160	1 G16-2	13.60	
161	1 G17-0	17.40	
163	1 G17-2	10.50	
168	1 G19-1	10.00	
169	1 G19-2	0.50	
177	1 G22-1	13.80	
178	1 G22-2	62.20	
179	1 G23-0	14.00	
203	1 RA-0	0.30	RESIDENTIAL AREA
204	1 RA-1	0.60	
205	1 RA-2	1.20	
206	2 RA-0	0.20	
207	2 RA-1	0.10	
208	2 RA-2	3.70	

S.No.	Sample ID	Hg (mg/kg)	Location
209	1 B-0	13.30	BAKERY BUILDING
210	1 B-1	34.90	
211	1 B-2	54.40	
213	2 B-1	21.70	
214	2 B-2	20.00	
233	9 B-0	36.40	
234	9 B-1	31.60	
235	9 B-2	39.90	
236	10 B-0	38.40	
237	10 B-1	6.20	
239	11 B-0	91.20	
240	11 B-0	0.30	
241	11 B-2	76.40	
242	12 B-0	15.80	
243	12 B-1	6.80	
244	12 B-2	66.40	
245	13 B-0	61.70	
246	13 B-1	25.80	
247	13 B-2	42.70	
248	14 B-0	17.20	
249	14 B-1	10.70	
250	14 B-2	10.20	
251	1 MA-0	226.00	Main Building area
252	1 MA-1	14.60	
253	1 MA-2	20.10	
254	2 MA-0	147.00	
255	2 MA-1	21.60	
256	2 MA-3	3.20	
257	3 MA-0	28.60	
258	3 MA-1	49.40	
259	3 MA-2	15.50	
260	4 MA-0	386.00	
261	4 MA-1	35.80	
262	4 MA-3	5.10	
263	5 MA-0	374.00	
264	5 MA-1	17.60	
265	5 MA-2	19.00	
266	6 MA-0	170.00	
267	6 MA-1	7.40	
268	6 MA-2	14.80	
269	7 MA-0	19.80	
270	7 MA-1	15.40	
271	7 MA-3	21.90	
272	8 MA-0	30.20	
273	8 MA-1	36.00	
274	8 MA-2	48.40	
275	9 MA-0	46.70	

S.No.	Sample ID	Hg (mg/kg)	Location
276	9 MA-1	15.20	Main Building area
277	9 MA-3	8.00	
278	10 MA-0	17.30	
279	10 MA-1	16.70	
280	10 MA-2	10.60	
281	11 MA-0	22.30	
282	11 MA-1	9.80	
283	11 MA-3	4.90	
284	12 MA-0	4.20	
285	12 MA-1	4.80	
286	12 MA-2	12.70	
287	13 MA-0	5.20	
288	13 MA-1	4.10	
289	13 MA-2	3.90	
290	14 MA-0	6.30	
291	14 MA-1	3.80	
292	14 MA-3	5.30	
293	15 MA-0	33.40	
294	15 MA-1	7.40	
295	15 MA-2	8.40	
296	16 MA-0	13.30	
297	16 MA-1	6.10	
298	16 MA-3	6.80	
299	17 MA-0	129.00	
300	17 MA-1	10.70	
301	17 MA-2	18.60	
302	18 MA-0	13.20	
303	18 MA-1	6.70	
304	18 MA-3	7.60	
305	19 MA-0	18.60	
306	19 MA-1	8.70	
307	19 MA-2	5.80	
308	20 MA-0	9.20	
309	20 MA-1	9.10	
310	20 MA-3	3.00	
311	21 MA-0	9.20	
312	21 MA-1	1.50	
313	21 MA-2	3.20	
314	22 MA-0	31.50	
315	22 MA-1	12.20	
316	22 MA-3	1.30	
317	23 MA-0	195.00	
318	23 MA-1	60.30	
319	23 MA-2	40.90	
320	24 MA-0	1,020.00	
321	24 MA-1	62.40	
322	24 MA-3	6.70	

S.No.	Sample ID	Hg (mg/kg)	Location
323	26-1	5.70	
324	I UB-0	1.50	UTILITY BUILDING
325	1 NM-2	4.50	NON MERCURY AREA
326	7 TC-1	5.20	
327	8 TC-1	0.20	TEST CHAMBER
328	8 TC-2	0.10	