BEFORE THE NATIONAL GREEN TRIBUNAL (SZ) CHENNAI
IA No. 151 of 2021

In
ORIGINAL APPLICATION No. 161 OF 2021 (Suo Motu)

Between:
Navroz Mody ... Applicant/ proposed respondent

Vs

The Chief Secretary
Government of Tamilnadu
Fort St George
Chennai & Ors .. Respondents/ Respondents

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Dated this the 7th day of October, 2021 at Chennai

Counsel for the Applicant

BEFORE THE NATIONAL GREEN TRIBUNAL (SZ) CHENNAI
MEMORANDUM OF INTERLOCUTORY APPLICATION

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NOTE ON SUBMISSIONS FILED ON BEHALF OF THE APPLICANT

1. At the outset, it is submitted that the purpose of this application is not to stop the remediation work at the project site. Rather, it is to highlight that existing information including studies available point to ongoing contamination of the downstream of the factory site and the need to assess the adequacy of erosion control and soil conservation measures in light of clear felling of trees and removal of vegetation, and the need for risk assessment and risk mitigation for ecologically sensitive wildlife areas.

2. It is submitted that the following issues need to be considered by this Hon'ble Tribunal in the present proceedings:

   a) The ongoing remediation and the measures undertaken at the site to deal with soil erosion as a result of rainfall is as per the approved plan for upscaling of remediation and was designed for a site with dense vegetation. The clear felling of trees, undergrowth and leaf litter significantly increases runoff and soil erosion – the existing soil erosion control and soil conservation measures (such as silt traps, silt settling tanks etc.) are not designed for this increased run off of rainwater and soil.

   b) The joint committee's conclusions which are based on complete concurrence with NEERI's site assessment report dated August 2021, are not borne out by the data presented in the report. NEERI's comparison of the data with incorrect screening guidelines has conveyed a false picture that all is well, while the data triggers serious concern.

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Importance of vegetation in preventing soil erosion

3. It is undisputed that the mercury contamination is predominantly in the soil of the contaminated site. The contaminated site has been categorized as Area A, Area B, Area C1 and Area C2 based on contour. The mercury is tightly bound to the soil and travels wherever the soil moves. During rainfall, soil from the contaminated sites is mobilized and carried by the rain water. When soil is carried from the factory site to offsite (outside the factory perimeters) – so is the mercury contamination.

4. The extent of soil running off with the rain water will depend on land cover and intensity of rainfall. For a given rainfall, when the land is covered by trees, undergrowth and leaf litter, the run-off is reduced. The protective vegetative cover typically offers three layers of protection to the soil –
   a) layer one is the canopy of the trees which break the velocity of falling rains and allows the rain water to drop gently to the ground.
   b) The dense undergrowth beneath the trees (shrubs, bushes) offer the second layer of protection and further retards the force with which the rain strikes the ground.
   c) Leaf litter accumulated over time due to falling leaves from the trees and shrubs form a thick cushion above the soil surface and offer a third layer of protection by absorbing and storing rain water and reducing runoff.

5. Devoid of these vegetative protections, there is nothing between the skies and the soil and the rain water strikes the soil with unimpeded force, resulting in greater soil erosion.

Felling of trees and clearing of the site renders the approved remediation plan irrelevant – Need for further studies

6. In 2010 the 5th respondent submitted a report titled "**Trees protection measures during decontamination process of mercury polluted soil**" prepared by the National Botanical Institute, Lucknow. Extracts from the report are presented below:

3

Tree status and fine roots:

A tentative assessment of the biomass status of the standing trees and fine roots indicates the highest index for area C1 (Table 2). There is a great risk of falling of the trees during soil excavation process and hence, precautions are required to save the maximum intact roots on the site. Even then it could not be possible to safeguard the fine roots. Fine roots absorb water and minerals from the soil solution required to perform the various metabolic processes/physiological functions for the sustenance of plants. It has been estimated that about 7Mg/ha (Area A) to 24Mg/ha (Area C1) fine root mass will be cut out and removed from different contaminated area. However, fine roots are ephemeral (short lived) and it will be generated in due course of time between 3-6 months. It is estimated that nearly 60-70% of the fine roots remain confined to upper soil layer up to 30cm depth. So the trees will be under nourished till the formation of their fine root network and sustain their physiological function in a great stress. Some of them may become dry at wilting coefficient when the water absorption from the soil through fine roots fails to compensate the transpirational losses. It is, therefore, suggested to fill-up the dug- out soil from the uncontaminated site near by as soon as possible.

7. The report also records the leaf litter in the various sections of the contaminated site. Relevant extract from the report is extracted below:

Assessment of risk potential and recommendations for the protection of trees & plants during excavation of surface soil up to 30 cm depth

Removal of top soil up to 30cm depth from the mercury polluted site of HUL, Kodaikanal particularly from the steep slope is quite dangerous for the growing trees as well as other associated vegetation. This needs to be looked carefully for the sustenance of many old trees (≈300) in the area of 2.3 acre of the contaminated site. Some of our preliminary investigations made so far reveal possible damage to the Rhizosphere ecology in terms of following losses:

Forest floor litter:

Organic matter of the forest floor litter serves a buffer stock for release of nutrients to the plants slowly, conserves soil moisture and checks soil runoff during rainwater flow or windstorms. It is decomposed and mineralized gradually forming ectoorganic layers (LFH) on the mineral soil in different state of decay (Table1). It has been estimated that about 5.9Mg/ha (Area A) to 12.4Mg/ha (Area B) organic carbon will be washed away during decontamination process (Fig1). It is, therefore, recommended to replenish the same from the nearby forest areas within a safe limit of <25% removal at one time.

Table 1: Litter mass on the ground floor

Sampling Site	Ground floor litter (Mg/ha)			Mean ±LSD 01 0.42
	L layer	F Layer	H layer	
Area- A	0.66	2.11	3.12	1.96
Area- B	1.19	5.33	5.91	4.14
Area- C2	1.41	2.29	4.26	2.65
Area- C1	0.80	3.10	6.01	3.30
control	1.55	1.08	2.79	1.80
Mean ± LSD 01 0.54	1.12	2.78	4.42	

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8. It is seen from this report that not only is vegetation and leaf litter considered important in mitigating soil run off but that such vegetation should be carefully preserved during the remediation process. A copy of this report is annexed as **Annexure A3.**

9. In the same year, another report titled "**Study on soil conservation while undertaking soil remediation process in mercury contaminated site of Hindustan Unilever ltd, Kodaikanal**" was submitted by the Central Soil and Water Conservation Research and Training Institute (now known as Indian Institute of Soil and Water Conservation), Ooty.

10. This report deals with measures to be taken to conserve soil and minimize the impact of the remediation process on soil and soil erosion. This report informs the erosion control measures such as the construction of random rubble stone masonry check dam, Gabion check dams, silt traps and bunds that have been established at the subject site.

11. It is clear from the report that the above-mentioned measures have been designed for a site with intact vegetation and are accompanied with other measures to safeguard standing trees. Some relevant extracts from the report are reproduced below.

> remediation will comprise of soil washing followed by vacuum retorting. The entire site of HUL is covered with thick vegetation and population of trees. Hence, excavation of soil may disturb the ecology of the site. In addition, it may lead to soil erosion from the site. Considering the fragile ecosystem of the area, it is not advisable to excavate the soil in all areas.

(Page 7 of the report)

5.0. Effects of soil remediation process on soil and vegetation

5.1. Effect of rainfall

The annual rainfall data (2000-2009) of Kodaikanal area (Fig.1.) shows that the average annual rainfall is 1812 mm. The North-East monsoon accounts for about 43 per cent (769 mm) of total rainfall followed by 20 per cent (359 mm) during the South-West monsoon and 37 per cent (142 mm) during summer and winter. The month of October receives

highest rainfall followed by November and September whereas the months of January and February receive lowest rainfall. The maximum daily rainfall received during the period was 500 mm during May, 2006. Hence, maximum erosion is expected while excavation and backfilling of soil during the months of May, August, September, October and November.

(Page 7-8 of the report)

7.0. Proposed conservation measures to be carried out while undertaking soil remediation process

Keeping in view of high rainfall during the months of May, August, September, October and November, the excavation and backfilling may be attempted during the Months of December to April, June and July. Heavy wind speeds are encountered during the months of January to April, hence proper care needs to be taken while excavating the soil near the trees. In general where the trees are located in dense or close spacing, excavation of soil should be completely avoided. At other places, for specified distances as given in Table 4, the soil should not be disturbed.

Table 4. Recommended distances from the major trees where soil should not be disturbed

Sl. No	Name of the tree	Radius of soil not to be disturbed around the trees (m)
1	Eucalyptus	3.00 m
2	Ber	1 m
3	Cybrus	1 m
4	Casuarina	1.5 m
5	Katti Sali (Local name)	1.0 m

(page 14 of the report)

7.2. Area B

The following erosion control measures have to undertaken while excavating the soil and backfilling process in the area "B".

- In parts of the area nearby trees, immediate filling is recommended by filling external soil. Necessary quantity of soil may be excavated from the area of residential quarters located within the premises and filled in this area followed by immediate grass turfing. The excavated soil in these patches may be treated and backfilled in area C1 and C2.
- Stone bunds at 0.5 m vertical interval may be constructed in slope area where trees are available to avoid soil erosion. The boulders which are already available in the site may be utilized.

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(Page 15 of the report)

12. It is submitted that the technical details of conservation measures have been described from pages 17 to 21 of the report and include gabion support wall, loose boulder terrace support wall, random rubble masonry

check wall, Gabion check dam, stone bunding, grass turfing etc. A copy of this report is annexed as **Annexure A4.**

13. It is submitted that thereafter in February 2018, a soil remediation upscaling plan was prepared by NEERI and the Indian Institute of Soil and Water Conservation, Ooty, annexed as **Annexure A5**. Relevant extracts from this report which reiterate the erosion control measures and the importance of tree and vegetative cover are reproduced below:

2.2 *DESCRIPTION OF REMEDIATION WORK*

The main component of the remediation work will involve excavation and remediation of the contaminated soils via soil washing and retorting. Excavation of the soils will be carried out by a combination of small excavation equipment and manual excavation. Excavated soils will thereafter be processed in the remediation area through a combination of soil washing and retorting.

The mercury distillation room, recovery room, scrap storage shed (old bakery building) and other old structures at the site will be demolished prior to excavating the soil in this area. The main factory building and the utilities building are to be demolished at the end of remediation work. The building materials and the soils from beneath the main factory building and utilities, if found to have mercury concentrations over 20 mg/kg, will be disposed off to an authorised Treatment, Storage, and Disposal Facility located in Virudhunagar District, Tamil Nadu.as per the applicable Hazardous Waste Rules (2016).

After the remediation activity is over, residual hardware, materials and scrap generated during the process will be disposed off in safe manner in line with TNPCB guidelines.

(Page 5 of the report)

4.4 SOIL EROSION CONTROL MEASURES

Various erosion prevention measures shall be undertaken during the excavation work, as per the recommendations of the Indian Institute of Soil and Water Conservation (IISWC), Udhagamandalam. The general recommendations include:

- 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 proper thickness suited to the compaction equipment;

PAGE 19

applying the necessary compaction to obtain the required densities; ensuring that compaction is of a nature that aeration to the root zone of surrounding trees is maintained. Proper bond shall be provided between each backfilled layer and also between the backfill and the sides of the excavation pits. 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.

(page 19-20 of the report)

Specific recommendations for Area C2 (gentle slopes)

- Soil will be excavated in horizontal and vertical slope near the factory building;
- Terrace walls with supporting walls to be developed as part of the backfilling activities
- Root slips of vegetative barriers with appropriate species of plants as recommended by IISWC, will be planted on the terrace after backfilling.

During heavy periods of rain, all excavation will be stopped and pits shall be covered with HDPE sheets, until a time when surface water runoff has ceased across the excavation area. Surface water runoff will be routed to the silt settling tank and silt traps.

PAGE 20

(Page 20 of the report)

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4.7 *PRESERVATION OF TREES DURING EXCAVATION*

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, to the extent possible. Backfilling and provision of adequate soil cover after manual excavation will ensure that trees will be subjected to minimal stress, to the extent possible. 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, to ensure safety. For each tree that is felled or that falls down, two native species of trees will be replanted on site. The trees that are found at the site include the non-native eucalyptus trees, cypress and acacia trees, rhododendron and magnolia plants/ flowers.

PAGE 21

(Page 21 of the report)

14. It is seen that this approved remediation plan provides for the preservation of trees as an erosion control measure and insists on their protection. In order to obviate any doubt, the remediation plan does not in any manner foresee, assess or consider the clear felling of trees from the entire contaminated site or make suggestions on enhanced mitigation measures if such vegetation were removed.

15. However, it is a known fact that erosion will occur and soil (along with mercury) will be carried by rain water from the contaminated site. It is to mitigate and control this run off that erosion control and soil conservation measures were provided.

16. In order to ensure and monitor the efficacy of these measures in preventing the run off of mercury laden soil into the downstream pambar shola, the approved remediation plan also contains an environmental monitoring framework inter alia to monitor air, soil and water quality. The framework requires the taking of weekly samples of water and soil/sediment from all silt traps, and the Levange Path in Pambar Shola. However, such sampling has not been done at all. The relevant page of the report is extracted below :

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Table 7.3 *Excavation and Process Area soil monitoring framework*

Sampling location	Number of samples
Sampling and analysis of soils from excavation areas and feed soil into soil washing plant	2 samples per excavation grid of 2mX 2 m and 3 samples from feed soil at soil washing plant loading area. Corresponds to approximating 5 samples per 2 tons of soil.
Sampling and analysis of output soil of the remediation equipment	Three soil samples collected per drum (~200 kg, one from the bottom, middle and top of the drum) and composited into one sample for analysis.
Sampling and analysis of soil from the silt traps.	Weekly sampling and analysis from one sample from every slit trap.
Fence line monitoring - soil sample from the southern boundary of the site, at the point where the onsite stream and at Levinge path meet	Weekly sampling and analysis of one soil sample from Levinge Path.

7.5.2 *Water Quality Monitoring Framework*

The inlet and outlet of the process water treatment plants will be sampled and analysed for mercury. Discharge criteria as per the Environment (Protection) Rules, 1986 (Fifth Amendment, 2014), "General standards for discharge of mercury as (Hg) in effluents" will be followed. Treated water will be predominantly reused in the soil washing train.

Table 7.4 *Process Water Monitoring framework*

Sampling location	Number of samples
Sampling and analysis of raw water used for soil washing.	One sample for every tanker brought in (or) daily sampling of in-house well water used.
Sampling and analysis of inlet and outlet water to process/grey/sewage water treatment plant.	Hourly samples from inlet and outlet of the process water treatment plant. Daily sample from inlet and outlet of the grey water treatment plant. Weekly sample from inlet and outlet of the sewage treatment plant.
Sampling and analysis of bleed water (when applicable) from the treatment process for soil reconditioning etc.	One sample of bleed water prior to being used for soil re-conditioning etc.
Sampling and analysis of water from the silt traps	Weekly sampling and analysis of one sample from every slit trap
Fence line monitoring - surface water from the stream at Levinge path, located at the southern boundary of the factory	One sample per week

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(Page 44 of the report)

17. It is clear that the existing erosion control measures and soil conservation measures were designed for an entirely different land cover – namely vegetated grounds with standing trees – than the presently existing denuded land cover.

18. Neither NEERI in its latest report dated August 2021 report nor the joint committee or the authorities that have granted permission for tree felling have assessed the impact of such felling on rainwater and soil runoff (along with mercury) from the factory site. It is clear that under denuded conditions, the run off would be vastly enhanced and likely the overwhelm the stormwater drain, and the erosion control and soil conservation measures designed and constructed for a fully vegetated site.

19. The quantum of rainwater run off or soil carried by the rainwater ought to be assessed and form the basis of the design and augmentation of erosion control and soil conservation measures for the newly denuded site.

20. It is submitted that the time is opportune as monsoon is upon us, and excavation of contaminated soil is to be suspended temporarily during October-November according to the soil conservation study. A suitable assessment to study the quantum of rainwater and contaminated soil mobilized from the site and entering the Pambar Shola, and the adequacy of the erosion control and soil conservation measures can be performed in the interim, which will help prescribe augmentation of existing erosion control and soil conservation measures if required and help an informed decision to protect the wildlife and downstream environment. TILL DATE, THERE IS NO STUDY AVAILABLE ON RAINWATER RUNOFF AND RESULTANT MERCURY LOSS INTO THE PAMBAR SHOLA. A conservative estimate of the run off and mercury lost into the pambar shola as calculated by Mr. Nityanand Jayaraman, Chennai Solidarity group, published on kodaimercury.org is annexed as **Annexure A6.** A letter was addressed by 65 prominent ecologists and academics on this issue to the Hon'ble Chief Minister and other authorities, which is annexed as **Annexure A7.**

Conclusions of NEERI – August 2021 Report and Joint committee report not borne out by its findings

21. It is submitted that the Joint committee entirely relies on the NEERI report and its interpretation of results to conclude that there is no offsite (outside the factory) contamination of mercury .

22. The NEERI report submitted in August 2021 is a result of the order of the Hon'ble NGT that a detailed site assessment be carried out to ascertain the extent of contamination. This report was not designed to assess the impact of tree felling on the mobilization of mercury into the downstream and offsite environments.

23. The Joint committee report on the other hand, should have addressed the changed circumstances at the site and its impact on erosion and other issues. In fact, the PCCF & CLW has not filed his independent report till date. The affidavit and documents purportedly filed on behalf of the 7th and 8th

Respondents contains assertions beyond the remit of the DFO who has filed the counter affidavit. It is necessary that the PCCF&CLW examines the issue and file a report as directed by this Hon'ble Tribunal.

24. The Joint committee however, has neither collected samples from offsite locations nor has it critically evaluated the data presented by NEERI but has only blindly concurred with NEERI's conclusions. It has also not studied the environmental impact of tree felling and removal of vegetation.

25. Therefore, once it is established that the NEERI's report is flawed and the data therein does not support the conclusions reached, then the joint committee report also automatically is liable to be rejected.

26. NEERI has presented results of analysis for Soil, Water and Vegetation taken from Pambar shola forest area and along Pambar stream. While the findings indicate serious cause for concern, NEERI concludes to the contrary, arguing that there is no contamination as the mercury levels are below Canadian guideline values. However, this conclusion is erroneous for the following reasons:

Sediment – Wrong standards

27. In the NEERI report at 8.2.4 at page 31 states as follows :

Table 11

Summary of Sediment Samples Collected from Pambar River

	Hg concentration Range (mg/kg)	**Hg Average Concentration ± SD (mg/kg)**
Pambar river (premonsoon)	ND– 0.412	0.076 ± 0.104
Pambar river (post monsoon)	ND– 0.256	0.019 ± 0.059
Levinge Pathway (premonsoon)	0.099	–
Levinge Pathway (postmonsoon)	0.015	–
MoEF&CC guideline value for sediment	Not specified	
Canadian Guideline value	0.486 mg/kg	
Dutch Intervention Value	Not specified	
USEPA	0.486 mg/kg	

SD: standard deviation; ND: not detected

28. The screening levels considered for comparison of sediment samples in the report refers to the Canadian Council of Ministers of Environment Sediment Quality Guidelines. Relevant pages of the NEERI Report have been filed as **Annexure A1** along with the IA and the Canadian sediment quality guidelines have been filed as **Annexure A2.**

29. The Sediment samples taken from Pambar Stream returned with values as high as 0.251, 0.256 and 0.412 mg/kg (Please see Annexure II and III of the NEERI report).

30. It is seen from the report that NEERI has stated " that all sediment samples were reported at concentrations less than the most conservative screening criteria of the Canadian guidelines of 0.486 mg/ kg". The same value has also been shown against the appropriate entry in table 11 of the report.

31. However, a perusal of the Canadian sediment quality guidelines for the protection of aquatic life shows that 0.486 mg / kg is not the sediment quality guideline.

32. It is seen from the document annexed as Annexure 2 that the Interim freshwater Sediment Quality Guideline (ISQG) for mercury is 0.17 mg/kg and NOT 0.486 mg/kg.

33. The Canadian guidelines contains the following prescriptions:

a) Interim sediment quality guidelines (ISQG)
b) Probable effect levels (PEL)
c) Incidence (%) of adverse biological effects in concentration ranges defined by these values

34. As stated above, the ISQG is 0.17 mg/kg, and the PEL is 0.486 mg/kg, and it is the former, not the latter that is the appropriate and most conservative screening criteria that ought to have been used for comparison.

35. The fact that considerable biologically adverse effects will occur when sediment mercury levels are above 0.17 mg/kg is evident from the Canadian Guidelines which states that the incidence of biologically adverse effects is 34% when sediment mercury levels are between 0.17 mg/kg and 0.486 mg/kg. At levels above 0.486, the incidence of adverse effects increases marginally to 36%. I submit that this makes it clear that considerable biologically adverse effects are certain at the levels detected by NEERI in its study and that its interpretation and conclusion on the sediment quality being benign is deeply flawed. The presence of such high levels of mercury in sediment 20 years after the factory has closed is a clear indicator that the factory site is continuously leaking mercury into the Pambar watershed.

Water – Guideline values far lower than Detection Level used by NEERI

36. The NEERI report at page 27 and 28 contains the summary of results of analysis of water samples collected from Pambar river and the screening guidelines including the Canadian guideline value.

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37. The report states that the screening levels of Canadian guideline value (0.000026 mg/l) and Dutch intervention value (0.003 mg/l) are lower than the detection limits of the analytical methodology followed in this study (0.0009 mg/liter). It is relevant to note that the limit of quantitation has been set by NEERI at 0.003 mg/l. Setting the Limit of quantitation at 0.003 mg/l means that only values greater than 0.003 mg/l will be reported.

38. In order to arrive at a conclusion that the water is not contaminated at levels of concern, the RoA of water samples have to compared with the most conservative Canadian guideline value as this value would represent the level below which adverse effects are insignificant. The Dutch intervention values, on the other hand, would represent a level above which some intervention would be required.

39. It is seen from the report that NEERI has stated that the concentration of mercury in all the water samples was less than the applicable screening standards (MoEFCC, BIS, USEPA RSL). This statement is incorrect and misleading.

a) Firstly, the value referred to as MoEF's guideline value is actually the standard for discharge of treated effluent into surface water and not for the quality of water in the river.
b) Secondly, the comparison with BIS drinking water standards (human health) is also not applicable as the standards for protection of aquatic systems are fixed keeping in mind the fact that mercury will bioaccumulate and concentrate in far more sensitive organisms and move up the food chain. Additionally, as stated above, the limit of quantitation in the present study has been set at 0.003 mg/l and levels lesser than 0.003 mg/l will not be reported and hence reference to this standard (0.001 mg/l) is meaningless.
c) Thirdly, the USEPA of 0.002 mg/l for which no reference document has been provided, is higher than the quantitation level. As stated above, the limit of quantitation in the present study has been set at 0.003 mg/l and levels lesser than 0.003 mg/l will not be reported and hence reference to this standard (0.002 mg/l) is meaningless.

40. Therefore there is no evidence to conclude that water is not contaminated and no such conclusion can be reached from the present report as all values less than LOQ have been reported as "Not detected (ND)". The LoQ of 0.003 mg/l used in the present report is 115 times higher than the appropriate Canadian guideline value of 0.000026 mg/l.

Soil – Residential and recreational (parkland) land-use standard incorrectly used for soil within Wildlife Sanctuary

41. It is seen from the report that NEERI has stated at page 22 section 6.2 that the Canadian soil quality guideline for protection of human health is 6.6 mg/kg and for environmental health is 12 mg/kg for agricultural, residential and parkland land use. NEERI has also stated that tier I screening

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would only be triggered if analytical data exceeded 12 mg/kg. The actual guidelines have however not been provided in the report nor has the joint committee referred to it. A reading of the Canadian soil guidelines would show that residential and parkland land use guideline values are wholly inapplicable to assess the health of soil inside a notified wildlife sanctuary. A copy of the Canadian soil quality guidelines is annexed as **Annexure A8**.

42. In fact, the document titled "A protocol for the derivation of environmental and human health soil quality guidelines" published by the Canadian council of Ministers of the Environment, 2006 (same agency that published the guidelines referred to by NEERI) clarifies that the applicability of different guideline values to different land uses. Extract from the report is annexed as **Annexure A9**. Relevant portion is extracted below :

> The definition of each land use accommodates generic conditions and puts boundaries on the receptors and exposure pathways considered in the guideline derivation for that land use. The four defined land uses are as follows:
>
> **Agricultural**: where the primary land use is growing crops or tending livestock. This also includes agricultural lands that provide habitat for resident and transitory wildlife and native flora.
>
> **Residential/Parkland**: where the primary activity is residential or recreational activity; parkland is defined as a buffer between areas of residency, and also includes campground areas, but excludes wildlands such as national or provincial parks.

43. It is seen from the above extract that the protocol itself categorially states that residential / parkland values cannot be used for wildlands etc. The use of the Parkland / residential standards for the adjacent wildlife sanctuary is wholly inappropriate

Moss

44. NEERI report has dealt with the concentration of mercury in Moss in section 8.2.5 at page 32 and found mercury concentrations ranging upto 6.36 mg/kg inside the sanctuary. The sample containing 6.36 mg/kg of mercury was taken from near a stream entering the sanctuary from the "HUL Stream discharge point (R01)". Even during post monsoon season, the mercury level in moss from this location was 1.148 mg/kg.

45. Moss absorbs and accumulates nutrients from the surrounding air and is used as a bio indicator for air pollution. The levels of mercury in moss samples ought to be compared with the naturally occurring background levels within the same region, namely, the Pambar shola and the wildlife sanctuary. It is seen from the other results presented for moss in Annexure I, II and III of the NEERI report that background levels of mercury in moss are below the limit of quantitation of 0.008 mg/kg set by NEERI.

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46. The mercury level of 6.36 mg/kg present in Moss collected at the HUL stream is 795 times higher than background levels (detection limit : 0.008 mg/kg) in NEERI's data set from other parts of the sanctuary. The high level of mercury suggests that the stream bed is an active source of mercury. This is evidence that mercury is being discharged from the site into the sanctuary.

47. The Results of Analysis (RoA) of sediment from silt traps has been presented by the Joint committee in page 9 of its report. The levels range from 2.21 mg/kg to 14.03 mg/kg, which conclusively proves the contention that mercury tainted soil is mobilized by rainfall. Given the intensity of rainfall in the mountains – recorded 24 hour maximum of 500 mm in May 2006, it goes without saying that the rainwater run-off will flow not merely through the narrow stream fitted with silt traps but will follow the gradient, thus escaping the factory site and into the adjacent sanctuary.

48. It is submitted that the hazardous waste authorization does not reflect the quantum of silt accumulated over 21 years of maintenance of the silt trap. RTI information available from the year 2016 reveal that returns were submitted only once on 31.12.2004 and no data was available with TNPCB subsequently. The fact that 7505 kg of silt was reportedly collected during 2001 to 2004 suggests that an average of 2.5 tons of silt per year should have been collected from the silt traps. The fact that this has not been collected can only mean that it has been lost to the environment. A copy of the RTI reply is annexed as **Annexure A10.**

49. The forest department and the joint committee have concluded that all activities are legally compliant and that the tree felling was carried out with permission from appropriate authorities. It is submitted that it has been clearly demonstrated that the felling of trees is in contravention of the approved remediation plan and any permission that has been given falls afoul of the remediation plan and the Hon'ble NGT's order which mandates remediation in accordance with the plan. Further, the permitting authorities are duty bound to issue permission on a scientific basis – based on detailed impact assessments of the proposed action – and not arbitrarily as has been done. It is to be noted that the factory site fell within the ESZ of the Kodaikanal Wildlife sanctuary, which is adjacent to the factory site and any permission for tree felling would have to be issued by the PCCF (HOD) and not the DFO or any other authority.

Immediate measures necessary

a) Since the monsoon is imminent, the denuded site will be exposed to heavy rainfall. The runoff from the site, its sediment load and quality has to be assessed in real-time with field measurements including quantum and quality of storm water and sediment at the entrance to the sanctuary. This will aid in determining the additional erosion control and soil conservation measures that need to be put in place to prevent further run off into the sanctuary during subsequent rains during this season. This study has to be conducted by any of the agencies who are involved in the process presently – as they have all concluded that there is no impact because of tree felling or clearing the site and has to be conducted by an independent expert eco-hydrologists familiar with the western ghats. The need for ecological risk assessment can only be decided based on such studies.

b) As required by the approved monitoring framework, weekly samples of water and soil / sediment from all silt traps and from Levinge path in pambar shola have to be taken immediately.

c) The TNPCB should also collect independent samples as required by the Consent to operate.

d) Detailed mercury mass balance of the remediation exercise should be carried out to account for all mercury inputs with a view to assess the extent of mercury lost to the environment.

50. It is submitted that NEERI in the latest report has rejected the need for an ecological risk assessment study based on a flawed interpretation of results as demonstrated above and it is a fact that contamination is found in the silt and in the stream leading from the HUL factory etc. There is a need to conduct an independent ecological risk assessment. It is submitted that the onus is on the actor carrying on the activity to prove that their actions do not cause environmental harm and in the instant case, there is enough evidence to demonstrate otherwise.

It is prayed that this Hon'ble Court be pleased to record these submissions and pass necessary orders in the facts and circumstances of the case and thus render justice.

Dated this the 7th day of October, 2021 at Chennai

Counsel for the Applicant

Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

SUMMARY TABLES

Table 1. Interim freshwater sediment quality guidelines (ISQGs; dry weight), probable effect levels (PELs; dry weight), and incidence (%) of adverse biological effects in concentration ranges defined by these values.[*]

Substance	ISQG	PEL	% ≤ ISQG	ISQG < % < PEL	% ≥ PEL
Acenaphthene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Acenaphthylene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Anthracene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Aroclor 1254 [See Polychlorinated biphenyls (PCBs)]					
Arsenic	5.9 mg·kg^{-1}	17.0 mg·kg^{-1}	5	25	12
Benz*(a)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Benzo*(a)*pyrene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Cadmium	0.6 mg·kg^{-1}	3.5 mg·kg^{-1}	11	12	47
Chlordane	4.50 µg·kg^{-1}	8.87 µg·kg^{-1}	2	17	70
Chromium	37.3 mg·kg^{-1}	90.0 mg·kg^{-1}	2	19	49
Chrysene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Copper	35.7 mg·kg^{-1}	197 mg·kg^{-1}	4	38	44
DDTs					
DDD[†] (2,2-Bis(*p*-chlorophenyl)-1,1,-dichloroethane; Dichloro diphenyl dichloroethane)	3.54 µg·kg^{-1}	8.51 µg·kg^{-1}	3	30	85
DDE[†] (1,1-Dichloro-2,2,bis(*p*-chlorophenyl)-ethene; Diphenyl dichloro ethylene)	1.42 µg·kg^{-1}	6.75 µg·kg^{-1}	6	20	47
DDT[†] (2,2-Bis(*p*-chlorophenyl)-1,1,1-trichloroethane; Dichloro diphenyl trichloroethane)	1.19 µg·kg^{-1} [‡]	4.77 µg·kg^{-1} [§]	8	5	59
Dibenz*(a,h)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Dieldrin	2.85 µg·kg^{-1}	6.67 µg·kg^{-1}	1	10	60
Endrin	2.67 µg·kg^{-1}	62.4 µg·kg^{-1}	1	64	59
Fluoranthene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Fluorene [See Polycyclic aromatic hydrocarbons (PAHs)]					

Continued.

Table 1. Continued.

Substance	ISQG	PEL	% ≤ ISQG	ISQG < % < PEL	% ≥ PEL
Heptachlor epoxide	0.60 µg·kg^{-1}	2.74 µg·kg^{-1}	3	12	67
Hexachlorocyclohexane [See Lindane]					
Lead	35.0 mg·kg^{-1}	91.3 mg·kg^{-1}	5	23	42
Lindane (Hexachlorocyclohexane)	0.94 µg·kg^{-1}	1.38 µg·kg^{-1}	0	50	49
Mercury	0.17 mg·kg^{-1}	0.486 mg·kg^{-1}	8	34	36
2-Methylnaphthalene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Naphthalene [See Polycyclic aromatic hydrocarbons (PAHs)]					
PAHs [See Polycyclic aromatic hydrocarbons (PAHs)]					
PCBs [See Polychlorinated biphenyls (PCBs)]					
PCDD/Fs [see Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans]					
Phenanthrene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Polychlorinated biphenyls (PCBs)					
Aroclor 1254	60 µg·kg^{-1} #	340 µg·kg^{-1} **			
Total PCBs	34.1 µg·kg^{-1}	277 µg·kg^{-1}	4	40	50
Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans	0.85 ng·TEQ/kg dw §§	21.5 ng·TEQ/kg dw §§	0##	24##	46##
Polycyclic aromatic hydrocarbons (PAHs)					
Acenaphthene	6.71 µg·kg^{-1} ‡	88.9 µg·kg^{-1} §			
Acenaphthylene	5.87 µg·kg^{-1} ‡	128 µg·kg^{-1} §			
Anthracene	46.9 µg·kg^{-1} ‡	245 µg·kg^{-1} §			
Benz*(a)*anthracene	31.7 µg·kg^{-1}	385 µg·kg^{-1}	13	6	38
Benzo*(a)*pyrene	31.9 µg·kg^{-1}	782 µg·kg^{-1}	11	16	30
Chrysene	57.1 µg·kg^{-1}	862 µg·kg^{-1}	8	14	25
Dibenz*(a,h)*anthracene	6.22 µg·kg^{-1} ‡	135 µg·kg^{-1} §			
Fluoranthene	111 µg·kg^{-1}	2355 µg·kg^{-1}	8	23	49
Fluorene	21.2 µg·kg^{-1} ‡	144 µg·kg^{-1} §			
2-Methylnaphthalene	20.2 µg·kg^{-1} ‡	201 µg·kg^{-1} §			
Naphthalene	34.6 µg·kg^{-1} ‡	391 µg·kg^{-1} §			
Phenanthrene	41.9 µg·kg^{-1}	515 µg·kg^{-1}	4	17	44
Pyrene	53.0 µg·kg^{-1}	875 µg·kg^{-1}	7	16	32
Pyrene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Toxaphene	0.1 µg·kg^{-1} ††	— ‡‡			
Zinc	123 mg·kg^{-1}	315 mg·kg^{-1}	5	32	36

* ISQGs and PELs presented here have been calculated using a modification of the NSTP approach (CCME 1995).
† Sum of *p,p´* and *o,p´* isomers.
‡ Provisional; adoption of marine ISQG.
§ Provisional; adoption of marine PEL.
# Provisional; adoption of lowest effect level from Ontario (Persaud et al. 1993).
** Provisional; 1% TOC; adoption of severe effect level of 34 µg·g^{-1} TOC from Ontario (Persaud et al. 1993).
†† Provisional; 1% TOC; adoption of the chronic sediment quality criterion of 0.01 µg·g^{-1} TOC of the New York State Department of Environmental Conservation (NYSDEC 1994).
‡‡ No PEL derived.
§§ Values are expressed as toxic equivalency (TEQ) units, based on WHO 1998 TEF values for fish.
Note that the incidence of adverse biological effects below the TEL, between the TEL and PEL, and above the PEL were 22%, 24% and 65%, respectively, prior to the application of a safety factor.

Table 2. Interim marine sediment quality guidelines (ISQGs; dry weight), probable effect levels (PELs; dry weight), and incidence (%) of adverse biological effects in concentration ranges defined by these values.*

Substance	ISQG	PEL	% ≤ ISQG	ISQG < % < PEL	% ≥ PEL
Acenaphthene [See Polycyclic aromatic hydrocarbons; (PAHs)]					
Acenaphthylene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Anthracene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Aroclor 1254 [See Polychlorinated biphenyls (PCBs)]					
Arsenic	7.24 mg·kg^{-1}	41.6 mg·kg^{-1}	3	13	47
Benz*(a)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Benzo*(a)*pyrene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Cadmium	0.7 mg·kg^{-1}	4.2 mg·kg^{-1}	6	20	71
Chlordane	2.26 µg·kg^{-1}	4.79 µg·kg^{-1}	9	12	17
Chromium	52.3 mg·kg^{-1}	160 mg·kg^{-1}	4	15	53
Chrysene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Copper	18.7 mg·kg^{-1}	108 mg·kg^{-1}	9	22	56
DDTs					
DDD† (2,2-Bis(*p*-chlorophenyl)-1,1,-dichloroethane; Dichloro diphenyl dichloroethane)	1.22 µg·kg^{-1}	7.81 µg·kg^{-1}	4	11	46
DDE† (1,1-Dichloro-2,2,bis(*p*-chlorophenyl)-ethene; Diphenyl dichloro ethylene)	2.07 µg·kg^{-1}	374 µg·kg^{-1}	5	16	50
DDT† (2,2-Bis(*p*-chlorophenyl)-1,1,1-trichloroethane; Dichloro diphenyl trichloroethane)	1.19 µg·kg^{-1}	4.77 µg·kg^{-1}	8	5	59
Dibenz*(a,h)*anthracene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Dieldrin	0.71 µg·kg^{-1}	4.30 µg·kg^{-1}	4	13	50
Endrin	2.67 µg·kg^{-1} ‡	62.4 µg·kg^{-1} §			
Fluoranthene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Fluorene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Heptachlor epoxide	0.60 µg·kg^{-1} ‡	2.74 µg·kg^{-1} §			
Hexachlorocyclohexane [See Lindane]					
Lead	30.2 mg·kg^{-1}	112 mg·kg^{-1}	6	26	58
Lindane (Hexachlorocyclohexane)	0.32 µg·kg^{-1}	0.99 µg·kg^{-1}	3	21	26

Continued.

Table 2. Continued.

Substance	ISQG	PEL	% ≤ ISQG	ISQG < % < PEL	% ≥ PEL
Mercury	0.13 $mg\cdot kg^{-1}$	0.70 $mg\cdot kg^{-1}$	8	24	37
2-Methylnaphthalene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Naphthalene [See Polycyclic aromatic hydrocarbons (PAHs)]					
PAHs [See Polycyclic aromatic hydrocarbons (PAHs)]					
PCBs [See Polychlorinated biphenyls (PCBs)]					
PCDD/Fs [see Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo furans					
Phenanthrene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Polychlorinated biphenyls (PCBs)					
Aroclor 1254	63.3 $\mu g\cdot kg^{-1}$	709 $\mu g\cdot kg^{-1}$	1	24	76
Total PCBs	21.5 $\mu g\cdot kg^{-1}$	189 $\mu g\cdot kg^{-1}$	16	37	55
Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo furans	0.85 ng TEQ/kg dw++	21.5 ng TEQ/kg dw++			
Polycyclic aromatic hydrocarbons (PAHs)					
Acenaphthene	6.71 $\mu g\cdot kg^{-1}$	88.9 $\mu g\cdot kg^{-1}$	8	29	57
Acenaphthylene	5.87 $\mu g\cdot kg^{-1}$	128 $\mu g\cdot kg^{-1}$	7	14	51
Anthracene	46.9 $\mu g\cdot kg^{-1}$	245 $\mu g\cdot kg^{-1}$	9	20	75
Benz*(a)*anthracene	74.8 $\mu g\cdot kg^{-1}$	693 $\mu g\cdot kg^{-1}$	9	16	78
Benzo*(a)*pyrene	88.8 $\mu g\cdot kg^{-1}$	763 $\mu g\cdot kg^{-1}$	8	22	71
Chrysene	108 $\mu g\cdot kg^{-1}$	846 $\mu g\cdot kg^{-1}$	9	19	72
Dibenz*(a,h)*anthracene	6.22 $\mu g\cdot kg^{-1}$	135 $\mu g\cdot kg^{-1}$	16	12	65
Fluoranthene	113 $\mu g\cdot kg^{-1}$	1 494 $\mu g\cdot kg^{-1}$	10	20	80
Fluorene	21.2 $\mu g\cdot kg^{-1}$	144 $\mu g\cdot kg^{-1}$	12	20	70
2-Methylnaphthalene	20.2 $\mu g\cdot kg^{-1}$	201 $\mu g\cdot kg^{-1}$	0	23	82
Naphthalene	34.6 $\mu g\cdot kg^{-1}$	391 $\mu g\cdot kg^{-1}$	3	19	71
Phenanthrene	86.7 $\mu g\cdot kg^{-1}$	544 $\mu g\cdot kg^{-1}$	8	23	78
Pyrene	153 $\mu g\cdot kg^{-1}$	1 398 $\mu g\cdot kg^{-1}$	7	19	83
Pyrene [See Polycyclic aromatic hydrocarbons (PAHs)]					
Toxaphene	0.1 $\mu g\cdot kg^{-1}$ #	—**			
Zinc	124 $mg\cdot kg^{-1}$	271 $mg\cdot kg^{-1}$	4	27	65

* ISQGs and PELs presented here have been calculated using a modification of the NSTP approach (CCME 1995).

† Sum of *p,p′* and *o,p′* isomers.

‡ Provisional; adoption of freshwater ISQG.

§ Provisional; adoption of freshwater PEL.

\# Provisional; 1% TOC; adoption of the chronic sediment quality criterion of 0.01 $\mu g\cdot g^{-1}$TOC of the New York State Department of Environmental Conservation (NYSDEC 1994).

** No PEL derived.

++ Values are expressed as toxic equivalency (TEQ) units, based on WHO 1998 TEF values for fish.

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Reference listing:

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Trees protection measures during decontamination process of mercury polluted soil

First Interim Report

To

Hindustan Unilever Limited
Kodaikanal

By

Dr. S. N. Singh
Project Investigator
Scientist 'G' & Head
Environmental Science Division
National Botanical Research Institute
Lucknow

Assessment of risk potential and recommendations for the protection of trees & plants during excavation of surface soil up to 30 cm depth

Removal of top soil up to 30cm depth from the mercury polluted site of HUL, Kodaikanal particularly from the steep slope is quite dangerous for the growing trees as well as other associated vegetation. This needs to be looked carefully for the sustenance of many old trees (≈300) in the area of 2.3 acre of the contaminated site. Some of our preliminary investigations made so far reveal possible damage to the Rhizosphere ecology in terms of following losses:

Forest floor litter:

Organic matter of the forest floor litter serves a buffer stock for release of nutrients to the plants slowly, conserves soil moisture and checks soil runoff during rainwater flow or windstorms. It is decomposed and mineralized gradually forming ectoorganic layers (LFH) on the mineral soil in different state of decay (Table1). It has been estimated that about 5.9Mg/ha (Area A) to 12.4Mg/ha (Area B) organic carbon will be washed away during decontamination process (Fig1). It is, therefore, recommended to replenish the same from the nearby forest areas within a safe limit of <25% removal at one time.

Table 1: Litter mass on the ground floor

Sampling Site	Ground floor litter (Mg/ha)			Mean ±LSD
	L layer	F Layer	H layer	01 0.42
Area- A	0.66	2.11	3.12	1.96
Area- B	1.19	5.33	5.91	4.14
Area- C2	1.41	2.29	4.26	2.65
Area- C1	0.80	3.10	6.01	3.30
control	1.55	1.08	2.79	1.80
Mean ± LSD 01 0.54	1.12	2.78	4.42	

55

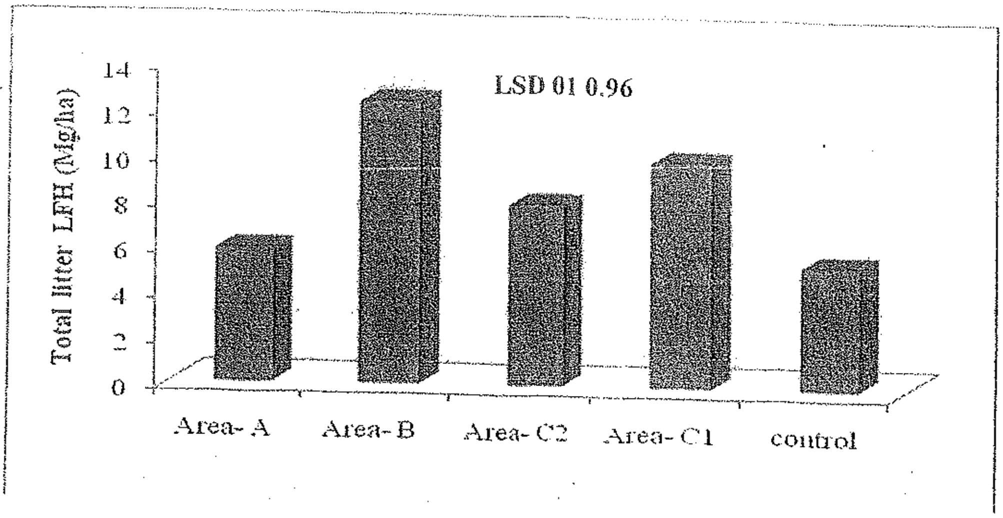

Fig 1 : Total ground floor litter (LFH) on different sites

Tree status and fine roots:

A tentative assessment of the biomass status of the standing trees and fine roots indicates the highest index for area C1 (Table 2). There is a great risk of falling of the trees during soil excavation process and hence, precautions are required to save the maximum intact roots on the site. Even then it could not be possible to safeguard the fine roots. Fine roots absorb water and minerals from the soil solution required to perform the various metabolic processes/physiological functions for the sustenance of plants. It has been estimated that about 7Mg/ha (Area A) to 24Mg/ha (Area C1) fine root mass will be cut out and removed from different contaminated area. However, fine roots are ephemeral (short lived) and it will be generated in due course of time between 3-6 months. It is estimated that nearly 60-70% of the fine roots remain confined to upper soil layer up to 30cm depth. So the trees will be under nourished till the formation of their fine root network and sustain their physiological function in a great stress. Some of them may become dry at wilting coefficient when the water absorption from the soil through fine roots fails to compensate the transpirational losses. It is, therefore, suggested to fill-up the dug- out soil from the uncontaminated site near by as soon as possible.

Table 2: Tree and fine root biomass at various sites

Sampling Site	Aboveground tree biomass (Mg/ha)	Fine root biomass (Mg/ha) <2mm diameter
Area- A	124	7
Area- B	269	14
Area- C2	99	10
Area- CI	321	24
Control	276	6
±LSD 0.01	**10.09**	**6.19**

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Soil Nature:

Soil appears to be slightly acidic with low concentrations of soluble salts (Table 3,4). Efforts have to be made to ensure almost same level of pH and EC concentration in the refilled soil as it affects the microbial activity and nutrient availability in the soil.

Table 3: Soil pH

Mercury levels (µg/g)	pH		
	Depth 0-15 (cm)	Depth 15-30 (cm)	Mean± LSD 0.01 0.417
50-100	6.69	6.57	6.63
100-500	5.40	5.68	5.54
> 500	6.06	6.34	6.20
Mean± LSD 0.01 NS	6.05	6.20	

Table 4: Soil Electrical conductivity

Mercury levels (µg/g)	EC values (µS/cm)		
	Depth 0-15 (cm)	Depth 15-30 (cm)	Mean LSD 0.01 ± 17.93
50-100	87.2	60	73.6
100-500	100	72.2	86.1
> 500	171	140	155.5
Mean± LSD 0.01 21.95	119.40	90.73	

Soil organic matter:

Organic carbon in the soil is considered as one of the major parameters for the determination of soil fertility for the growth and development of plants. The soil appears to be very rich in % carbon between 100-500µg/g Hg level in lower depth (Table5). Since organic carbon will be removed to the extent of 60-120Mg/ha from the sites having > 500 to 100-500µg/g of mercury levels (Fig 2), it is recommended that the excavated sites should be refilled next day from the surface soil of nearby forest area by scraping up to 10cm depth only.

Table 5: Organic carbon

Mercury levels in ppm	Organic Carbon (%)		
	Depth 0-15cm	Depth 15-30cm	Mean ±LSD 0.01 0.305
50-100	2.24	3.23	2.74
100-500	3.69	4.42	4.06
> 500	1.53	2.50	2.02
Mean± LSD 0.01 0.43	2.49	3.39	

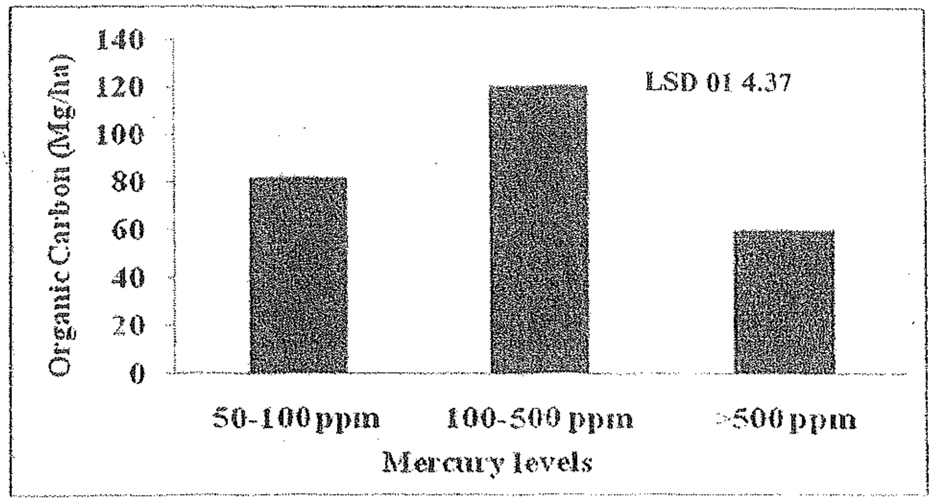

Fig 2: Loss of organic carbon per ha

Nitrogen availability:

Nitrogen is required in high amount during active growth period which is released by the mineralization of the soil organic matter. At a given time, available nitrogen fraction is directly proportional to organic carbon (Table 6). The entire fraction of the available nitrogen will be washed away during decontamination process. This loss is measured as 319 -578kg/ha from the sites of different Hg levels (Fig 3.) It is to be compensated in the same way as suggested for carbon.

Table 6: Concentration of available nitrogen

Mercury (μg/g)	Available Nitrogen (mg/kg)		Mean LSD 0.01= ± 16.68
	Depth 0-15	Depth 15-30	
50-100	142.68	165.76	154.22
100-500	176.96	208.32	192.64
> 500	122.72	90.04	106.38
Mean, LSD 0.01= NS	147.45	154.71	

91

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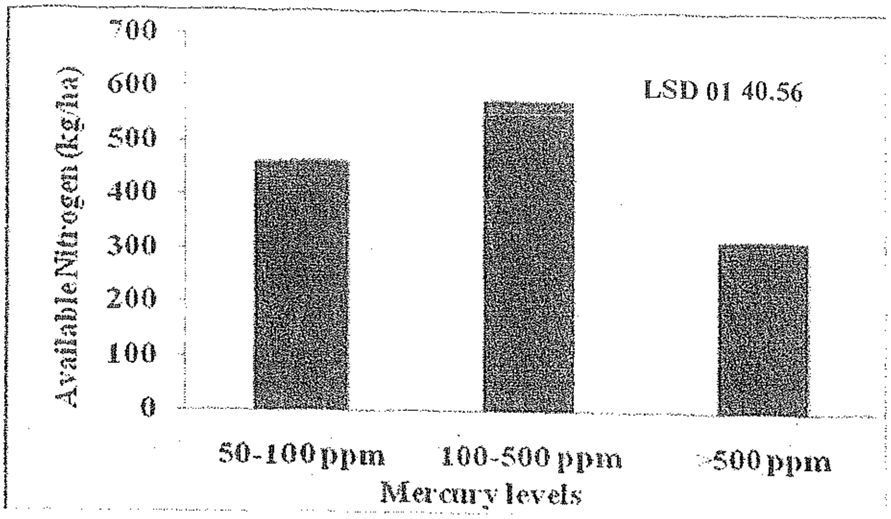

Fig 3: Loss of available nitrogen per ha

Other nutrients:

It is estimated that different magnitudes of Ca, Mg, K and P will be lost when the contaminated soil is treated for Hg removal and their replenishment in the soil may not be possible quickly to sustain the trees. So we must replace it by fertile soil as soon as possible in order to sustain the growing trees. Till now, we have estimated the levels phosphorus and potassium (Table 7, 8 and Fig 4,5)

Table 7: Concentration of available Potassium

Mercury (µg/g)	Available Potassium (mg/kg)		Mean LSD 0.01= ± 15.16
	Depth 0-15	Depth 15-30	
50-100	156.00	123.00	**154.22**
100-500	120.00	80.00	**192.64**
> 500	136.00	80.00	**106.38**
Mean, LSD 0.01= ± 18.57	**137.33**	**94.33**	

32

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Table 8: Concentration of available Phosphorus

Mercury (µg/g)	Available Phosphorus (mg/kg)		Mean LSD 0.01= ± 10.21
	Depth 0-15	Depth 15-30	
50-100	55	30	42.65
100-500	45	30	37.52
> 500	9	7	8.25
Mean, LSD 0.01= ± 12.51	36.54	22.41	

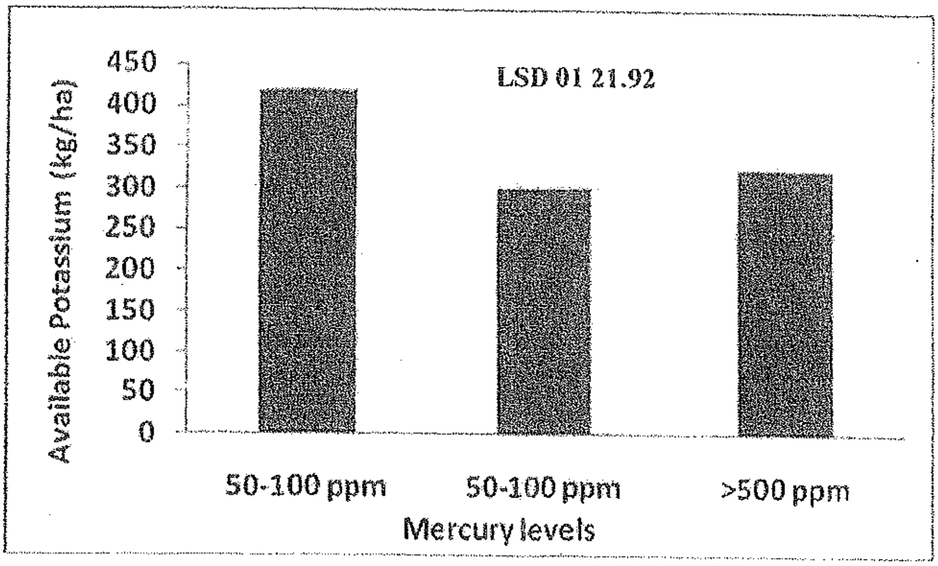

Fig 4: Loss of available potassium per ha

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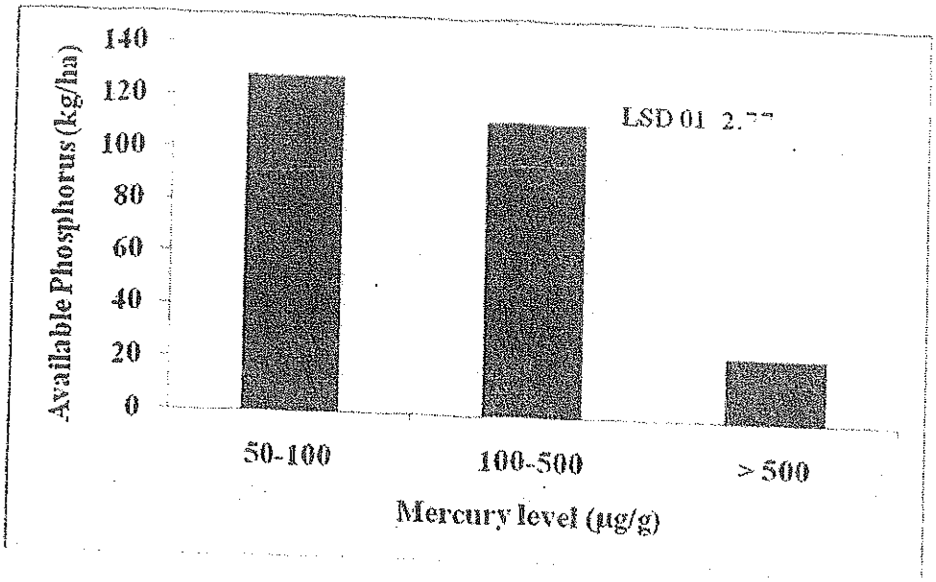

Fig 5: Loss of available Phosphorus per ha

Microbial Biomass Carbon:

It is an index to examine the biological health status of the soil, which varied from 113 to 534µg/g and closely relates the soil organic carbon with a greatest amount in the soils having 100-500 Hg level (Table 9). It has been estimated that microbial biomass carbon will be washed away to the extent of 738 to 1383kg/ha from the soils of different Hg levels of contamination and it will take much time to build up this level (Fig6). Therefore, suitable cultures, isolated from the nearby forest soils, need to be inoculated throughout the dug-out and refilled mineral soil.

Table 9: Microbial biomass carbon

Mercury (µg/g)	Microbial Carbon (µg/g)		Mean LSD 0.01= ± 28.39
	Depth 0-15	Depth 15-30	
50-100	211.00	413.40	**154.22**
100-500	265.00	533.60	**192.64**
> 500	113.20	253.20	**106.38**
Mean, LSD 0.01= ± 34.77	**196.40**	**400.07**	

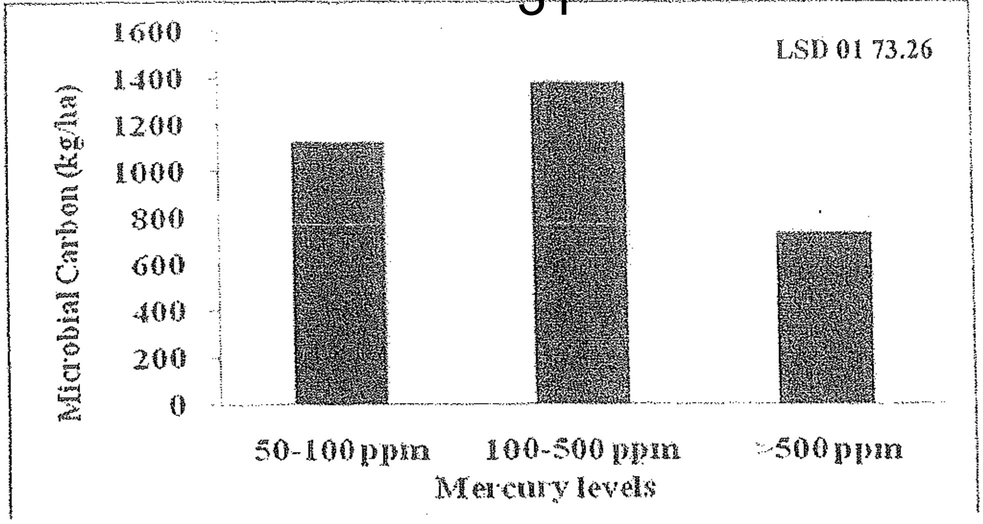

Fig 6: Loss of Microbial Biomass Carbon per ha

Microorganisms:

The entire population and diversity of microorganisms will disappear during treatment and their restoration is not quite easy unless it is well inoculated and incubated with the VAM fungi, nitrifying and phosphate solubilising bacteria. The rhizosphere is the soil zone in the immediate vicinity of a root system. Arbuscular mycorrhizal symbiosis affects the community and diversity of other organisms in the soil. Mycorrhizae diversity has been reported to increase plant species diversity as the potential number of associations increases. Dominant arbuscular mycorrhizal fungi can prevent the invasion of non-mycorrhizal plants on land where they have established symbiosis and promote their mycorrhizal host.

Recent research has shown that AM fungi release an unidentified diffusional factor, known as the **myc factor**, which activates the nodulation factor's inducible gene mtENOD11. This is the same gene involved in establishing symbiosis with the nitrogen fixing, rhizobial bacteria. When Rhizobium bacteria are present in the soil, mycorrhizal colonization is increased due to an increase in the concentration of chemical signals involved in the establishment of symbiosis. Effective mycorrhizal colonization can also increase the nodulations and symbiotic nitrogen fixation in mycorrhizal legumes. The extent of arbuscular mycorrhizal colonization and species affects the bacterial population in the rhizosphere. Bacterial species differ in their abilities to compete for carbon compound root exudates. A change in the amount or composition of root exudates and fungal exudates due to the existing

AM mycorrhizal colonization determines the diversity and abundance of the bacterial community in the rhizosphere. The influence of AM fungi on plant root and shoot growth may also have indirect effect on the rhizosphere bacteria. AMF contributes a substantial amount of carbon to the rhizosphere through the growth and degeneration of the hyphal network. There is also evidence that AM fungi may play an important role on mediating the plant species' specific effect on the bacterial composition of the rhizosphere.

Arbuscular mycorrhizae (AMs) are characterized by the formation of unique structures such as arbuscules and vesicles by fungi of the phylum Glomeromycota (AM fungi). AM fungi (AMF) help plants to capture nutrients such as phosphorus and micronutrients from the soil. It is believed that the development of the arbuscular mycorrhizal symbiosis played a crucial role in the initial colonisation of land by plants and in the evolution of the vascular plants. Arbuscular mycorrhizal fungi are most frequent in plants growing on mineral soils. The populations of AM fungi is greatest in plant communities with high diversity such as tropical rainforests where they have many potential host plants and can take advantage of their ability to colonize a broad host range. Kodaicanal lies in the broad zone of tropical rainforest.

It has been said that it is quicker to list the plants that do not form mycorrhizae than those that do. This symbiosis is a highly evolved mutualistic relationship found between fungi and plants, the most prevalent plant symbiosis known and AM is found in 80% of vascular plant families of today. The tremendous advances in research on mycorrhizal physiology and ecology over the past 40 years have led to a greater understanding of the multiple roles of AMF in the ecosystem. This knowledge is applicable to human endeavours of ecosystem management, ecosystem restoration and agriculture. The use of arbuscular mycorrhizal fungi in ecological restoration projects has been shown to enable host plant establishment on degraded soil and improve soil quality and health (phytoremediation).

Disturbance of herbaceous plant communities and plant propagules by excavating the soil from the contaminated areas will lead to degradation of physical and biological soil properties, soil structure, nutrient availability and organic matter. While reclaiming the polluted land, it is essential to restore the ground layer vegetation which also works as soil binders and controls run off and help to rejuvenate the biological and physical soil properties.

It is, therefore, suggested to inoculate the soil with arbuscular mycorrhizal fungi with the reintroduction of ground vegetation. A long term study demonstrated that a significantly greater long term improvement in soils' quality parameters was attained when the soil was inoculated with a mixture of indigenous arbuscular mycorrhizal fungi species compared to the non inoculated soil and soil inoculated with a single exotic species of AM fungi. The benefits observed were an increased plant growth and soil nitrogen content, higher soil organic matter content and soil aggregation. The improvements were attributed to the higher legume nodulation in the presence of AMF, better water infiltration and soil aeration due to soil aggregation. Inoculation with native AM fungi increases plant uptake of phosphorus, improves plant growth and health and it is a biological tool in the restoration of biotypes to self-sustaining ecosystems.

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Report

Of

Study on soil conservation while undertaking soil remediation process in mercury contaminated site of Hindustan Unilever Ltd., Kodaikanal

Consultants

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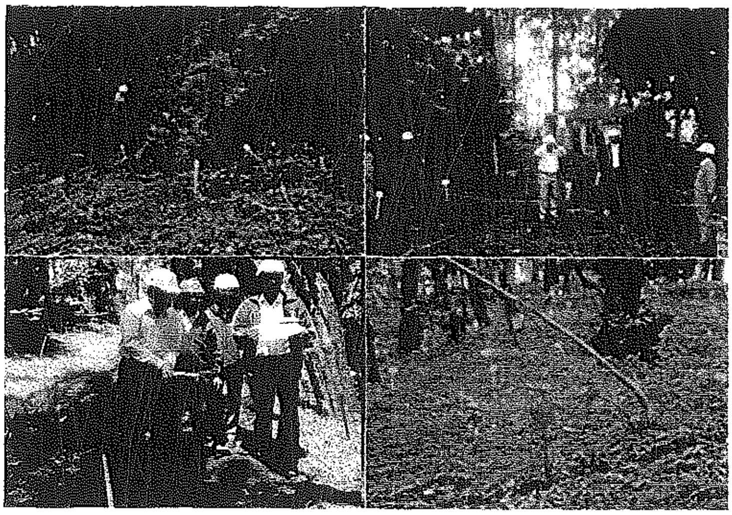

Prepared for

Hindustan Unilever Limited

Kodaikanal

Central Soil & Water Conservation Research & Training Institute: Research Centre

Udhagamandalam - 643 004

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October 2010

GLOSSARY

HUL	:	**Hindustan Unilever Limited**
SCMC	:	**Supreme Court Monitoring Committee**
TNPCB	:	**Tamil Nadu Pollution Control Board**
NEERI	:	**National Environmental Engineering Research Institute**
ERM		**Environmental Resources Management**
DPR	:	**Detailed Project Report**
ETP	:	**Effluent Treatment Plant**
LCC	:	**Land Capability Classification**
LBTSW	:	**Loose Boulders Terrace Support Wall**
RRCD	:	**Random Rubble Concrete Masonry Check Dam**
GCD	:	**Gabion Check Dam**
LBCD	:	**Loose Boulders Check Dam**

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Executive Summary

The mercury in glass thermometer factory was set up by Ponds India Limited at Kodaikanal in 1983 and commenced production in January 1984. It came under the management of Hindustan Lever Ltd. (Presently renamed as Hindustan Unilever Ltd.:- HUL) in September 1998 consequent to the merger of Ponds India Ltd. with it. The manufacturing process for thermometer making include stem cutting of imported glass, followed by end opening, end cutting, bulb forming, mercury filling, top chambering, scale setting, grading, top sealing, screen printing and certification. The manufacturing area had 36 exhaust fans to facilitate air change and maintain the workplace occupational safety standards for air 0.05 mg/Nm^3 of mercury. The expelled air containing mercury vapours from the manufacturing area settled down on the surrounding soils close to the manufacturing area causing contamination of soil and biomass. Detection of glass scrap with residual mercury in a scrap yard at Kodaikanal led the HUL management to close the factory operations in March 2001. Various remedial measures were initiated by HUL immediately thereafter which includes, Retrieval of glass scrap with residual mercury from the scrap yard, environmental site assessment and risk assessment study for mercury, construction of silt traps to prevent discharge of contaminated soil from the factory site, comprehensive medical examination of employees, export of 290 MT of all mercury bearing materials such as glass scrap, finished and semi-finished thermometers, elemental mercury, and ETP sludge to M/s Bethlehem Apparatus, USA for recycling and decontamination of plant and machinery and disposal.

A high power Supreme Court Monitoring Committee (SCMC) on hazardous waste management visited the HUL factory site in September 2004 and directed the Tamil Nadu Pollution Control

Board (TNPCB) to take immediate steps towards assessment and remediation of mercury contaminated areas. Subsequently, SCMC directed TNPCB to involve National Environmental Engineering Research Institute (NEERI), Nagpur during the assessment and remediation of mercury-contaminated areas. NEERI recommended the soil remediation process by excavating the top layer of soil and washing / vacuum retorting of excavated soil followed by backfilling. Necessary protocol for soil remediation process was also developed by NEERI (2008) and details of technical issues to be addressed during remediation process were elaborated. Following the last progress meeting held with TNPCB in Chennai in February, 2010, TNPCB directed HUL to conduct the following studies: (a) peer review of risk assessment report to verify the site specific remediation criteria; (b) report on tree conservation during excavation, treatment and backfilling by the National Botanical Research Institute; and (c) report on soil erosion and suitable control measures by the Central Soil and Water Conservation Research and Training Institute. As directed, Central Soil Water Conservation Research and Training Institute: Research Centre, Udhagamandalam is involved in conducting the soil erosion study while attempting excavation and to propose the suitable conservation measures for preventing soil erosion to the extent possible. As per Terms of Reference (TOR), the study involved the following objectives:

1. Soil conservation study including likely impact on soil while undertaking the remediation process (Excavation and backfilling) as detailed in DPR.
2. Suggest the measures to minimize the impact on soil and soil erosion while undertaking the remediation process as detailed in DPR.
3. Any other suggestions with regards to the soil remediation project including rehabilitation of soil.

4. Presentation of the findings and recommendations of the study to Tamil Nadu Pollution Control Board and Scientific Experts Committee constituted by the Supreme Court Monitoring Committee to monitor soil remediation.

Study area was inspected by study team and the information on soil type and depth, land use pattern were generated. Contour survey at 1m grid was conducted and slope map was prepared. Rainfall and wind velocity data for 10 years period was collected from India Meteorological Department, Chennai and data was analyzed. Nature of vegetation and root distribution system was also examined for stability of erosion. Soil depth study was conducted in 30 locations randomly selected. The information was also generated based on discussion with officials of the Hindustan Unilever Limited and Environmental Resources Management. Mercury distribution and steps involved in soil remediation process was taken from previous reports submitted by NEERI and URS. The major problems expected during the soil excavation and backfilling process were identified and preventive measures to be followed are suggested.

The following problems are identified while excavation of mercury contaminated soil and backfilling the treated soil.

Area 'A': There is the possibility of soil erosion due to steeper slope (33 to 50 per cent) coupled with high intensity of rainfall and high surface runoff. Soil depth is shallow $\leq$ 0.25 m and the rocky patches will be exposed if the soil is excavated up to the depth of 25 cm, resulting in the possibility of movement of mass soil towards valley side. Shallow rooted trees which exist in this area may fall down, even if 30 cm soil is excavated due to heavy wind (6.0 to 9.6 km / hr) and shallow distribution of root system. Backfilling of the soil is not possible in this area due to steep slope and shallow soil depth. As a result of the soil washing process, the cohesion and adhesion properties of soil will be washed away through water. If backfilling of the soil is done after washing, the soil will not stand over the bed rocks since continuous water lubrication will exist between backfilled soil and parent rock (Due to less compactness in backfilled soil, critical slope and accumulation of leaf litter on the top surface).

Area 'B': There is the possibility of soil erosion due to steeper slope (33 to 50 per cent) coupled with higher intensity of rainfall and higher runoff. Shallow rooted trees which are exists in this area may fall down, even if 30 cm soil is excavated due to heavy wind (6.0 to 9.6 km / hr) and shallow distribution of root system. Backfilling of the soil is possible in this area where flat land is available and in sloppy area, only excavation can be done.

Area 'C': Soil erosion will occur, while excavation and refilling process without adopting suitable conservation measures due to slopes ranges from 6 to 20 per cent and high runoff. Removal of top soil containing organic carbon during excavation and backfilling process may bring the land to low productivity.

The following preventive measures are recommended while excavation and backfilling process.

- Keeping in view of high rainfall during the months of May, August, September, October and November, the excavation and backfilling may be attempted during the Months of December to April, June and July. Heavy wind speeds are encountered during the months of January to April, hence proper care needs to be taken while excavating the soil near the trees.
- Keeping in view of steep slope, high rainfall, and shallow soil depth and existing of trees, excavation should be avoided in Area 'A'. Excavation and backfilling can be done in part of the Area 'B' and Area C1 and C2 (As demarked in Map 3) with suitable erosion control measures as recommended in sections 7 and 8.

- In general where the trees are located in dense or close spacing, excavation of soil should be completely avoided. At other places, for specified distances as given in Table 4, the soil should not be disturbed.
- It is suggested to not to disturb the soil where the steep slope area of 'A' Zone (as demarked in Map 3) having above 50 % land slope. Instead, in-situ measures should be taken up to avoid the movement of mercury contaminated soil from this area to neighboring areas. Covering with Geo-Jute blankets and planting grass species will be the suitable option to avoid the soil movement.
- Gabion type of terrace support wall may be constructed on the lower portion of the area 'A' over a length of 150 m which will not allow the mercury contaminated soil to spread over other areas in future. The boulders which are already available in the site can be used for this purpose.
- In part of the area 'A' (near scrap yard), excavation of soil may be restricted to 25 cm depth and backfill the washed soil in Area C2. While excavating in the leveled portion of this area, inward terrace system may be followed with 2:1 slope. Riser part may be maintained with 1:1 slope ratio. Riser part may be covered with Geo-Jute erosion control blanket and grass roots may be planted.
- In parts of the area 'A' (Only leveled portion where there is no trees and area 'B' (Near the tress) where soil can be excavated up to 20 cm depth, immediate backfilling is recommended by filling external soil. Necessary quantity of soil may be excavated from the residential quarters located within the premises and filled in this area followed by immediate grass turfing. The excavated soil in these patches may be treated and backfilled in area C1 and C2.

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- Stone bunds at 0.5 m vertical interval may be constructed in slope area where trees are available to avoid soil erosion in Area 'B'. The boulders which are already available in the site may be utilized.
- It is suggested that Gabion type of retaining wall on the lower portion of the area "B" over a length of 150 m which will not allow the contaminated soil to spread to over other areas.
- It is proposed to construct Random Rubble Stone Masonry Check Dam (RRCD) in the lower portion of the gully located in between area A & area B.
- Gabion Check Dam (GCD) on the upper portion of the gully may be constructed to collect the eroded soil which will be washed with runoff after immediate backfilling. This soil can be desilted and it can be spread over the areas in future time.
- In area 'C1", Excavation of soil may be restricted up to 0.35 m depth.
- Soil may be backfilled by forming terraces and terrace support walls may be constructed in each terrace.
- Root slips of the Vegetative barriers viz. Guatemala (*Tripsacum laxum)* and Kikyu *(Pennisetum clandestinum)* should be planted at recommended spacings on terrace after backfilling the treated soil to control erosion in Area C1 and C2.
- In slope area nearby factory building, soil may be excavated at 1:1 slope ratio and turfing of Kikyu grass *(Pennisetum clandestinum)* may be laid out.
- Drainage lines passing through the area C1 and C2 may be treated with three numbers of loose boulders check dam with trapezoidal section.
- In area C2, Excavation of soil should not exceed the depth of 0.6 m in this area. In vertical slope area near factory building, the excavation should be restricted to a depth of 0.30 m.

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Study on soil conservation while undertaking soil remediation process in mercury contaminated site of Hindustan Unilever Ltd., Kodaikanal

1.0 Introduction

The mercury in glass thermometer factory was set up by Ponds India Limited at Kodaikanal in 1983 and commenced production in January 1984. It came under the management of Hindustan Lever Ltd. (Presently renamed as Hindustan Unilever Ltd.:- HUL) in September 1998 consequent to the merger of Ponds India Ltd. with it. The factory was a 100 % export oriented unit and the clinical thermometers were mainly exported to the countries such as USA, Europe, South America and Australia. The factory produced around 9 million thermometers per year; and about 165 million pieces were exported between 1984 and 2001. The manufacturing process for thermometer making include stem cutting of imported glass, followed by end opening, end cutting, bulb forming, mercury filling, top chambering, scale setting, grading, top sealing, screen printing and certification. The manufacturing area had 36 exhaust fans to facilitate air change and maintain the workplace occupational safety standards for air 0.05 mg/Nm^3 of mercury. The expelled air containing mercury vapours from the manufacturing area settled down on the surrounding soils close to the manufacturing area causing contamination soil and biomass. Detection of glass scrap with residual mercury in a scrap yard at Kodaikanal led the HUL management to close the factory operations in March 2001. The following remedial measures were initiated by HUL immediately thereafter:

1. Retrieval of glass scrap with residual mercury from the scrap yard
2. Environmental site assessment and risk assessment study for mercury
3. Construction of silt traps to prevent discharge of contaminated soil from the factory site
4. Comprehensive medical examination of employees
5. Export of 290 MT of all mercury bearing materials such as glass scrap, finished and semi-finished thermometers, elemental mercury, and ETP sludge to M/s Bethlehem Apparatus, USA for recycling, and

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6. Decontamination of plant and machinery and disposal.

A high power Supreme Court Monitoring Committee (SCMC) on hazardous waste management visited the HUL factory site in September 2004 and directed the Tamil Nadu Pollution Control Board (TNPCB) to take immediate steps towards assessment and remediation of mercury contaminated areas. Subsequently, SCMC directed TNPCB to involve National Environmental Engineering Research Institute (NEERI), Nagpur during the assessment and remediation of mercury-contaminated areas. NEERI recommended to soil remediation process by excavating the top layer of soil and washing / vacuum retorting of excavated soil followed by backfilling. Necessary protocol for soil remediation process was also developed by NEERI (2008) and details of technical issues to be addressed during remediation process were elaborated. Following the last progress meeting held with TNPCB in Chennai in February, 2010, TNPCB directed HUL to conduct the following studies:

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1.1 Scopes and Objectives

As directed, Central Soil Water Conservation Research and Training Institute: Research Centre (CSWCRTI RC) Udhagamandalam is involved in conducting the soil erosion study while attempting excavation and propose the suitable conservation measures to prevent soil erosion to the extent possible. As per Terms of Reference (TOR), the study involved the following objectives:

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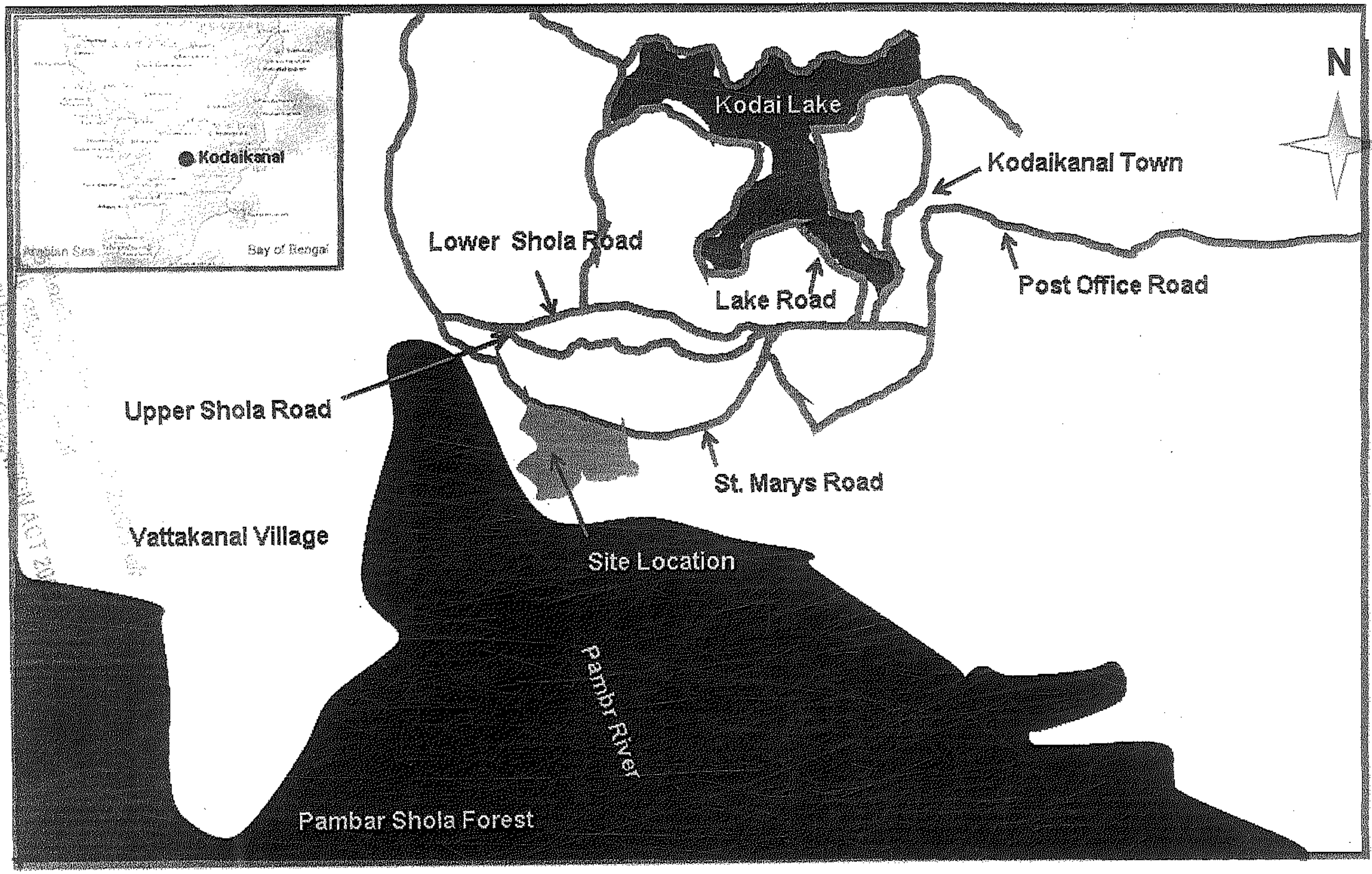
4. Presentation of the findings and recommendations of the study to Tamil Nadu Pollution Control Board and Scientific Experts Committee constituted by the Supreme Court Monitoring Committee to monitor soil remediation.

2.0 Description of the study area

The former HUL factory site is located at an elevation of 2,180 m 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 (Map 1). The Kodai Lake is located approximately 1.0 km north of the site. The nearest surface water body to the site is the Pambar River which 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.

2.1. Geological conditions of the site

The whole site is underlain by shallow Archaean bedrock, mainly granite gneiss and chaipockite, which is impermeable apart from the 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 centimeters of predominantly sandy material in the upper part of the site grading down into densely vegetated peaty soils in the south and depth is varies from 0.30 m to 1.5 m. Two shallow wells on site which are blasted into the rock have limited supplies of water which decline markedly in the summer season.



Map 1: Location of Mercury Contaminated site of Hindustan Unilever Limited, Kodaikanal

2.2. Land Use of study area

In area A, 70-80 percent of the area is covered with Eucalyptus plantations, 10 per cent area is covered with shrubs and Shola species and remaining area is full of rocky areas .

In area B, more than 80 percent of the area is covered with Eucalyptus plantations, remaining 20 per cent area is covered with shrubs and grass lands .

In area C1, more than 45 percent of the area is covered with Horticulture plantation like Beri and Plums, 15 per cent area is covered with grass lands and remaining 40 per cent area was covered with buildings

In area C2, more than 90 percent of the area is covered with grass land remaining 10 per cent area is covered with buildings

2.3 Land capability classification

Land capability classification (LCC) is crucial for choosing suitable land use options and appropriate soil and water conservation practices. Field survey was carried out in HUL area to classify the land into different LCC classes. The prevailing LCC in the HUL area are I, II, III, IV and V with (Table 1). The LCC map is shown in Map 2.

Table 1: Area under various LCC classes of HUL factory site at Kodaikanal

LC class	Area (ac)	Area (Per cent)	Mapping Unit
I	1.00	6.00	$\frac{cl\text{-}d_5}{A\text{-}e_1}$
II	-	-	-
III	7.01	42.05	$\frac{cl\text{-}d_4}{C/D\text{-}e_2/e_3}$
IV	2.75	16.50	$\frac{cl\text{-}d_{2/4}}{E/F\text{-}e_3}$
V	-	-	-
VI	0.89	5.34	$\frac{cl\text{-}d_{2/3}}{G\text{-}e_4}$
VII	5.02	30.11	$\frac{cl\text{-}d_{2/3}}{H\text{-}e_4}$

cl: sandy clay loam, A, C, D,E,F & G: slope group, e: erosion status

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2.3.1 Land Capability Class I: It is observed that 1.0 ac is occupied by class I Almost entire area under this class has slope less than 0-1 per cent. Deep soils exist with clay loam as the dominant surface textural classes.

2.3.2 Land Capability Class III: The highest per cent of area (42.05) is under this class, found mostly near the factory and building side. Around fifty per cent of land in this class has slopes ranging from 5-10 per cent while the rest fall in the slope group of less than 5 per cent. Soils are shallow and gravelly in nature with erosion being relatively moderate.

2.3.3 Land Capability Class IV:, Land under this class is distributed in different pockets of the HUL area covering an area of 2.75 ac. It is mostly encountered in the middle reaches of the watershed. Clay loam are the predominant soil textural classes and shallow soil depth is the major root zone limitation. Slope of this class ranges from 10-15 & 15-25 per cent with severe erosion hazards.

2.3.4 Land Capability Class VI: A small portion of (0.89 ha) of the HUL area comes under this class.

2.3.5 Land Capability Class VII: The second highest per cent of area (30.11) is under this class, found mostly in lower side of the HUL area. Around this class has slopes ranging from 33-50 per cent. Soils are shallow depth and gravelly in nature with erosion being relatively very severe.

3.0. Soil remediation process

It was learnt from the report (Protocol for Remediation of Mercury submitted by NEERI, the soil remediation involves following processes.

- Preparation and Implementation of health and safety plan
- Site preparation
- Excavation of contaminated soil
- Stockpiling of excavated soil
- Soil washing
- Thermal retorting of fine / high mercury concentration soil
- Analysis of remediated soil
- Backfilling of remediated soil
- Decontamination / disposal of buildings and structures
- Validation of Site Remediation

The excavation and secured land filling is an *ex-situ* method for remediation of hazardous waste contaminated areas. The contaminated soil is usually excavated, treated, transported and disposed off in a secured landfill system. 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. Impacted soils will be transported to the main plant area where remediation will comprise of soil washing followed by vacuum retorting. The entire site of HUL is covered with thick vegetation and population of trees. Hence, excavation of soil may disturb the ecology of the site. In addition, it may lead to soil erosion from the site. Considering the fragile ecosystem of the area, it is not advisable to excavate the soil in all areas.

4.0. Methodology of soil erosion study

Study area was inspected by study team and the information on soil type and depth, land use pattern were generated. Contour survey at 1m grid was conducted and slope map was prepared. Rainfall and wind velocity data for 10 years period was collected from India Meteorological Department, Chennai and data was analyzed. Nature of vegetation and root distribution system was also examined for stability of erosion. Soil depth study was conducted in 30 locations randomly selected. The information was also generated based on discussion with officials of the Hindustan Unilever Limited and Environmental Resource Management. Mercury distribution and steps involved in soil remediation process was taken from previous reports submitted by NEERI and URS. The major problems expected during the soil excavation and backfilling process were identified and preventive measures to be followed are suggested.

5.0. Effects of soil remediation process on soil and vegetation

5.1. Effect of rainfall

The annual rainfall data (2000-2009) of Kodaikanal area (Fig.1.) shows that the average annual rainfall is 1812 mm. The North-East monsoon accounts for about 43 per cent (769 mm) of total rainfall followed by 20 per cent (359 mm) during the South-West monsoon and 37 per cent (142 mm) during summer and winter. The month of October receives highest rainfall followed by November and September whereas the months of January and February receive lowest rainfall. The maximum daily rainfall received during the period was 500 mm during May, 2006. Hence, maximum erosion is expected while excavation and backfilling of soil during the months of May, August, September, October and November.

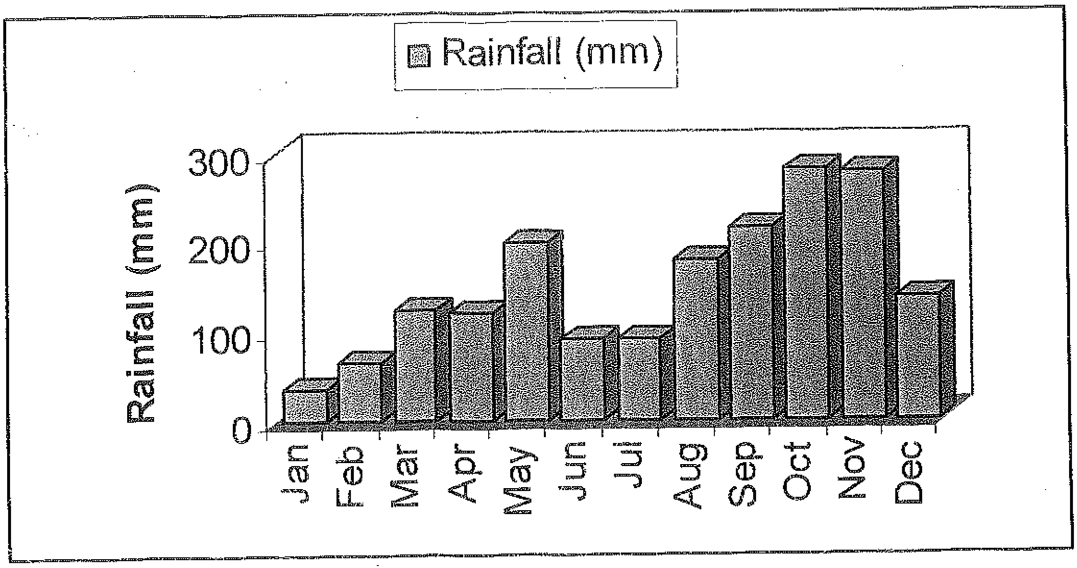


Fig. 1. Mean monthly rainfall of Kodaikanal (2000-09)

5.2. Effect of wind velocity on trees

The mean monthly wind velocity is highest during January (10.1 km hr^{-1}), December (9.42 km hr^{-1}) and February (9.0 km hr^{-1}) and lowest during September (6.0 km hr^{-1}). The maximum Wind velocity occurs (70 Km hr^{-1}) during May, 2006 and the overall mean wind velocity was observed is 7.8 Km hr^{-1}). There is the possibility of damages to the trees existing in the site due to excavation of soil and shallow root distribution combined with heavy wind speed during the months of December, January, February and March.

Table 2. Mean daily wind velocity at HUL site, Kodaikanal

Months	Daily mean velocity (km/hour)
January	9.63
February	9.00
March	8.90
April	8.15
May	6.95
June	6.43
July	6.86
August	6.19
September	6.00
October	6.22
November	8.30
December	9.42

5.3. Effect of Soil type and depth

Area A: In most of the places, stones and rubbles are found in the soil surface. The soil depth is shallow i.e soil depth ≤ 0.35 m, out of which the top fertile soil along with leaf litter is 0.20 m deep and the sub-soil depth is only 0.10 to 0.20 m. The parent rock is chornokite.

Area B: In most of the places, stones and rubbles are noticed on the soil surface. The soil depth is shallow i.e soil depth ≤ 0.40 m., out of which the top fertile soil along with leaf litter is 0.20 m deep and the sub-soil depth is only 0.20 m. The parent rock is chornokite.

Area C1: The soil depth is ≤ 0.50 m., out of which the top fertile soil along with leaf litter is 0.30 m and the sub-soil depth is > 0.20 m. The parent rock is chornokite.

Area C2: The soil depth is > 0.60 m., out of which the top fertile soil along with leaf litter is 0.30 m and the sub-soil depth is > 0.30 m. The parent rock is chornokite. At present some stone terraces are in damaged conditions in few of the areas within Area C2.

5.4. Effect of Slope

Area A: This area has a slope ranging between 33 and 50 per cent (Map 2). A major portion of this area has steep slopes which may cause severe soil erosion and mass movement of soil when the top soil is disturbed. The eroded soil will be transported to nearby valleys and water bodies.

Area B: Generally, slope in this area is between 33 to 50 per cent which will cause the moderate to severe soil erosion when the top soil is disturbed.

Area C1: Area C1 has slope ranges from 6 to 10 per cent. Slight soil erosion may occur in this area when the vegetation is removed. There are also the possibilities of formation of rills in this area if backfilling is done without adopting suitable erosion control measures.

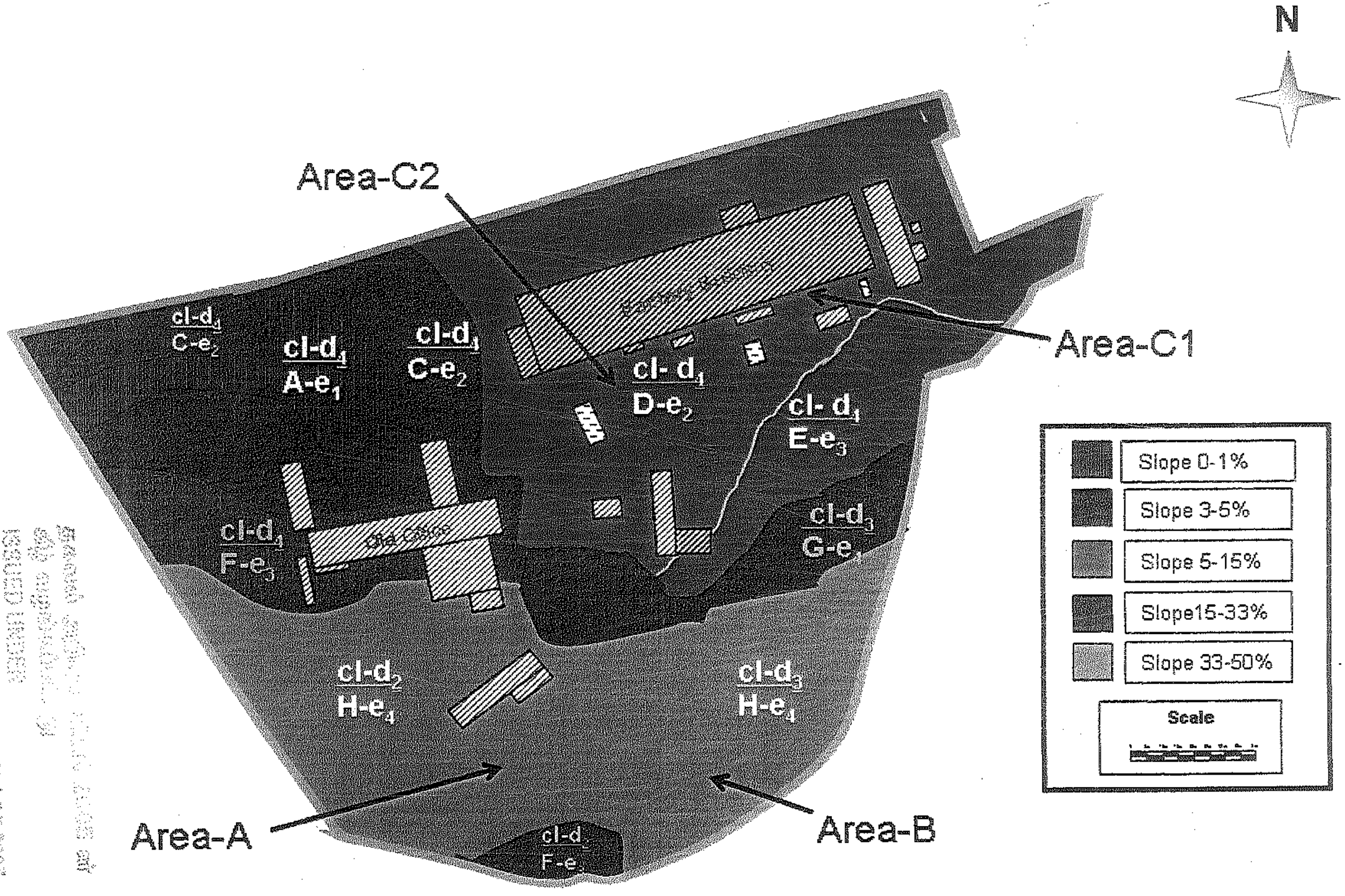
Area C2: General slope of this area is between 10 to 25 per cent which will cause the slight to moderate soil erosion and formation of rills.

5.5. Effect of Root distribution system of the trees

The root systems for most of the trees located at the site typically have shallow root distribution system. Effective root distribution systems vary from 1.0 to 3.00 m as mentioned in Table 3. The roots are distributed in shallow soil depth and even surface of the soil. Therefore, there is a possibility of trees falling while excavating soil near trees within the specified radius as indicated in Table 3.

Table 3. Effective root distribution system of various tree species at Mercury contaminated site of HUL, Kodaikanal

Sl. No	Name of the species	Radius of root distribution (m)
1	Eucalyptus	2.00-3.00 m
2	Ber	1 m
3	Cybrus	1 m
4	Casuarina	1.5 m
5	Katti Sali (Local name)	1.0 m



Map 2: Slope map of Hindustan Unilever Limited factory site at Kodaikanal

6.0. Expected problems while excavating soil and backfilling process

6.1. Area A

The following problems are identified while excavation of mercury contaminated soil and backfilling the treated soil in area 'A' based on the field observations and analysis of soil, slope, land use, rainfall and wind speed data.

- There is the possibility of soil erosion due to steeper slope (33 to 50 per cent) coupled with high intensity of rainfall and high surface runoff.
- Soil depth is shallow ≤ 0.25 m and the rocky batches will be exposed if the soil is excavated up to the depth of 25 cm, resulting in the possibility of movement of mass soil towards valley side. Soil depth is up to 0.3 m in few patches of this area where limited soil can be excavated up to 0.20 m but backfilling cannot be done due to deep slope in this area.
- Shallow rooted trees which exist in this area may fall down, even if 30 cm soil is excavated due to heavy wind (6.0 to 9.6 km / hr) and shallow distribution of root system.
- Backfilling of the soil is not possible in this area due to steep slope and shallow soil depth. As a result of the soil washing process, the cohesion and adhesion properties of soil will be washed away through water. If backfilling of the soil is done after washing, the soil will not stand over the bed rocks since continuous water lubrication will exist between backfilled soil and parent rock (Due to less compactness in backfilled soil, critical slope and accumulation of leaf litter on the top surface).
- Soil conservation measures such as Bench Terraces which may normally be adopted in such areas cannot be possible due to shallow soil depth and high gravel content of the soil.

6.2. Area B

The following problems are identified in area B.

- There is the possibility of soil erosion due to steeper slope (33 to 50 per cent) coupled with higher intensity of rainfall and higher runoff.

- Soil depth is moderate ≤ 0.40 m and excavation of soil should be restricted up to 0.30 m depth.
- Shallow rooted trees which are exists in this area may fall down, even if 30 cm soil is excavated due to heavy wind (6.0 to 9.6 km / hr) and shallow distribution of root system. Hence, excavation near the trees up to 3 m radius should be avoided.
- Backfilling of the soil is possible in this area where flat land is available and in sloppy area, only excavation can be done and backfill the soil in C area.
- Soil conservation measures such as Bench Terraces which will be normally adopted such areas cannot be possible due to shallow soil depth and high gravel content of the soil.

6.3. Area C1

Based on field observations the following problems were identified in Area C1.

- Moderate land degradation due to soil erosion on slope i.e ≥ 10 to 20 per cent and high runoff
- Excavation of soil can be done maximum up to 0.35 m due to moderate soil depth ≤ 0.45 m
- Backfilling the treated soil without soil conservation measures may cause severe soil erosion.
- Removal of top soil which contains organic carbon while excavation and backfilling process may bring the land to low productivity.

6.4. Area C2

Based on field observations the following problems were identified in Area C2.

- Soil depth is deep which is having more than 0.60 m may cause soil erosion due to slope land i.e ≥ 6 to 10 per cent
- Improper terrace system and retaining wall may also cause soil erosion during heavy storm events.
- Low land productivity due to loss of vegetation

7.0. Proposed conservation measures to be carried out while undertaking soil remediation process

Keeping in view of high rainfall during the months of May, August, September, October and November, the excavation and backfilling may be attempted during the Months of December to April, June and July. Heavy wind speeds are encountered during the months of January to April, hence proper care needs to be taken while excavating the soil near the trees. In general where the trees are located in dense or close spacing, excavation of soil should be completely avoided. At other places, for specified distances as given in Table 4, the soil should not be disturbed.

Table 4. Recommended distances from the major trees where soil should not be disturbed

Sl. No	Name of the tree	Radius of soil not to be disturbed around the trees (m)
1	Eucalyptus	3.00 m
2	Ber	1 m
3	Cybrus	1 m
4	Casuarina	1.5 m
5	Katti Sali (Local name)	1.0 m

7.1. Area A

This is a critical zone where depth of soil is very shallow $\leq$ 0.25 m, slopes are steep (33 to 50 per cent) and some of the patches the parent rocks are exposed. If soil is backfilled in this area, the soil could potentially be washed away in heavy rain events due to its reduced binding capacities and steep slopes. The estimated soil loss would be varies from 45 to 50 tonnes / ha / year. Hence, the following conservation measures are recommended in this area.

- It is suggested to not to disturb the soil where the steep slope area having above 50 % land slope. Instead, in-situ measures should be taken up to avoid the movement of mercury contaminated soil from this area to neighboring areas (Map 4).
- Covering with Geo-Jute blankets and planting grass species will be the suitable option to avoid the soil movement.
- Gabion type of support wall may be constructed on the lower portion of the area over a length of 150 m which will not allow the mercury contaminated soil to spread over other areas in future. The boulders which are already available in the site can be used for this purpose.
- In part of this area behind scrap yard, excavation of soil may be restricted to 25 cm depth and backfill the washed soil in Area C2. While excavating in the leveled portion of this area, terrace system may be followed with 2:1 slope (Map 4). Riser part may be maintained with 1:1 slope ratio. Riser part may be covered with Geo-Jute erosion control blanket and grass roots may be planted.
- In parts of the area (level surface) where soil can be excavated up to 20 cm depth, immediate backfilling is recommended by filling external soil. Necessary quantity of soil may be excavated from the residential quarters located within the premises and filled in this area followed by immediate grass turfing.

7.2. Area B

The following erosion control measures have to undertaken while excavating the soil and backfilling process in the area "B".

- In parts of the area nearby trees, immediate filling is recommended by filling external soil. Necessary quantity of soil may be excavated from the area of residential quarters located within the premises and filled in this area followed by immediate grass turfing. The excavated soil in these patches may be treated and backfilled in area C1 and C2.
- Stone bunds at 0.5 m vertical interval may be constructed in slope area where trees are available to avoid soil erosion. The boulders which are already available in the site may be utilized.

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- It is suggested that Gabion type of supporting wall on the lower portion of the area "B"over a length of 150 m which will not allow the contaminated soil to spread to over other areas (Map 4).
- It is proposed to construct Random Rubble Stone Masonry Check Dam (RRCD) in the lower portion of the gully located in between area A & area B (Map 4).
- Gabion Check Dam (GCD) on the upper portion of the gully may be constructed to collect the eroded soil which will be washed with runoff after immediate backfilling. This soil can be desilted and it can be spread over the areas in future time.

7.3. Area C1

- Excavation of soil may be restricted up to 0.35 m in this area.
- Soil may be excavated by forming terraces and terrace support walls may be constructed in each terrace.
- It is suggested that Terrace support wall over a length of 365 m (Including all terraces) is suggested / repair of existing terrace support wall over a length of 280 m (Including all terraces) is suggested to hold the filled soil on benches and it will not permit erosion.
- Root slips of the Vegetative barriers viz. Guatemala (*Tripsacum laxum)* and Kikyu *(Pennisetum clandestinum)* should be planted at recommended spacing on terrace after backfilling the treated soil to control erosion.
- In slope area nearby factory building, soil may be excavated at 1:1 slope ratio and turfing of Kikyu grass *(Pennisetum clandestinum)* may be laid out.
- Drainage lines passing through this area may be treated with three numbers of loose boulders check dam with trapezoidal section.
- Treated soil from area A & B may be refilled in this area by raising the lower level terraces.

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7.4. Area C2

- Excavation of soil should not exceed the depth of 0.6 m in this area. In vertical slope area nearby factory building, the excavation may be restricted to a depth of 0.30 m.
- Soil may be excavated by forming terraces and terrace support walls may be constructed in each terrace.
- It is suggested to construct the Terrace support walls over a length of 350 m (All terraces) / repair of existing terrace support wall over a length of 215 m (All terraces) to hold the filled soil on benches and control the erosion during post filling period.
- Root slips of the Vegetative barriers viz. Guatemala (*Tripsacum laxum)* and Kikyu *(Pennisetum clandestinum)* should be planted at recommended spacing on terrace after backfilling the treated soil to control erosion.

8.0. Technical details of conservation measures to be adopted during excavation and backfilling process

8.1. Gabion support wall

Gabion Support Wall has been successfully used in India and elsewhere for controlling soil erosion. Gabions are woven wire boxes, filled with stones / boulders. These structures retain debris and soil without impounding of water and thus support growth of natural vegetation. Gabions have fairly long life (20-25 years), flexible (bend without breaking), porous (water can seep through them), stable, economical and simple to construct. They are permeable to water but retain soil/debris and act as self draining units, thus relieve hydrostatic pressure. Since these Gabion units are heavy, they are able to withstand earth thrust and with time become a solid mass due to silt deposition in pores and helps in establishment of vegetation. Boxes can be woven at site or easily transported to the site in flat folded condition and filled. The construction of gabion structures is simple and can be done by unskilled labour themselves with a little experience or guidance.

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The materials are reusable if the structure failed due to rusted GI wire or due to deformation and can be easily repaired/strengthened by adding additional boxes if needed. Construction of gabion structures require wire knitted boxes or cages (ie. fabrication of gabion boxes) and laying at sites, filling with stones or boulders and joining or tying of individual boxes. Gabion boxes can be fabricated at site using Galvanised iron (GI) wire of 8 to 10 gauge thickness. The woven wire boxes serve as unit block for constructing gabion structures and these may be made of any convenient size. Gabion empty units are placed in position according to the plan in a foundation having a depth of 0.5 to 0.75m and tied together and kept ready with their sides top and flaps in the correct position by stretching to provide alignment after the boxes are tied together. All the required units are placed and tied to each other firmly, so that the whole structure acts as a single unit.

Gabion support wall in lowest portion of the Area 'A' for a length of 150 m is suggested to prevent the movement of mercury contaminated soil to other neighboring areas. The design and estimate for Gabion support wall is given in Annexure I.

8.2 Loose boulder Terrace support wall (LBTSW)

A total length of 700 m of terrace support wall is suggested in area C1 and C2 to support the terraces filled with treated soil. Terrace support wall for check the scouring or undercutting to protect erosion of fields and side slopes in which near/side by area will not get damaged during rainy season. The design and estimate of loose boulders terrace support wall is given in Annexure II.

8.3 Random rubble masonry check dam (RRCD)

Random Rubble Masonry Check Dam is suggested on the bottom most valley point in between Area A and Area B sites. The design and estimate for constructing one number of RRCD is given in Annexure III.

8.4. Gabion Check dam (GCD)

Three numbers of gabion check dams are suggested in drainage line passing through area C2 and Area B as shown in map 4. Construction of gabion structures require wire knitted boxes or cages (ie. Fabrication of gabion boxes) and laying at sites, filling with stones or boulders and joining or tying of individual boxes. Gabion boxes can be fabricated at site using Galvanized iron (GI) wire of 8 to 10 gauge thickness. Gabion empty units are placed in position according to the plan in a foundation having a depth of 0.5 to 0.75m and tied together and kept ready with their sides top and flaps in the correct position by stretching to provide alignment after the boxes are tied together. All the required units are placed and tied to each other firmly. The design and estimate for one number of GCD is given in Annexure IV. Totally three numbers are required to be constructed as shown in Map 4.

8.5. Loose boulders check dam

Three numbers of loose boulder check dams may be constructed(as shown in Map 4) by using loose boulders for a length of 3 m, 0.8 height (Below ground level- 0.3 m) and width of 0.7 m in upper reaches of drainage line in Area C1. The horizontal interval between each check dam should be 20 m. Estimate for one number of loose boulders check dam is given in annexure V.

8.6. Stone bunding

Stone bunding is the simple loose boulder stone wall arranged on contour at 0.5 m vertical interval at a height of 0.6 m. Use of grasses on upstream side of stone bunds are very common practice as it provides better stability to stone bund. To improve its conservation efficiency during initial years, one or two rows of grass need to be planted. This structure is essential in area B. The estimate and design is enclosed as Annexure VI.

8.7. Grass Turfing

The critical slope on the riser is $\leq 35^{\circ}$ behind the factory building, hence there is possible of severe erosion during rainy season due to insufficient compactness of the soil. Therefore, riser part behind the factory building has to be protected by spreading a thick layer/ bunch of locally available grasses. In general while removing soil on the riser portion nearby building side should be maintained with 1:1 or 1½: 1 slope. Some of the grasses may include *Chrysopogon fulvus, Cymbopogan spp., Eragrostis curvula (weeping love), Pennisetum clandestinum, Cynodon dactylon, Saccharum spp*. etc.

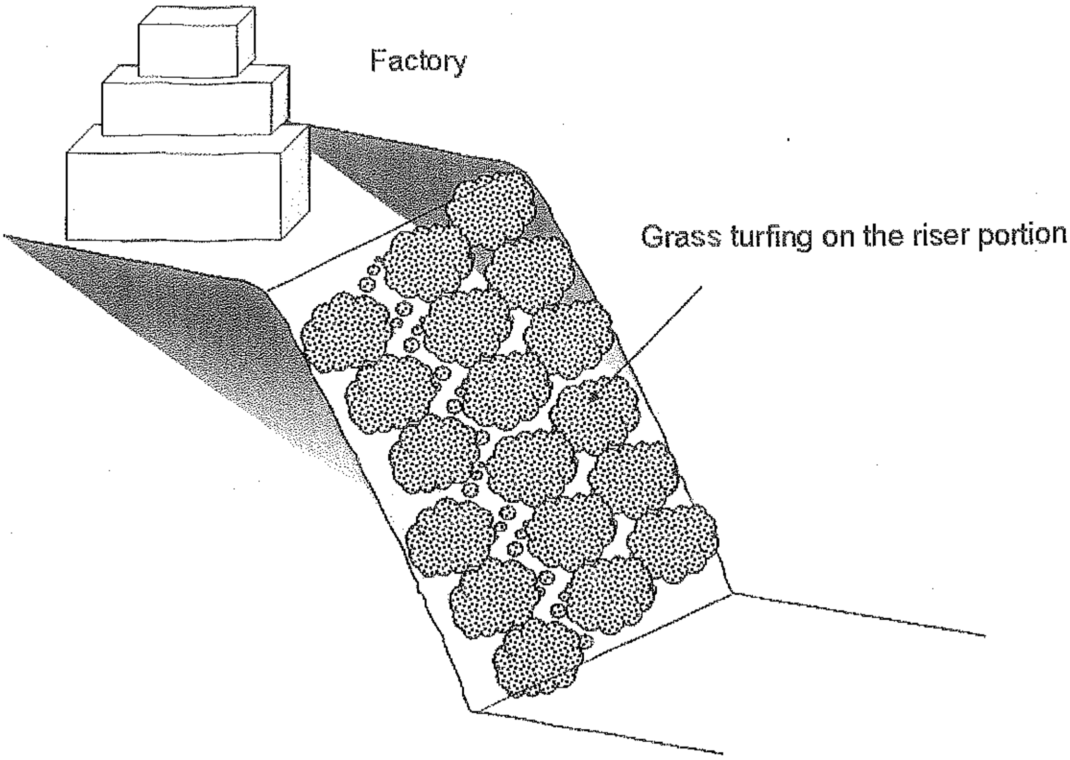


Fig. 2 Grass Turfing on riser portions behind factory building of HUL

8.8. Grass planting

Locally available grasses such as *Chrysopogon fulvus,, Cymbopogan spp., Eragrostis curvula (weeping love), Pennisetum clandestinum, Cynodon dactylon, Saccharum spp.* may be planted after backfilling the soil which will hold the soil and does not permit erosion during rainy season.

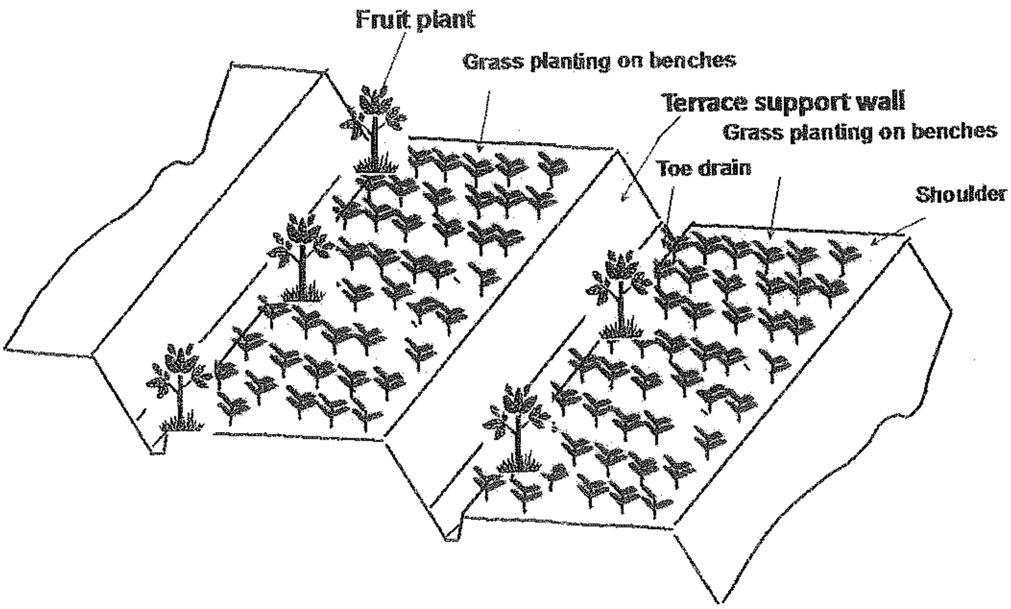


Fig. 3 Grass planting in terraces in area C1 and C2 after backfilling the soil

8.9. Geo-jute layering with grass plantation

Geo-jute (also called 'soil saver') blanket is a natural geo-textile. This is essentially a jute matting with an open mesh of 2 to 5 mm thick jute yarn having 10 mm apertures and is biodegradable. It has been successfully tried for stabilization of landslides, mine dumps and constructed slopes. It was successful in mine spoil rehabilitation at Sahastradhara, Dehradun by afforestation on affected areas. The technique of geo-jute application included (a) spreading of geo-jute by overlapping and joining adjacent widths, (b) driving wooden sticks to a depth of 0.5 m to secure matting in place, (c)planting rooted slips of local grasses and cuttings of bushes in openings between the geo-jute strands at close spacings. It was found successful for initial establishment of vegetation on degraded slopes (upto 60 - 70%). This technology is recommended for slope land in area A & B including riser part of terraces nearby canteen.

8.10. Contour vegetative barriers

In area 'C1', where the trees are available, vegetative barriers viz. Goutamala grasses in two rows may be planted after backfilling of soil as shown below:

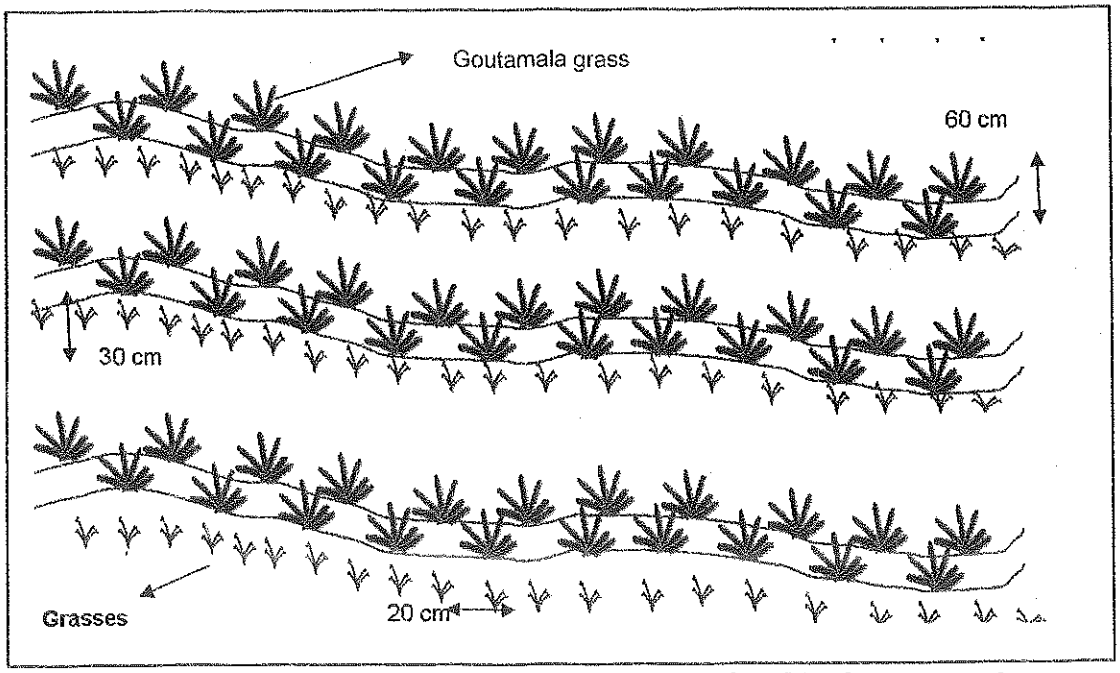
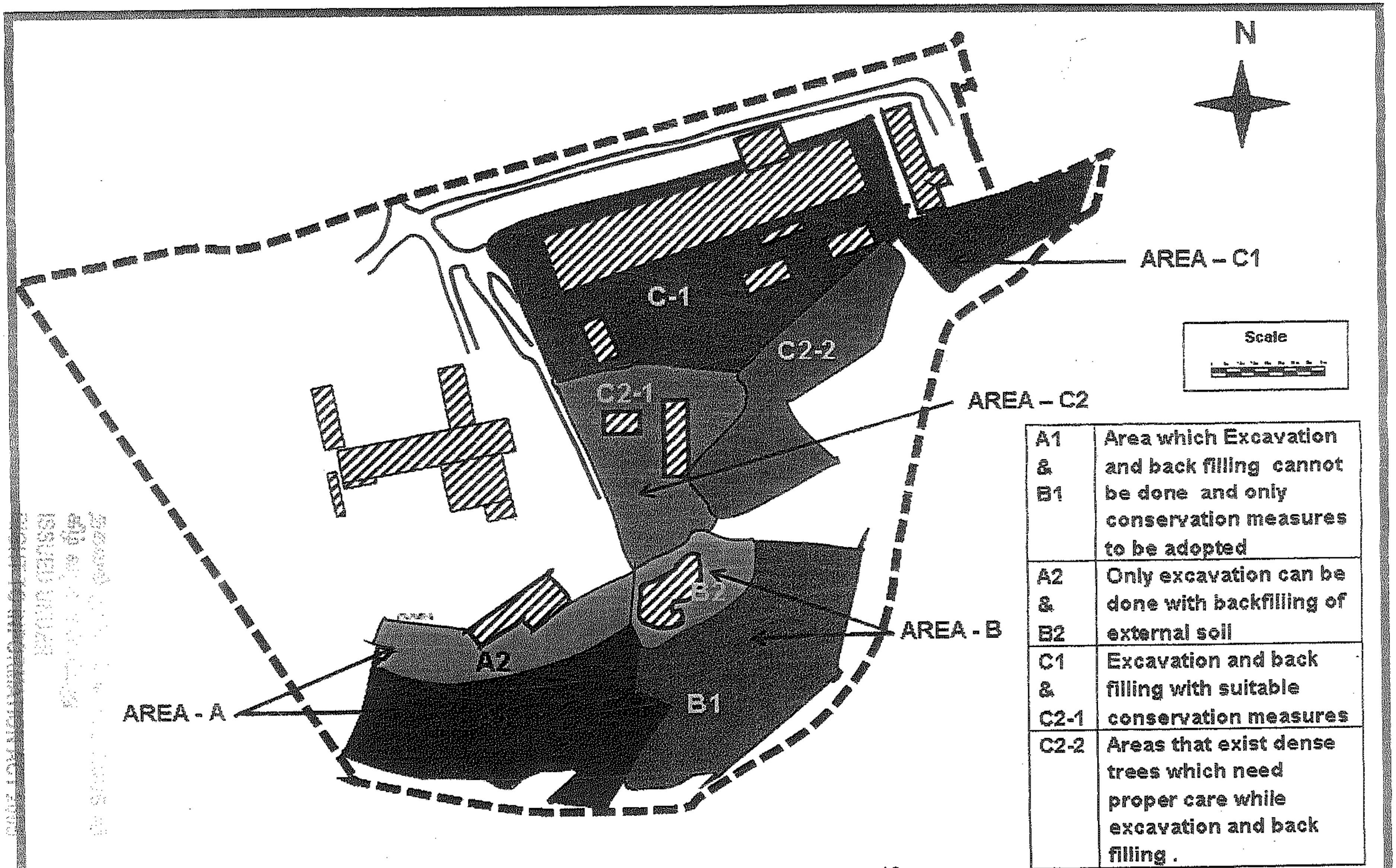
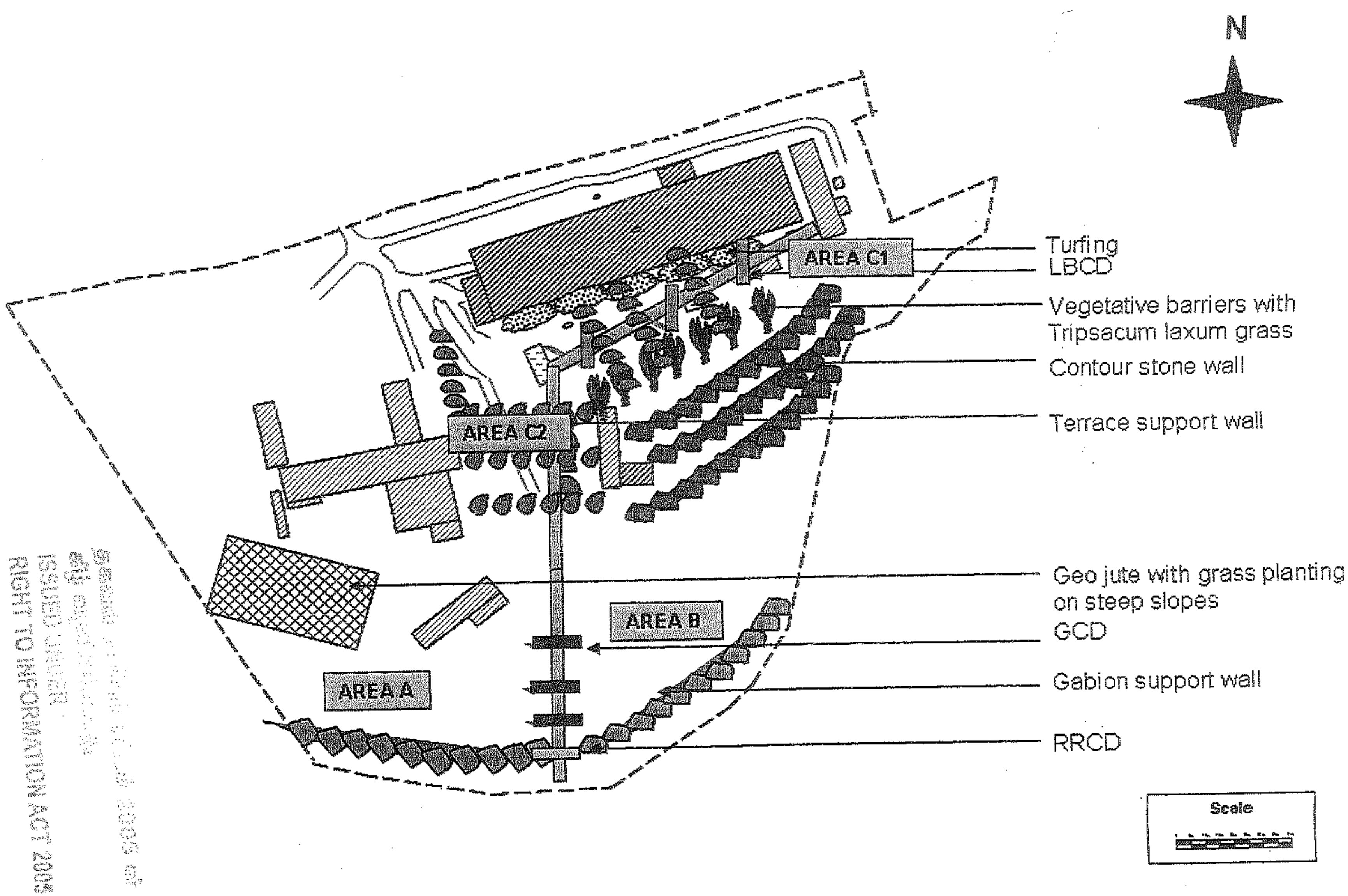


Fig 4. Contour vegetative barriers in area 'C1' in between trees



A1 & B1	Area which Excavation and back filling cannot be done and only conservation measures to be adopted
A2 & B2	Only excavation can be done with backfilling of external soil
C1 & C2-1	Excavation and back filling with suitable conservation measures
C2-2	Areas that exist dense trees which need proper care while excavation and back filling .

Map 3: Delineated area for conservation measures



Map 4: Map showing the proposed conservation measures

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9.0. Summary of Recommendations

- Keeping in view of high rainfall during the months of May, August, September, October and November, the excavation and backfilling may be attempted during the Months of December to April, June and July. Heavy wind speeds are encountered during the months of January to April, hence proper care needs to be taken while excavating the soil near the trees.
- Keeping in view of steep slope, high rainfall, and shallow soil depth and existing of trees, excavation should be avoided in Area 'A'. Excavation and backfilling can be done in part of the Area 'B' and Area C1 and C2 (As demarked in Map 3) with suitable erosion control measures as recommended in sections 7 and 8.
- In general where the trees are located in dense or close spacing, excavation of soil should be completely avoided. At other places, for specified distances as given in Table 4, the soil should not be disturbed.
- It is suggested to not to disturb the soil where the steep slope area of 'A' Zone (as demarked in Map 3) having above 50 % land slope. Instead, in-situ measures should be taken up to avoid the movement of mercury contaminated soil from this area to neighboring areas. Covering with Geo-Jute blankets and planting grass species will be the suitable option to avoid the soil movement.
- Gabion type of terrace support wall may be constructed on the lower portion of the area 'A' over a length of 150 m which will not allow the mercury contaminated soil to spread over other areas in future. The boulders which are already available in the site can be used for this purpose.
- In part of the area 'A' (below canteen), excavation of soil may be restricted to 25 cm depth and backfill the washed soil in Area C2. While excavating in the leveled portion of this area, inward terrace system may be followed with 2:1 slope. Riser part may be maintained with 1:1 slope ratio. Riser part may be covered with Geo-Jute erosion control blanket and grass roots may be planted.
- In parts of the area 'A' (Only leveled portion where there is no trees) and area 'B' (Near the tress) where soil can be excavated up to 20 cm

depth, immediate backfilling is recommended by filling external soil. Necessary quantity of soil may be excavated from the residential quarters located within the premises and filled in this area followed by immediate grass turfing. The excavated soil in these patches may be treated and backfilled in area C1 and C2.

- Stone bunds at 0.5 m vertical interval may be constructed in slope area where trees are available to avoid soil erosion in Area 'B'. The boulders which are already available in the site may be utilized.
- It is suggested that Gabion type of retaining wall on the lower portion of the area "B" over a length of 150 m which will not allow the contaminated soil to spread to over other areas.
- It is proposed to construct Random Rubble Stone Masonry Check Dam (RRCD) in the lower portion of the gully located in between area A & area B.
- Gabion Check Dam (GCD) on the upper portion of the gully may be constructed to collect the eroded soil which will be washed with runoff after immediate backfilling. This soil can be desilted and it can be spread over the areas in future time.
- In area 'C1", Excavation of soil may be restricted up to 0.35 m depth.
- Soil may be backfilled by forming terraces and terrace support walls may be constructed in each terrace.
- Root slips of the Vegetative barriers viz. Guatemala (*Tripsacum laxum)* and Kikyu *(Pennisetum clandestinum)* should be planted at recommended spacing on terrace after backfilling the treated soil to control erosion in Area C1 and C2.
- In slope area nearby factory building, soil may be excavated at 1:1 slope ratio and turfing of Kikyu grass *(Pennisetum clandestinum)* may be laid out.
- Drainage lines passing through the area C1 and C2 may be treated with three numbers of loose boulders check dam with trapezoidal section.
- In area C2, Excavation of soil should not exceed the depth of 0.6 m in this area. In vertical slope area near factory building, the excavation should be restricted to a depth of 0.30 m.

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ANNEXURES

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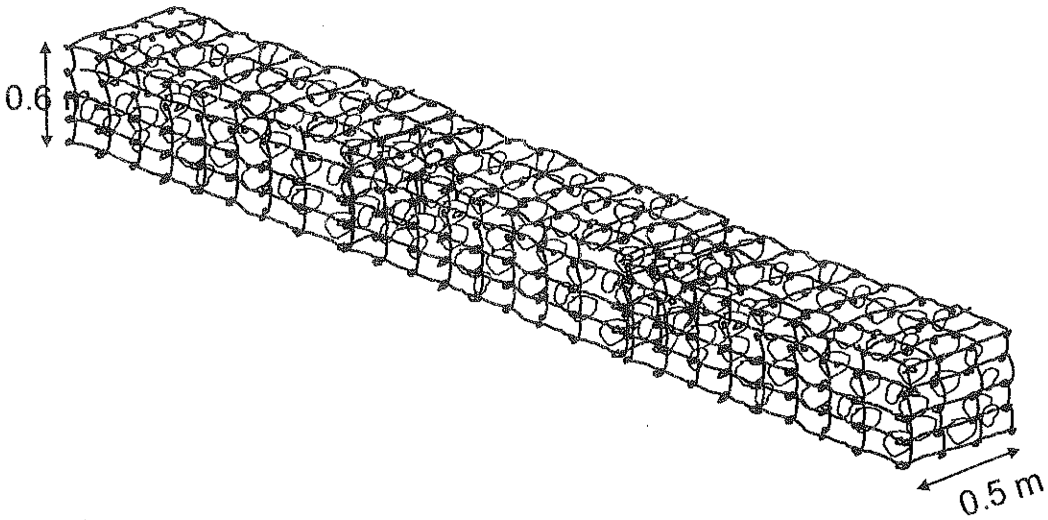
Annexure I

Design and estimate for Gabion support wall

Abstract estimate for constructing Gabion support wall for 150 rm in Area 'A'

SL. No	Descriptions of work	Qty	Rate	Amount (Rs.)
1	Earth work	15	40	600
2	Wire netting	330	8.5	2805
3	Cost of gabion wire @ 1.28 kg/sqm	423	65	27495
4	Dry stone masonry	45	650	29250
5	Rough stone dry packing	10	650	6500
6	Unforeseen item, if any			733
	Total			**67383**



Drawing of Gabion support wall

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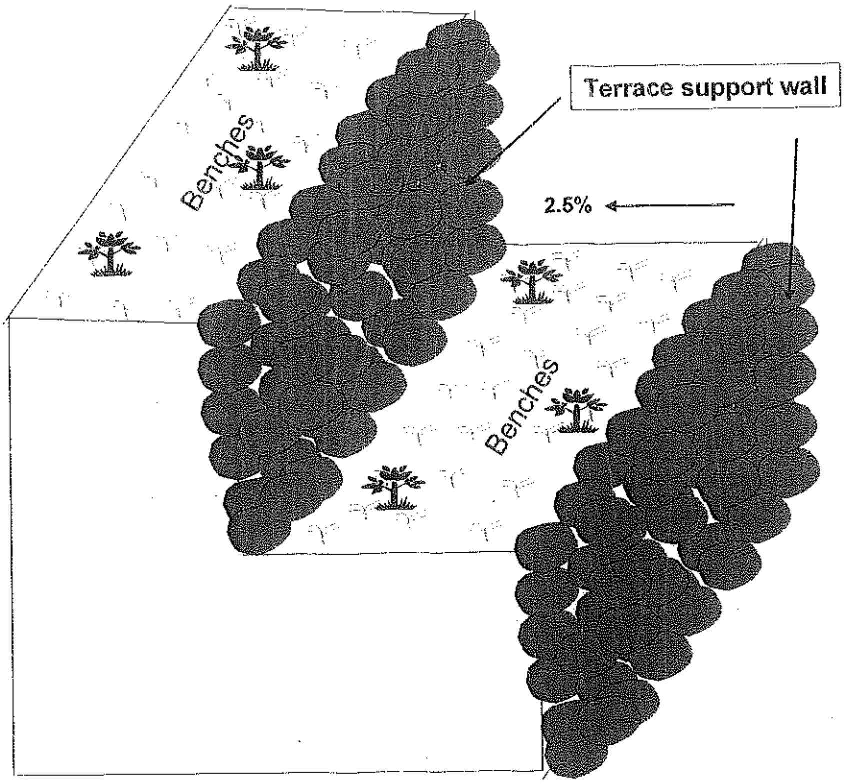
Annexure II

Design and estimate for loose boulder terrace support wall

Abstract estimate for constructing loose boulder terrace support wall for 700 rm in Area C1 and C2

S.No	Descriptions of work	Qty	Rate	Amount (Rs.)
1	Earth work	70 cum	40	2800
4	Dry stone masonry	126 cum	150	18900
6	Unforeseen item, if any			700
	Total			**22400**



Drawing of Terrace support wall

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Annexure III

Design and estimate for loose Random Rubble Masonry Check Dam (RRCD)

Detailed estimate for constructing Random Rubble Masonry Check dam in drainage line passing through Area 'A' and 'B'

Sl. No.	Description of work	No.	L (m)	B (m)	D(m)	Quantity	Unit
I	**Earth work for foundation**						
1	Head wall+Head wall extension	1	8	1.0	1.1	8.80	cum
2	Up stream side wall	2	2	0.75	1.0	3.00	cum
3	Down stream side wall	2	2	0.75	1.0	3.00	cum
4	Toe wall	1	4	0.3	0.6	0.72	cum
5	Apron	1	4	1.6	0.2	1.28	cum
	Sub-total					**16.80**	**cum**
II	**Cement concrete 1:4:8 using 40 mm Blue metal**						
1	Head wall+Head wall extension	1	8	1.0	0.2	1.60	cum
2	Up stream side wall	2	2	0.75	0.2	0.60	cum
3	Down stream side wall	2	2	0.75	0.2	0.60	cum
4	Toe wall	1	4	0.3	0.8	0.96	cum
5	Apron	1	4	1.6	0.2	1.28	cum
	Sub-total					**5.04**	**cum**
III	**Random Rubble Masonry in CM 1:4**						
a	**Below ground level**						
	Head wall+Head wall extension	1	8	1.0	0.9	7.20	cum
	Up stream side wall	2	2	0.6	0.8	1.92	cum
	Down stream side wall	2	2	0.6	0.8	1.92	cum
	Sub-total					**11.04**	**cum**
b	**Above Ground level**						
	Head wall+Head wall extension	1	8	(1.0+0.45)/2	1.0	5.80	cum

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	Head wall extension (top)	2	2	0.45	0.45	0.81	cum
	Up stream side wall	2	2	0.525	1.45	3.05	cum
	Down stream side wall	2	2.23	0.525	1.45	3.39	cum
	Sub-total					**13.04**	**cum**
	Total					**24.08**	**cum**
V	**Plastering**						
	Head wall+Head wall extension	1	8.9	0.6		5.34	sqm
	Up stream side wall	2	2	0.45		1.80	sqm
	Down stream side wall	2	2	0.45		1.80	sqm
	Toe wall	1	4	0.9		3.60	sqm
	Sub-total					**12.54**	**sqm**
VI	**Pointing**						
	Head wall+Head wall extension(U/S)	1	8		1.0	8.00	sqm
	Head wall+Head wall extension(D/S)	1	8		1.08	8.64	sqm
	Head wall extension (side)	2	2		0.45	1.80	sqm
	Up stream side wall	2	2		1.22	4.88	sqm
	Down stream side wall	2	2.23		1.22	5.43	sqm
	Sub-total					**28.75**	**sqm**

Abstract estimate for constructing Random Rubble Masonry Check dam in drainage line passing through Area 'A' and 'B'

Sl. No.	Description of work	Qty	Unit	Rate	Amount
1	Earth work for foundation	16.8	cum	56.00	940.80
2	Cement concrete 1:4:8 using 40 mm Blue metal	5.04	cum	2903.53	14633.79
3	Random Rubble Masonry in CM 1:4	24.08	cum	2589.00	62343.12
4	Plastering	12.54	sqm	169.70	2128.04
5	Pointing	28.75	sqm	169.70	4878.88
6	Unforseen items, if any @ 3%				2547.74
	Total for one RR Masonry CD				87472.36

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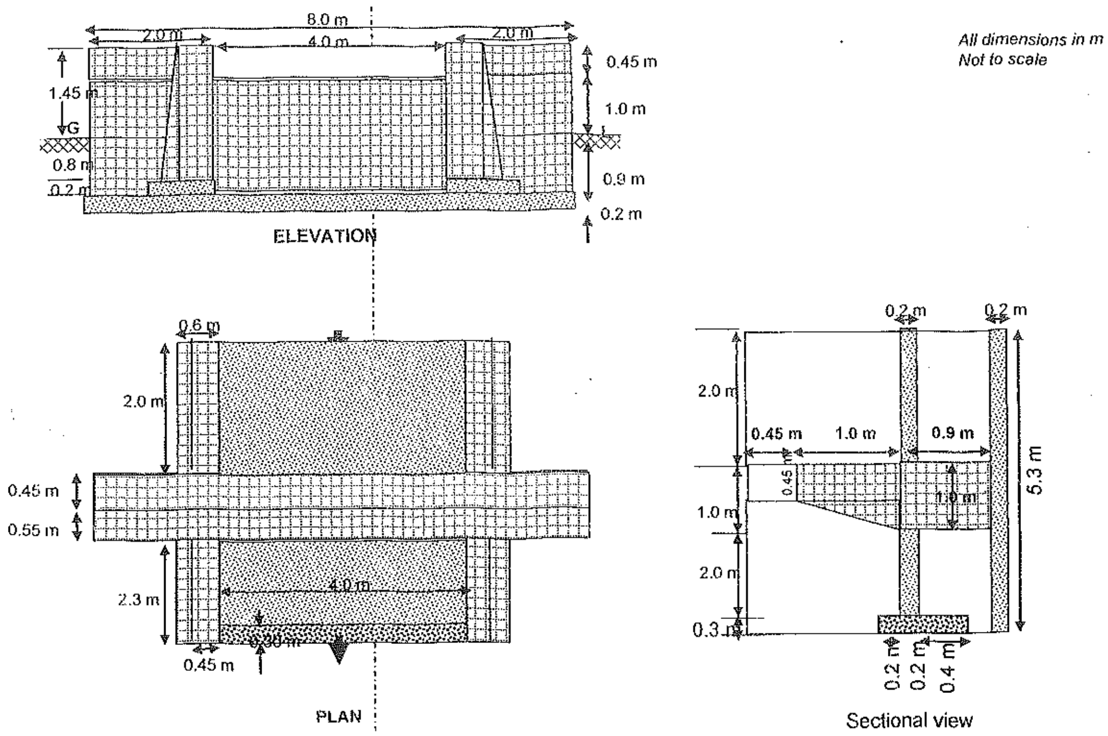
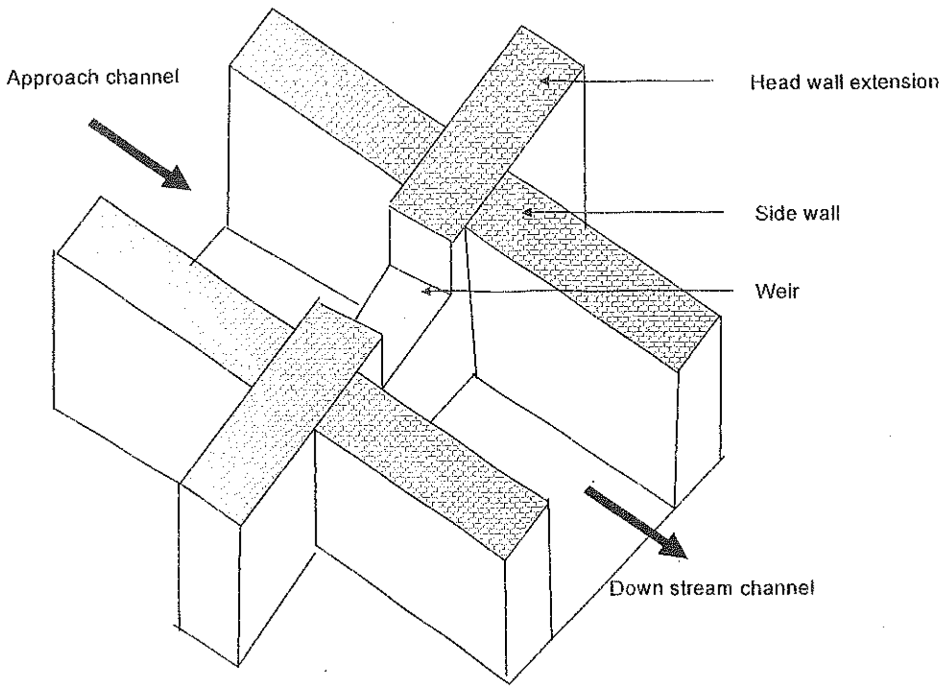


Drawing of RRCD in Drainage line passing through Area 'A' and 'B'



Drawing of RRCD

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Annexure IV

Detailed estimate for constructing Gabion Check Dam in HUL area at Kodaikanal

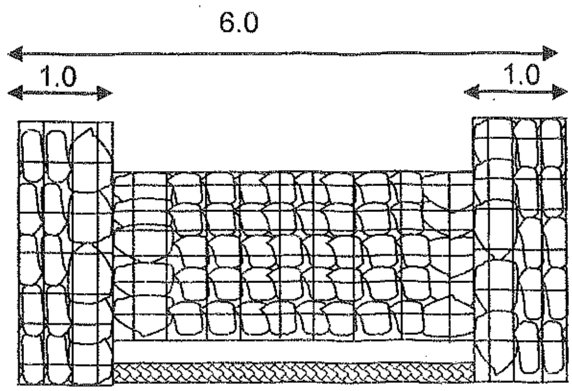
Sl. No.	Description of work	No.	L (m)	B (m)	D(m)	Quantity
1	Earth work excavation and depositing on bank within initial lead and lift in hard stiff clay stiff black cotton hard red earth shales murrams gravel stony earth mixed with small sized boulder and hard gravelly soil as per SS 20 B & SI 62.					
	For foundation					
	Body wall	1	6	1.2	0.8	5.76
	Upstream side wall	2	2	0.6	0.4	0.96
	Down stream side wall	2	2.6	0.6	0.4	1.248
	Toe wall	1	4	0.6	0.4	0.96
	Paving	1	4	2	0.2	1.6
	Sub-total					10.528
2	Supplying and fixing gabion boxes in 10 gauge GI wire with 10 cm x 10 cm opening including cost of mould labour charges for cutting etc. complete					
	Body wall					
	Bottom and top	2	6	1.2		14.4
	Front and back	2	6		2.2	26.4
	Earthern sides	2		1.2	2.2	5.28
	Vent sides	2		1.2	0.4	0.96
	Deduct vent	2	4		0.4	3.2
	Upstream side wall					
	Bottom and top	4	2	0.6		4.8
	Front and back	4	2		1.4	11.2
	Earthen sides	4		0.6	1.4	3.36
	Downstream side wall					
	Bottom and top	4	2.6	0.6		6.24
	Front and back	4	2		1.02	8.16
	Earthen sides	4		0.6	1.4	3.36
	Toe wall					
	bottom and top	2	4	0.6		4.8
	Front and back	2	4		0.7	5.6
	Earthen sides	2		0.6	0.7	0.84
	Sub-total					92.2
3	Dry stone masonry for the construction of gabion structures by using best quality of new stones from approved quarry with standard specifications					

	BGL					
	Body wall	1	6	1.2	0.8	5.76
	AGL					
	Body wall	1	6	1.2	1	7.2
	2	1	1.2	0.4	0.96	
	2	2	0.6	1	2.4	
	2	2.6	0.6	1	3.12	
	1	4	0.6	0.3	0.72	
	Sub total					12.96
4	Rough stone dry packing	1	4	2	0.2	1.6

Abstract estimate for constructing Gabion Check Dam in HUL area at Kodaikanal

S.No	Descriptions of work	Qty	Rate	Amount (Rs.)
1	Earth work	10.528	40	421.12
2	Wire netting	92.2	8.5	783.7
3	Cost of gabion wire @ 1.28 kg/sqm	118	65	7670
4	Dry stone masonry	12.96	650	8424
5	Rough stone dry packing	1.6	650	1040
6	Unforeseen item, if any @3%			550
	Total for one Gabion Check Dam			**18889**

Not to scale
All measurements in m



Drawing of Gabion check dam

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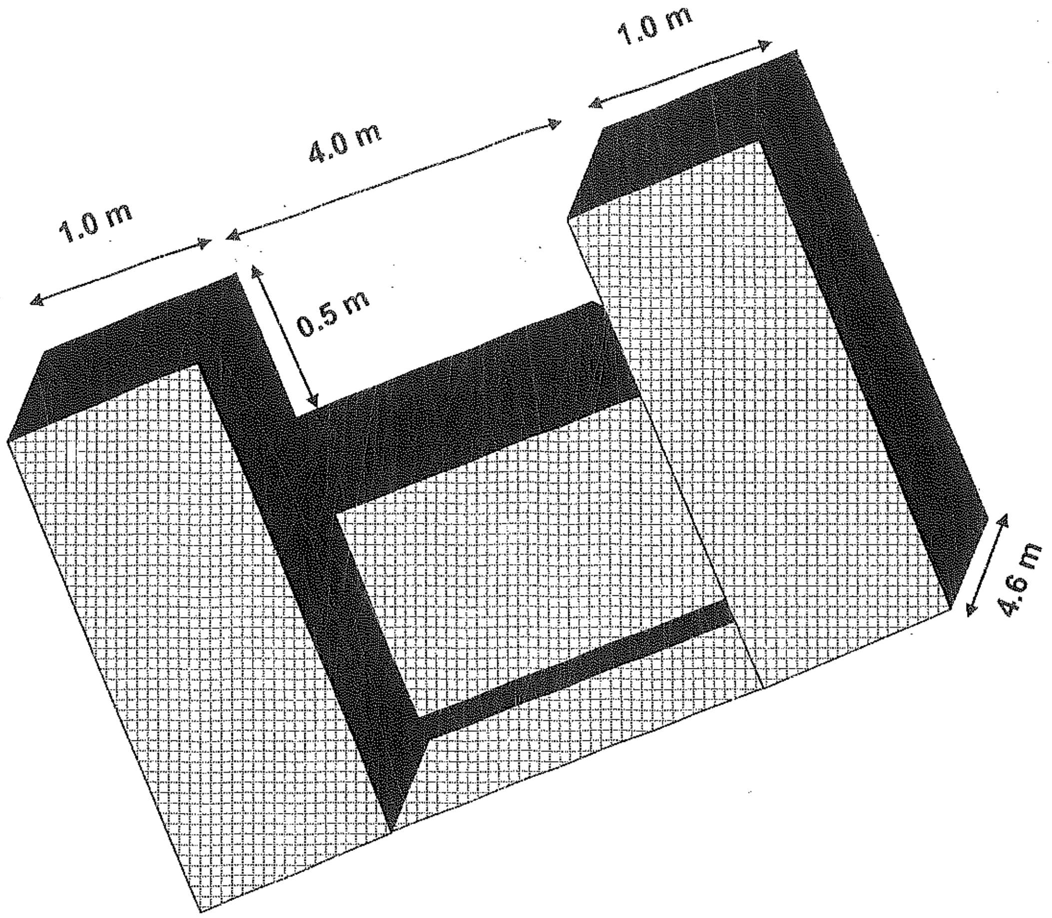

Isometric view of Gabion Check Dam with dimensions

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Annexure V

Cost estimate of proposed LBCD at HUL site in Kodaikanal

S. No	Item	No	Length (m)	Width (m)	D/Height (m)	Quantity (cum/sq m)	Rate Unit	Amount (Rs)
1	Clearing grass and other over growth of vegetation and small trees of girth upto 30 cm and removal of rubbish upto a distance of 150 m outside the periphery of the area cleared		10	10		100	0.5235	52.35
2	Excavation in foundation in hard soil including depositing the excavated stuff in uniform layers as and where directed within a lead of 50 m and upto 1.5 m depth of excavation							
	Apron	1	0.75	3.50	0.3	0.788		
	Headwall	1	3.00	0.90	0.3	0.810		
	headwall extension	2	1.00	0.45	0.4	0.360		
	End silll	1	3.50	0.30	0.3	0.315		
						2.273	57.5	130.67
3	Dry rubble masonry using blasted rubble							
	including chips							
	Apron	1	0.75	3.50	0.30	0.788		
	Headwall(below G.L.)	1	3.00	0.70	0.30	0.630		
	Headwall(above G.L.)	1	3.00	0.58	0.50	0.863		
	headwall extension	2	1.00	0.45	0.40	0.360		
	End silll (below G.L.)	1	3.50	0.30	0.30	0.315		
	End silll (above G.L.)	1	3.50	0.30	0.15	0.158		
						3.11	607	1889.29
	Total							**2072.31**
	Contingency (10%)							127.69
	Grand Total							**2200.00**

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Annexure VI

Estimate for constructing Stone bund for 500 rm in HUL area at Kodaikanal

S.No	Descriptions of work	Qty	Rate	Amount (Rs.)
1	Earth work	50	56	2800
4	Dry stone masonry	150	650	97500
6	Unforeseen item, if any @3%			650
	Total			**100950**
	Cost per rm			**Rs.202/-**

165

PLATES

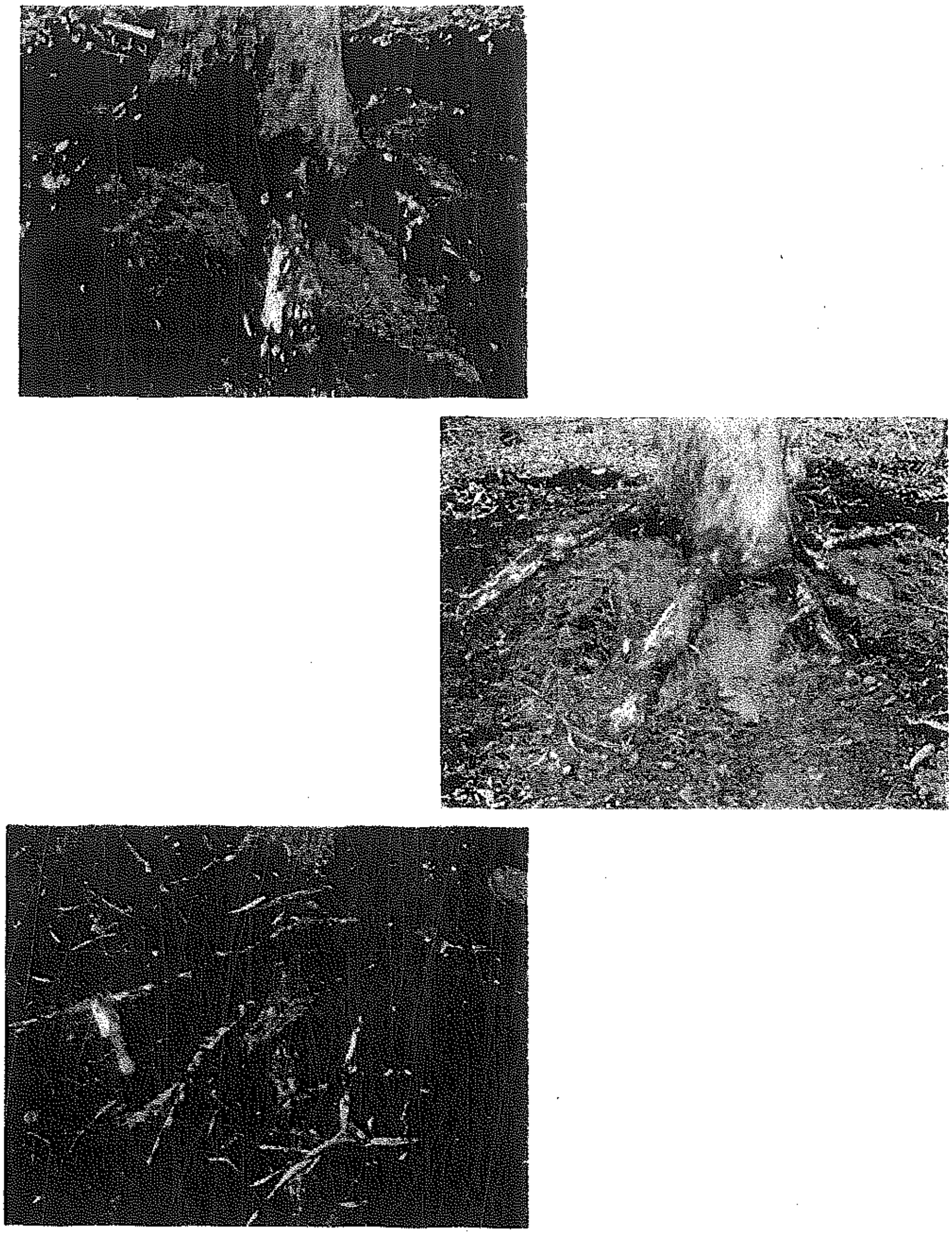
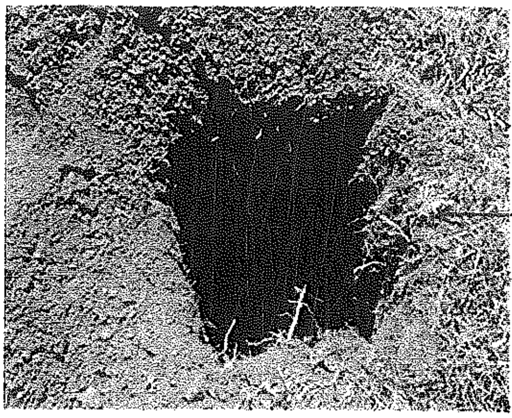


Plate 1: Shallow root distribution systems existing in study area

Plate 2: Forest area where stone bunds are proposed in Between trees after back filling

82



Area C -deep soil depth

Area B - Moderate soil depth

Area A - shallow soil depth

Plate 3: Soil depth of different mercury contaminated sites

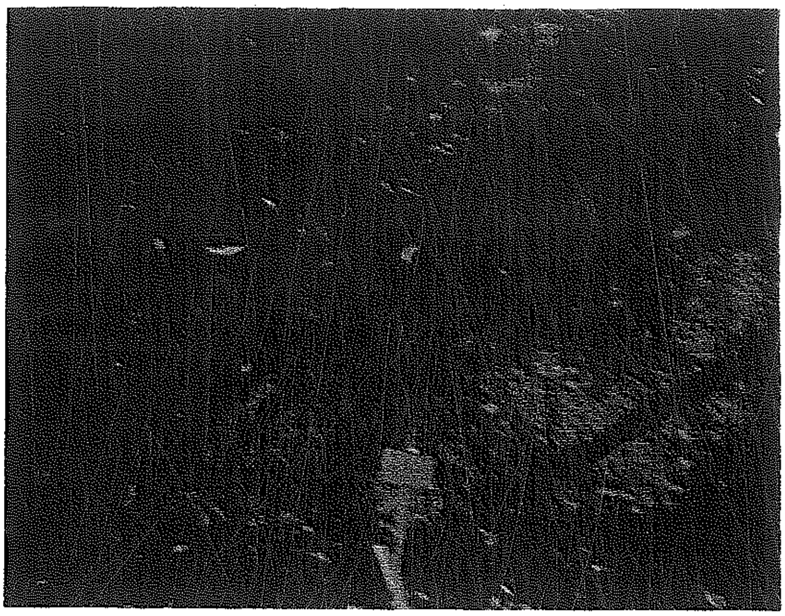


Plate 4: Steep slope area with rocky patches where excavation and backfilling is not possible in area A

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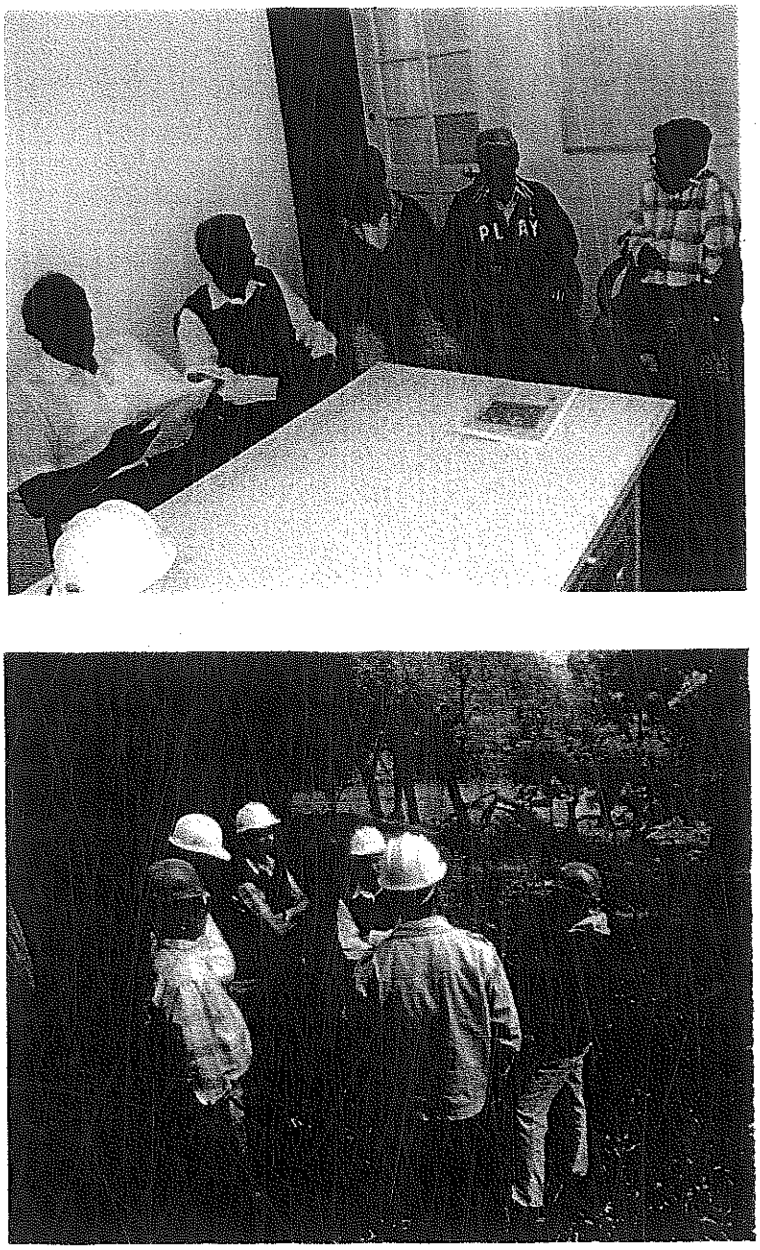

Plate 5: Interaction of consultants with HUL and ERM staffs

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Hindustan Unilever Limited

Hindustan Unilever Limited
St.Mary's Road,
Kodaikanal - 624101
Phone:- 04542-241098
Web: www.hul.co.in
CIN : L15140MH1933PLC002030

February 09, 2018

The Member Secretary,
Tamil Nadu Pollution Control Board,
76, Mount Salai, Guindy,
Chennai -600032.

Dear Sir,

Sub : Soil Remediation Upscaling Plan

This has reference to the letter No. T2/TNPCB/F 36448/27568/DGL/2018 dated 29.01.2018 attaching the minutes of the meeting of the Scientific Experts Committee (SEC) members, Tamil Nadu Pollution Control Board(TNPCB), Central Pollution Control Board, National Environmental Engineering Research Institute (NEERI) and Indian Institute of Soil and Water Conversation (IISWC)officials held on21st November, 2017 at TNPCB, Chennai.

As desired by the Scientific Experts Committee, we are enclosing 'Soil Remediation Upscaling Plan' for undertaking remediation of our closed thermometer factory site at Kodaikanal and to achieve the remediation standard of 20mg/kg. This plan is prepared under the guidance of the NEERI, Nagpur and IISWC, Udhagamandalam and we have incorporated the advice of the SEC.

We would request you to grant us permission to proceed with the remediation work in accordance with the soil remediation upscaling plan. We remain committed for completion of soil remediation and we will commence the remediation work on receipt of statutory approvals.

Thanking you,
For Hindustan Unilever Limited,

John George,
Factory Manager.

Enclosure: 3 copies of Soil Remediation Upscaling Plan

Copy to:
1. Joint Chief Environmental Engineer - II, TNPCB, Chennai
2. Joint Chief Environmental Engineer (M), TNPCB, Trichy.
3. District Environmental Engineer, TNPCB,Dindigul.

Soil Remediation Upscaling Plan

Hindustan Unilever Limited, Kodaikanal, Tamil Nadu

Prepared under the guidance of the National Environmental Engineering Research Institute, Nagpur and The Indian Institute of Soil and Water Conservation, Udhagamandalam.

February 2018

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1 INTRODUCTION

This document describes the Remediation Upscaling Plan for soil remediation at the Hindustan Unilever Limited (HUL) Site, located in Kodaikanal, Tamil Nadu.

The document follows the Detailed Project Report that was approved by the Tamil Nadu Pollution Control Board (TNPCB) and Scientific Experts Committee (SEC) in July 2008 and Revised DPR in Dec 2015. Following the approval from TNPCB, pilot scale soil remediation trials were undertaken at the site between August and November 2017. Based on the results of the soil remediation trials, and the meeting held with TNPCB/ SEC in Chennai on November 21st, 2017, the TNPCB/ SEC directed HUL to submit a Remediation Upscaling Plan that details the soil remediation activities to be undertaken at the site.

This Soil Remediation upscaling Plan has been prepared under the guidance of the National Environmental Engineering Research Institute (NEERI, Nagpur) and the Indian Institute of Soil and Water Conservation (IISWC), Udhagamandalam.

1.1 BACKGROUND

The project site of HUL occupies an area of approximately 81,058 square meters.

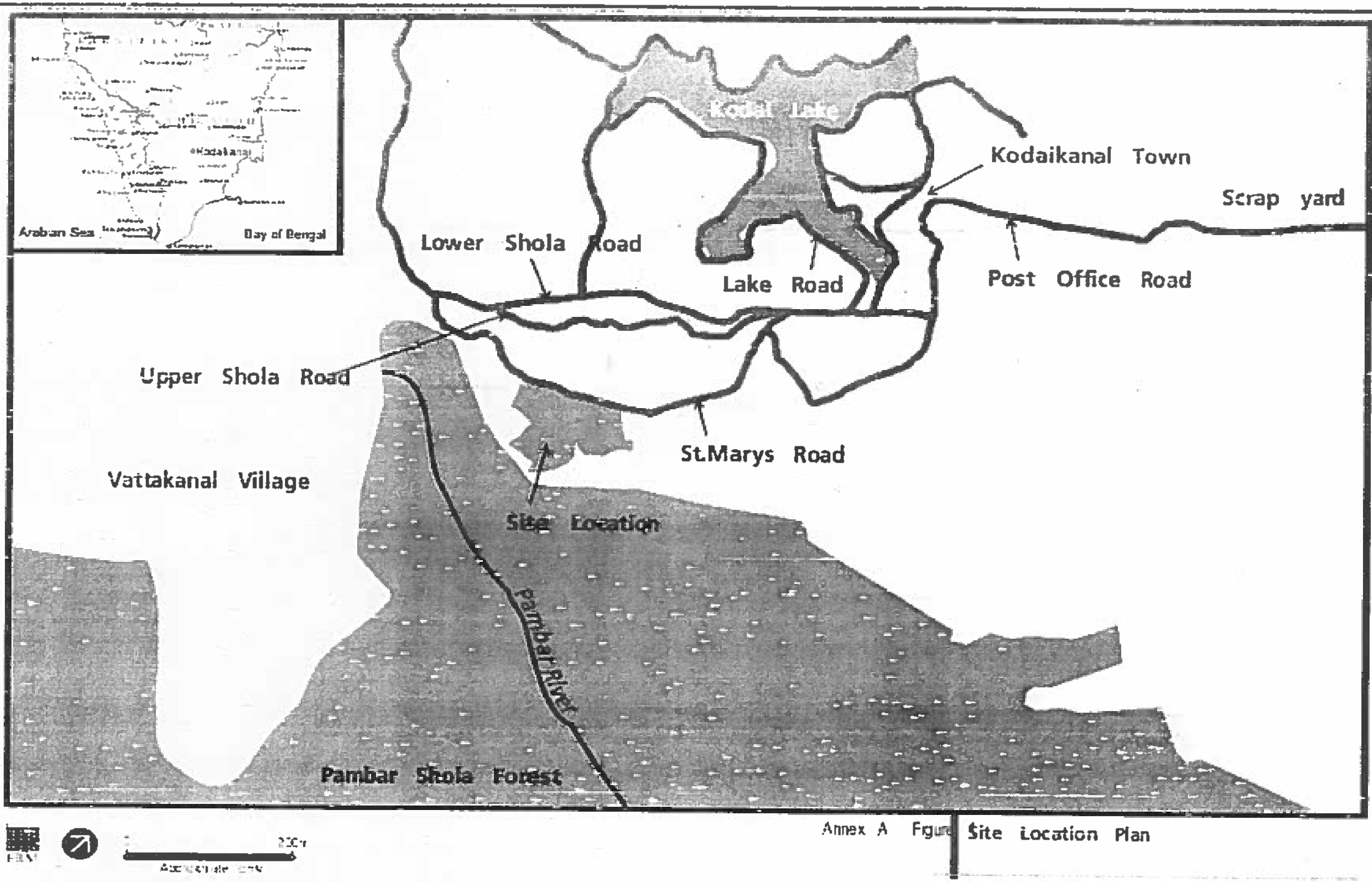
Various studies have been undertaken at the site to characterise the extent of the contamination, determine the site specific remediation standard, treatability studies, offsite assessment etc. Kindly refer to Annexure 1 for a summary of the studies undertaken since the factory was closed. Onsite and offsite assessments have been undertaken since 2001 and form the basis of this remediation upscaling plan.

1.2 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. The Kodai Lake is located approx. 1.0 km north of the site and is located 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 Kumbakarai Falls about 7 km to the southeast, thence draining eastward into the plains. A narrow access path, the Levinge path, is in the forest area 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 and a church and some low density private residential properties to the west of the site.

Please refer to Figure 1 for the site location map.

Figure 1 Site location map



1.3 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 in the central section of the site. Soil cover along the steep slopes towards the south of the site is much shallower and generally has a soil cover less than 1.5 m. Two shallow wells on site which are dug into the rock have limited supplies of water which decline in the summer season.

1.4 METEOROLOGICAL INFORMATION

Meteorological records indicate that average annual rainfall at the site is in the range of 1,400 to 2,000 mm spread over six months in a year.

The dominant wind directions are northeast/north northeast, northwest/north northwest and southeast, consistent with monsoons.
The above information on rainfall and wind directions has been considered for the maximum efficiency of environmental controls to be put in place for the remediation work.

2 OBJECTIVES AND DESCRIPTION OF REMEDIAL ACTION PLAN

2.1 OBJECTIVES OF REMEDIATION WORK

The objectives of the remediation work are as follows:

- Remediation of the contaminated soils at the site to the site specific target level of 20 mg/kg;
- Protection of the Environment and People during the remediation work;
- Completing the remediation work in accordance with the relevant statutory and local government requirements.

2.2 DESCRIPTION OF REMEDIATION WORK

The main component of the remediation work will involve excavation and remediation of the contaminated soils via soil washing and retorting. Excavation of the soils will be carried out by a combination of small excavation equipment and manual excavation. Excavated soils will thereafter be processed in the remediation area through a combination of soil washing and retorting.

The mercury distillation room, recovery room, scrap storage shed (old bakery building) and other old structures at the site will be demolished prior to excavating the soil in this area. The main factory building and the utilities building are to be demolished at the end of remediation work. The building materials and the soils from beneath the main factory building and utilities, if found to have mercury concentrations over 20 mg/kg, will be disposed off to an authorised Treatment, Storage, and Disposal Facility located in Virudhunagar District, Tamil Nadu.as per the applicable Hazardous Waste Rules (2016).

After the remediation activity is over, residual hardware, materials and scrap generated during the process will be disposed off in safe manner in line with TNPCB guidelines.

2.3 AREAS IDENTIFIED FOR SOIL REMEDIATION

Based on the soil investigation and delineation undertaken by URS and ERM, three areas of elevated total mercury concentrations in soil have been identified at the site.

Area A surrounds the old Bakery building. Area B is located southeast of Area A and immediately south of Ponds Path. Both Areas A and B are located in steep terrains.

Area C, consisting of Areas C1 and C2, is located immediately south of the main factory building and north of Area A and Area B. Area C also contains the mercury distillation and mercury recovery rooms. Area C is located on more gentle slopes.

Please refer Figure 2 for the mercury delineation map indicating the spatial distribution of mercury at the site.

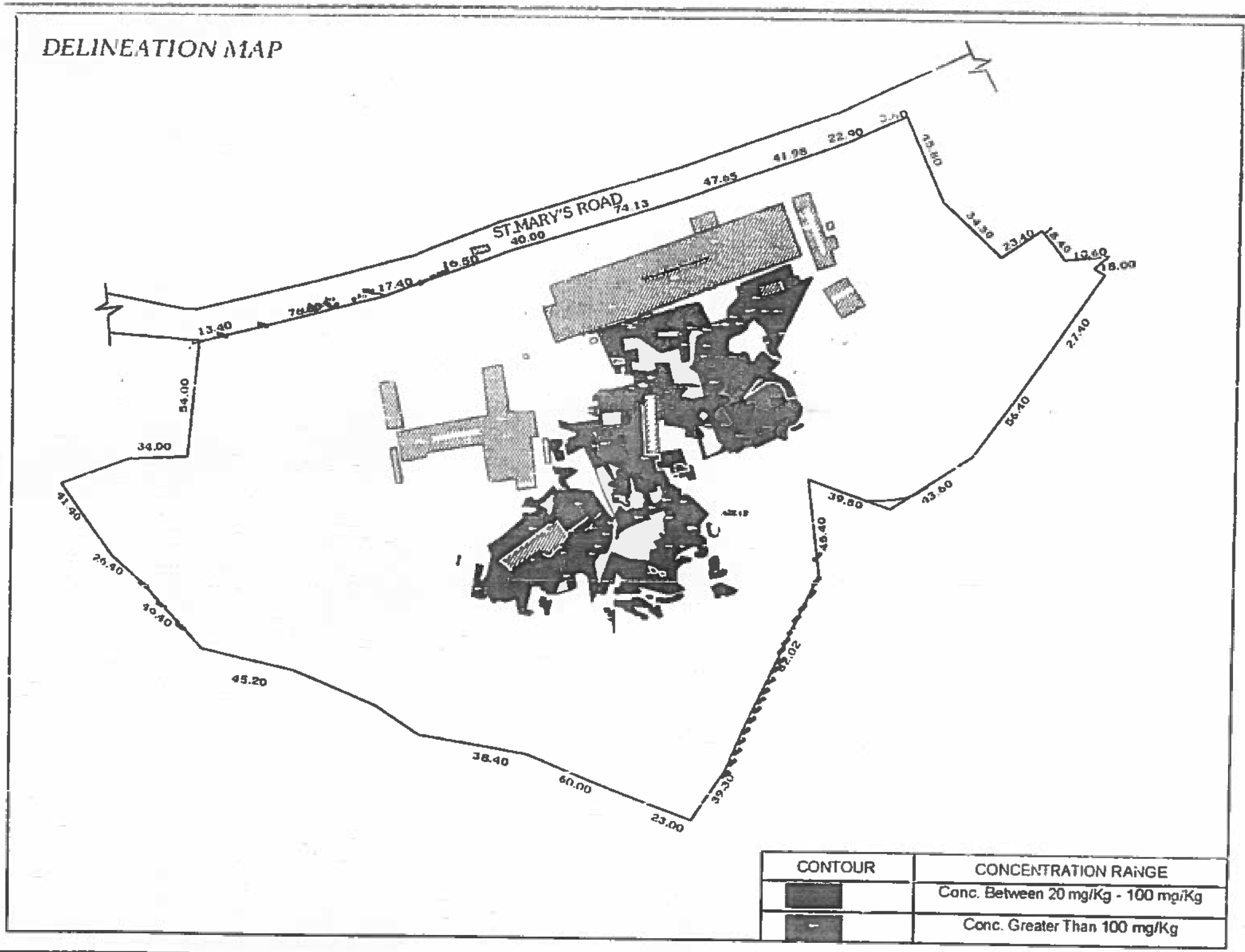
A small quantity of contaminated soil at the factory southern boundary, where the storm water stream from the factory drains onto the Levinge path is also identified for remediation.

It is estimated that between 5,200 to 6,900 MT of soil from the site will need to be remediated. This is only an estimate based on the data that is currently available and may vary once the actual remedial activities are undertaken.

The main component of soil remediation work will involve excavation of the shallow soils down to depths of 30 cm in Areas A, B and C. If required (based on sampling and analysis of the excavated pit), further excavation shall proceed at 30 cm depth intervals, until a point where soil mercury concentrations are below the remediation criteria of 20 mg/kg.

It is estimated that the building material from demolition activities and the soils beneath these buildings (Manufacturing building, Utilities Building, mercury distillation room, recovery room, scrap storage room old bakery) will be an additional 1,000-1,200 tons.

Figure 2 Delineation map



3 PRE-REMEDIATION ACTIVITIES

3.1 PERMISSIONS REQUIRED FOR CONDUCTING REMEDIATION

For full scale remediation activities, the following permits will be required:

- Air- Consent to Operate (CTO) will be applied for as per Section 21 of the Air (Prevention & Control of Pollution) Act, 1981; and
- Water- Consent to Operate (CTO) will be applied for as per Section 25/26 of the Water (Prevention & Control of Pollution) Act, 1974.
- Permits under the Hazardous Waste Rules (2016) for collection, storage, transportation and disposal of Hazardous Wastes generated at the site
- Permission from the Directorate of Industrial Safety and Health.
- Permission from the Tamil Nadu Electrical Inspectorate and Tamil Nadu Power Generation and Distribution Corporation.
- Permission from the Forest Department
- Permission from the Geo technical Centre, Mining and Geology Department.
- Permission from the Fire and Rescue services
- Permission from the Agricultural Engineering Department
- Permission from the Hill Area Conservation Authorities; and
- Permission from the Kodaikanal Municipality

3.2 ACCESS ROADS:

Access roads will be constructed in a manner that access to contaminated areas is available and movement of excavators and trucks is easily achieved. Please refer to Figure 3 below for the indicative access roads that are planned for the full scale remediation work at the site.

3.3 TERRACE WALLS

Terrace walls will be constructed in area C1 and C2 to prevent soil erosion and to help compact the treated soils which will be backfilled here. Please refer to Figure 4 for the indicative location of the terrace walls planned as part of the remediation work at the site. The walls may be made of stone masonry or be held together using wire meshing.

3.4 REROUTING OF DRAINS

The existing drains will be cleaned out and additional drains (as required) are planned to cover the areas identified for remediation. The drains will all pass through appropriately constructed silt settling tanks and silt traps and the locations provided in Figure 5. Additional new drains below Area A and Area B are also to be constructed and will be connected to the silt traps.

Figure 3 Access roads location map

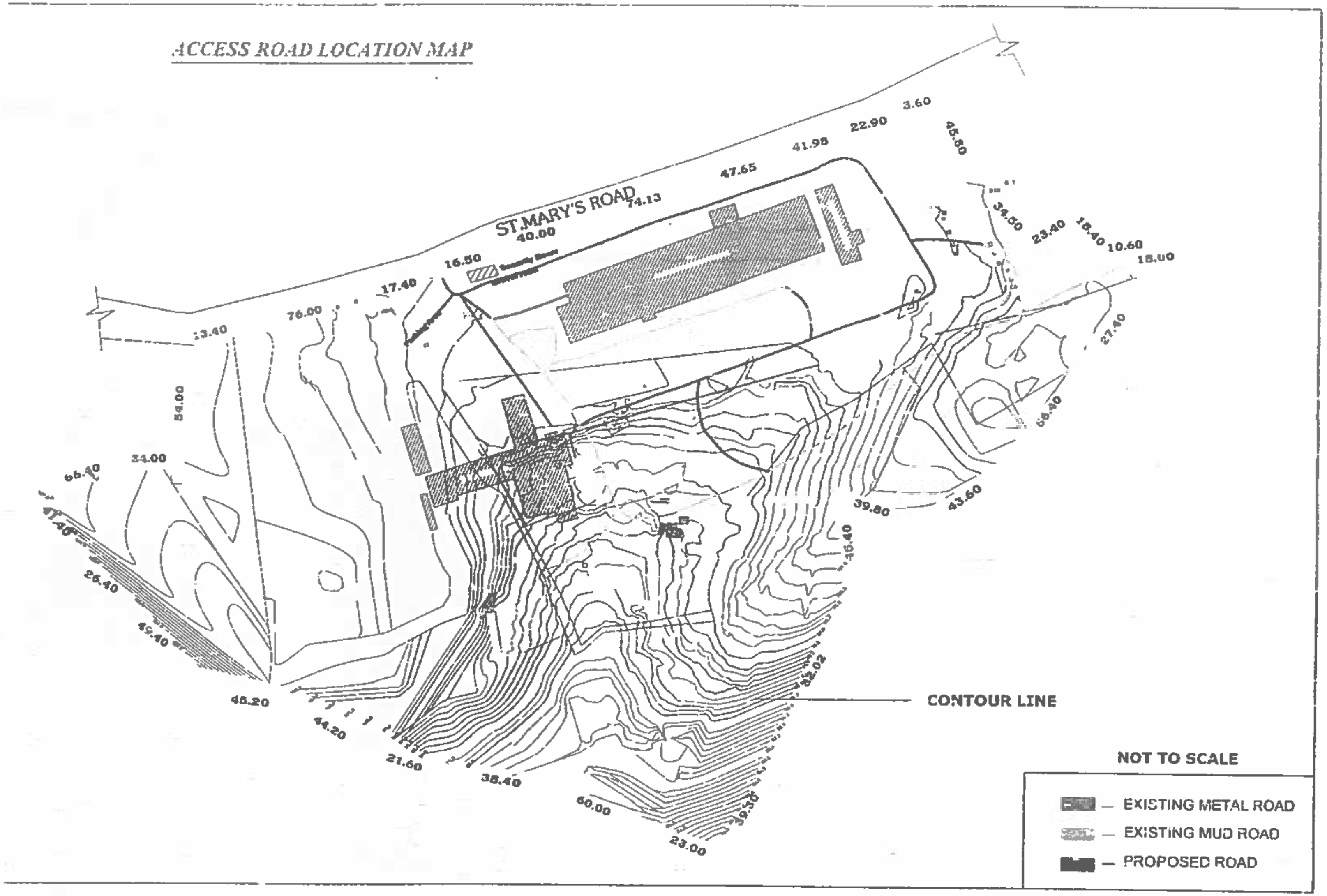


Figure 4: Terrace walls location map

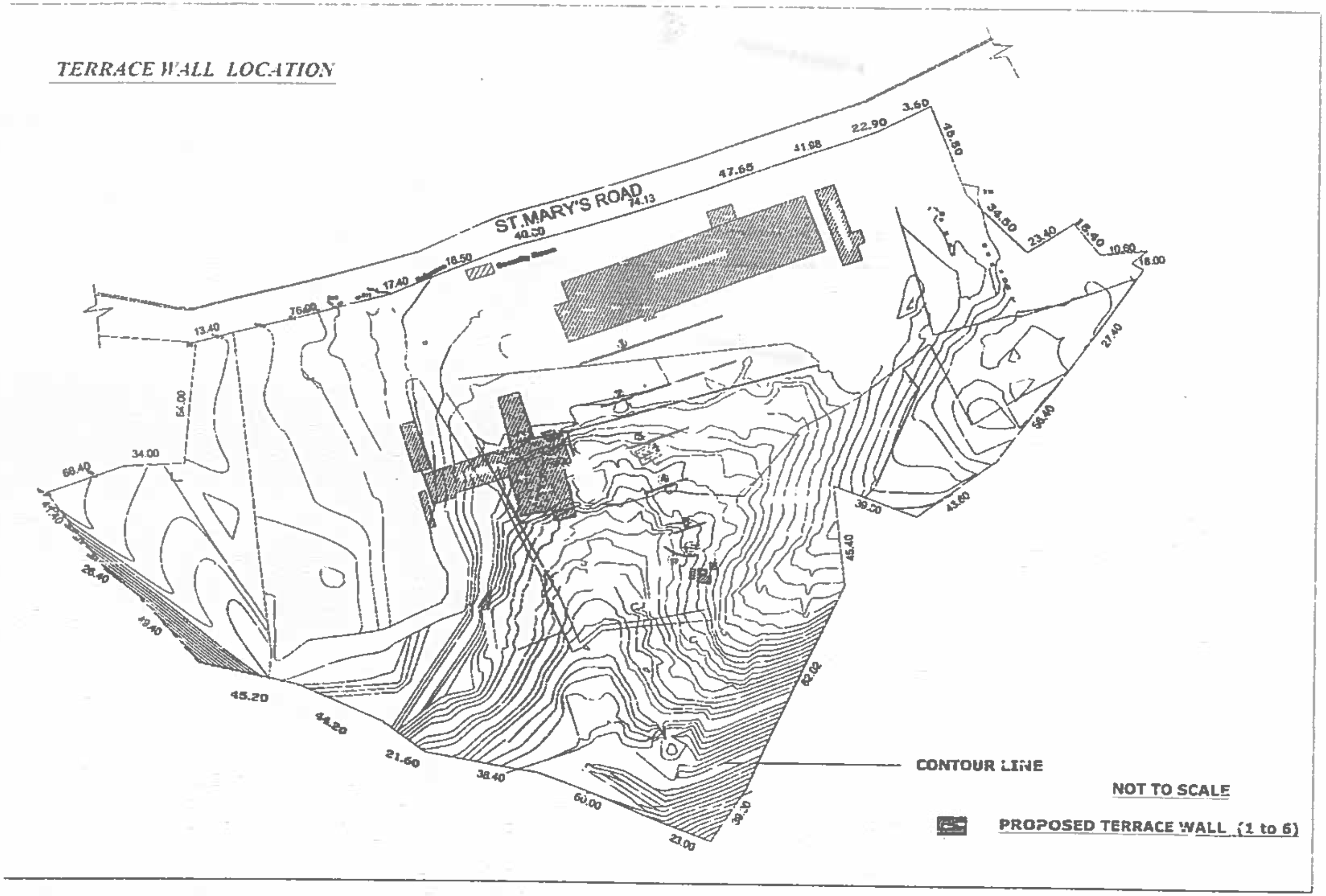
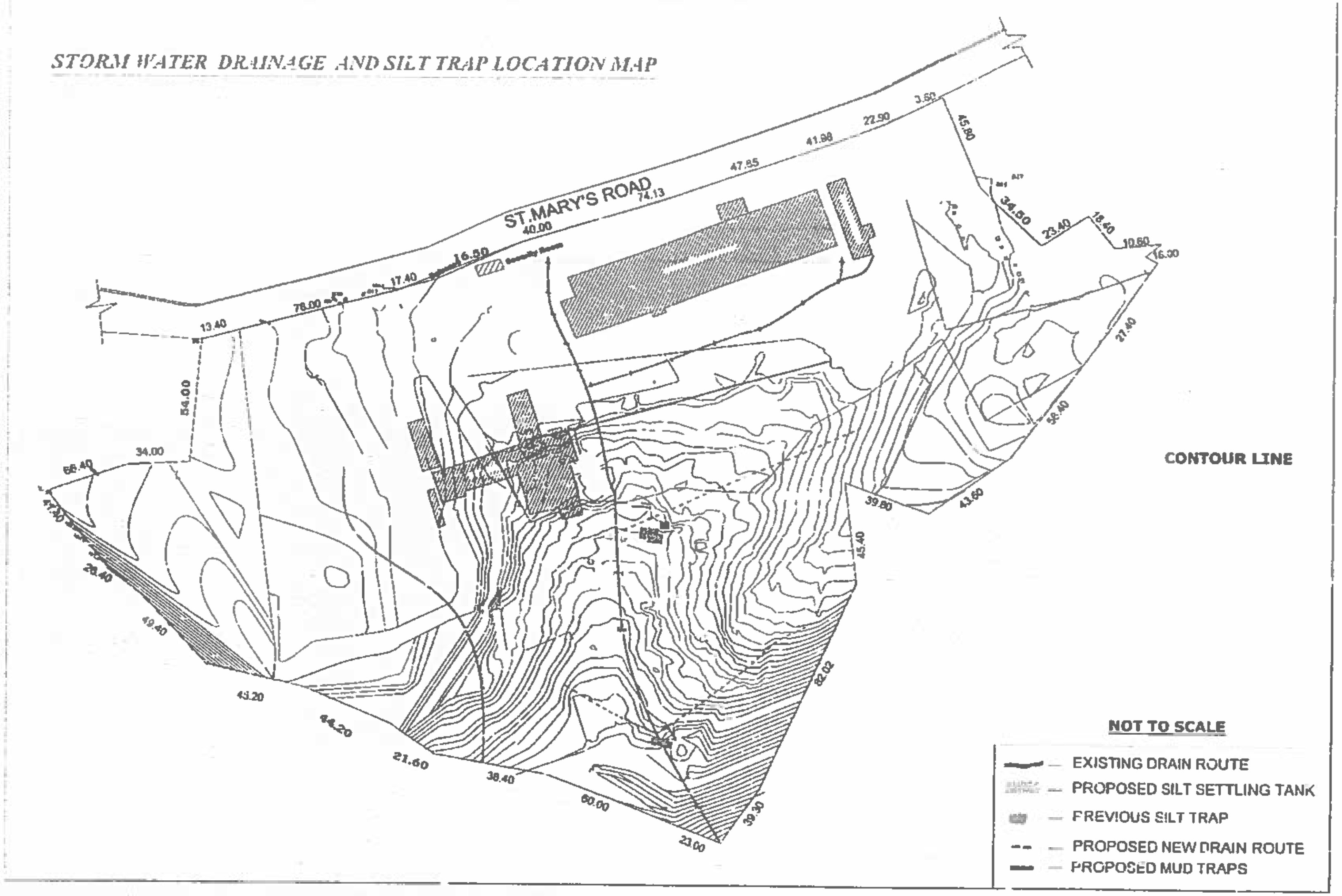


Figure 5: Storm water drainage and silt traps location map

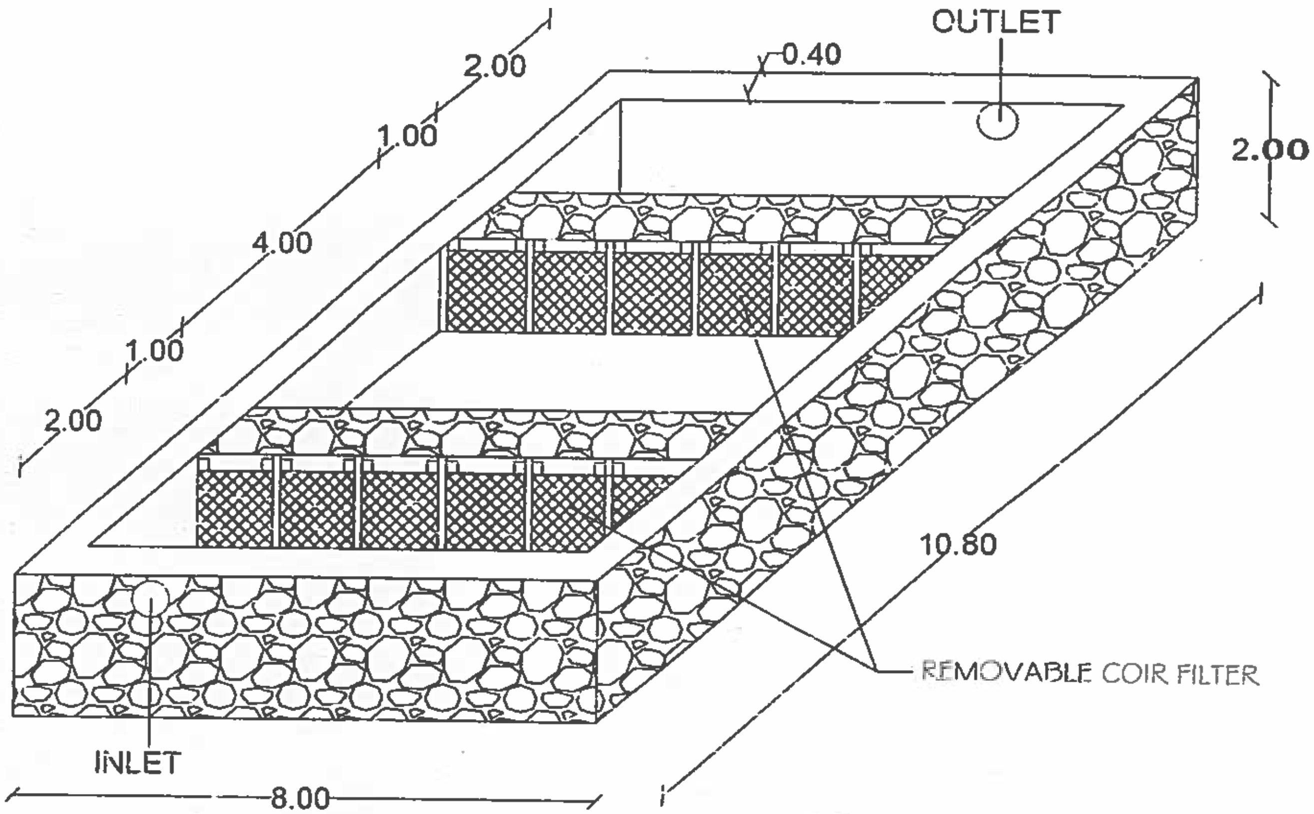


3.5 CONSTRUCTION OF SILT SETTLING TANK AND MODIFICATION OF SILT TRAPS

Storm water drains will be constructed at the site to appropriately collect and route the storm water through appropriate silt settling tank. The silt settling tank will allow the storm water to pass through the structure while holding back all soil and silt that may get generated through filtration. The proposed silt settling tank schematic is provided in Figure 6.

Figure 6 Silt settling tank schematic diagram

SILT SETTLING TANK SCHEMATIC

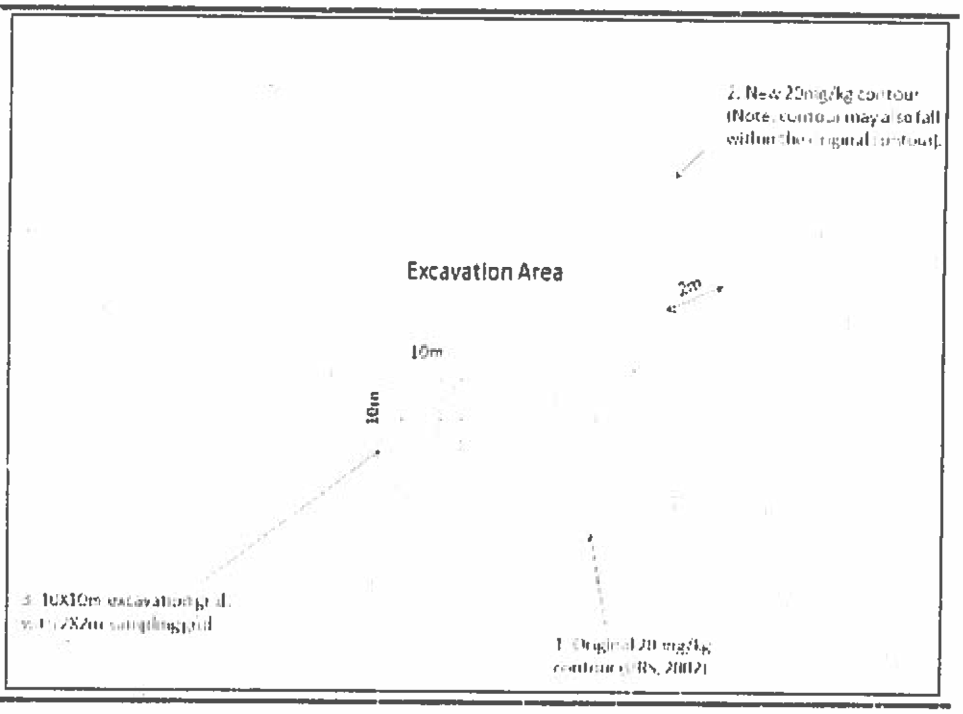


DIMENSIONS ARE IN METERS

3.6 SOIL SCREENING FOR CONTAMINATED AREA REVALIDATION

A Soil contamination survey will be conducted along the perimeter of the excavation areas prior to excavation and treatment to reconfirm the spatial distribution of mercury and fix the excavation boundaries. Please refer to the Figure 7 below for a broad schematic description of the pre excavation screening.

Figure 7 *Pre excavation soil screening and sampling schematic*



Sampling of soil in a 2m x 2m grid within the contaminated areas provides a reasonable level of confidence in the delineation of contamination.

Existing contour maps will be used as a base from which sampling will begin. Sampling shall be carried out along the identified 20 mg/kg contour of excavation area upto two (2) meters. In case the mercury concentration in the grid is found to be above 20 mg/kg, this grid will be included in the remediation plan and the adjacent 2m x 2m grids will be tested similarly. The process will be repeated till the mercury concentrations in the grids are found to be ≤ 20 mg/kg.

4 EXCAVATION RELATED ACTIVITIES

4.1 EXCAVATION PROCESS

Excavation in each of the Areas A, B, C1 and C2 will proceed in a phased sequence.

Area C2 will be excavated first. Following this, Area A, Area B and Area C1 will be excavated next. The sequence will be therefore from the top of the site to the bottom of the site to the extent possible. The sequence of excavation is based on a number of variables, including having to backfill treated soils from Area A and B, at Area C, in order to prevent potential soil erosion at these steep areas. In addition, excavation at the gentler slopes will allow for better management of excavation and backfilling as the rates will differ depending on the various areas to be excavated, with respect to grade/ slope issues. The shrubs with adhering contaminated soil from the excavation area will be removed and appropriately packed for further disposal to an authorised Treatment, Storage, and Disposal Facility located in Virudhunagar District, Tamil Nadu.

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. Excavation at Area B and Area A will be carried out manually due to the presence of steep slopes in these areas. For the manual excavation, a Safety support frame anchored to the ground with a lifeline provisions for tying of safety harnesses will be erected along the slopes. This frame will be fixed to the ground to provide sturdy support. All excavation personnel working on these slopes will have the appropriate safety harness worn and tied off to this safety support frame that is anchored at the top of the level surface. Adjacent to the safety frame, will be a moveable conveyor belt, wherein the excavated soil will be deposited for transport up the slope to the level surface. From here, the soils will then be loaded onto the 4 wheel drive utility vehicles and transported to the main factory building for remediation. Please refer to Figures 8 and 9 that show the plan and cross section elevation of Area A and Area B.

Figure 8 Plan/ Cross section elevation of Area A

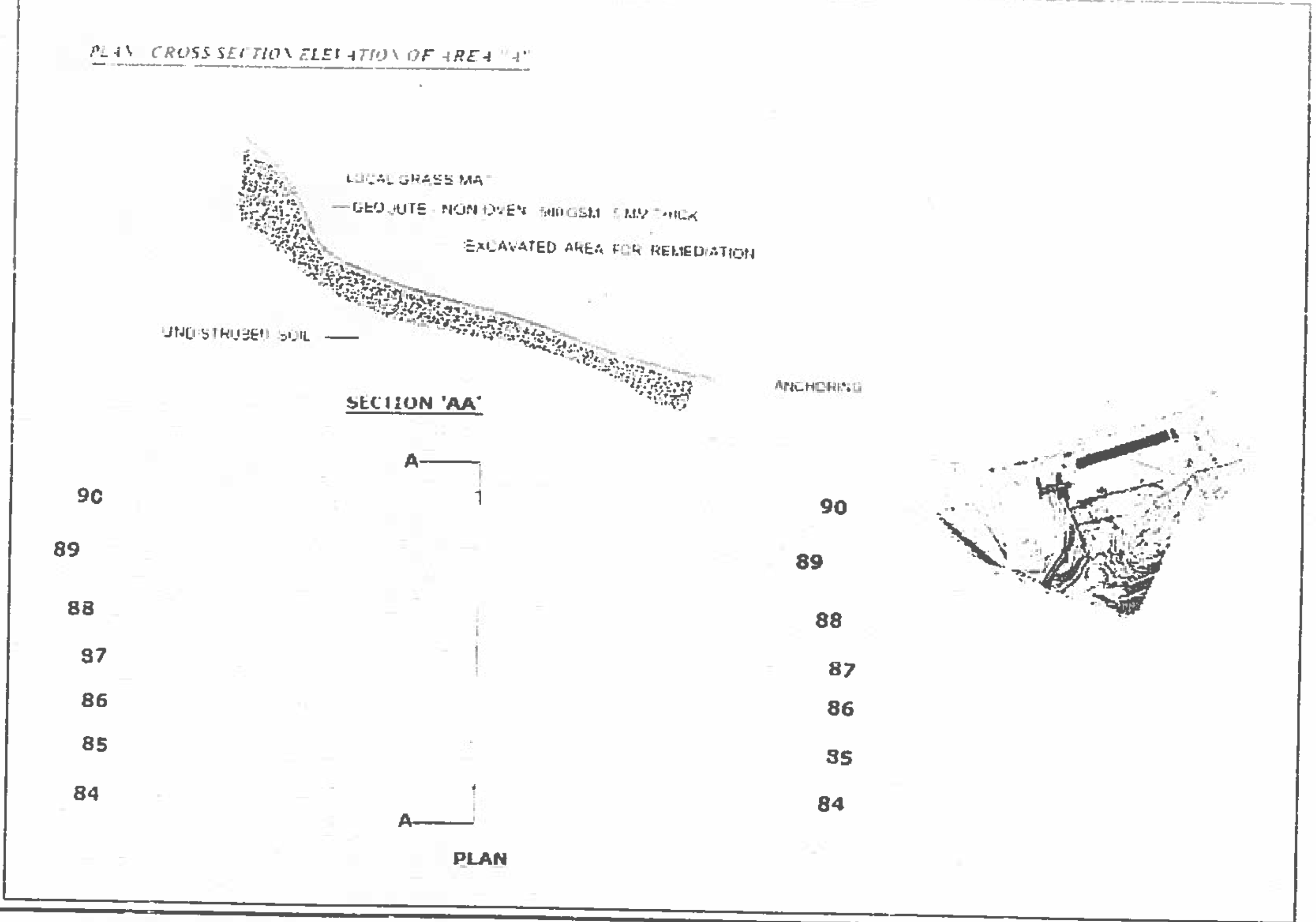
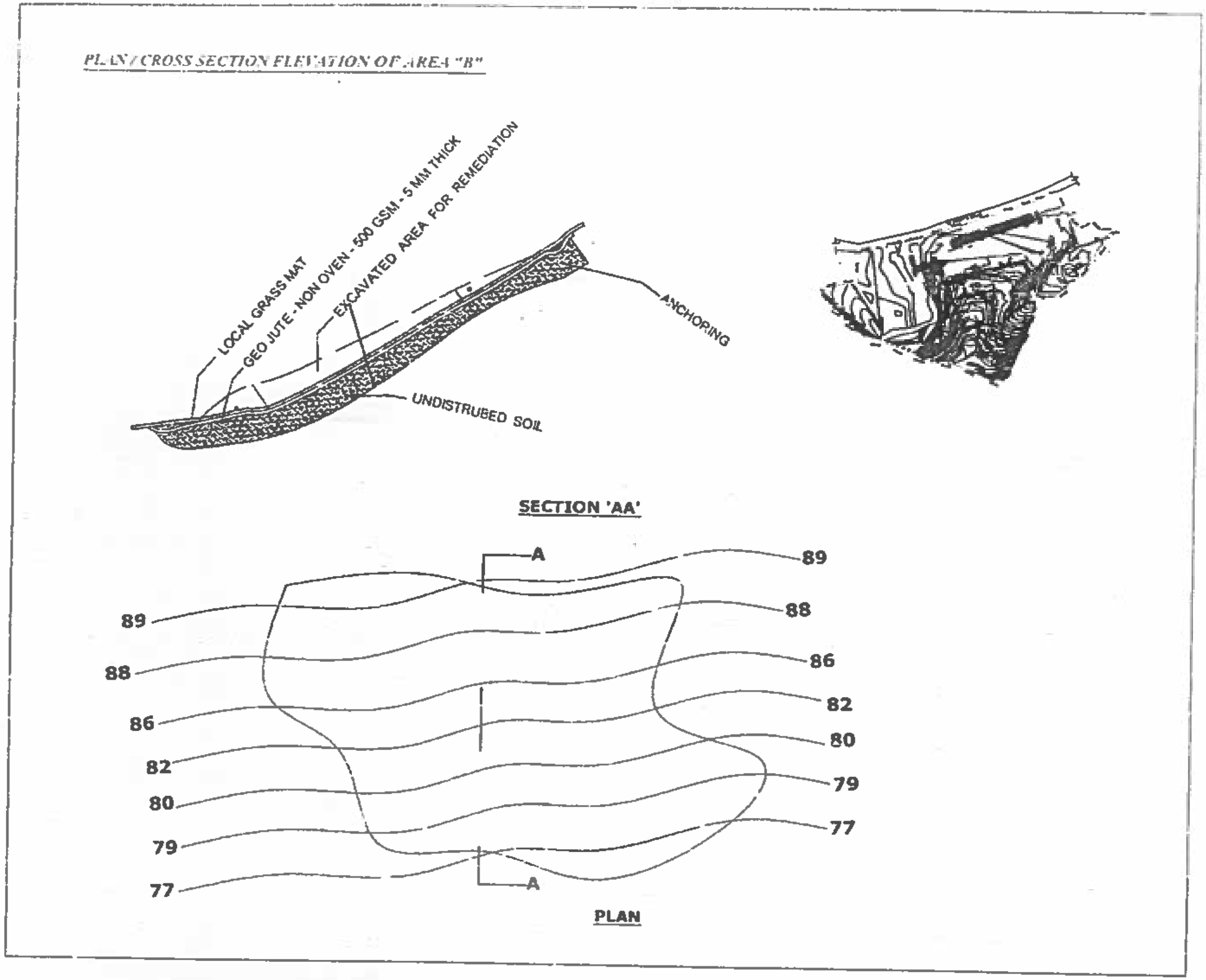


Figure 9 Plan/ Cross section elevation of Area B



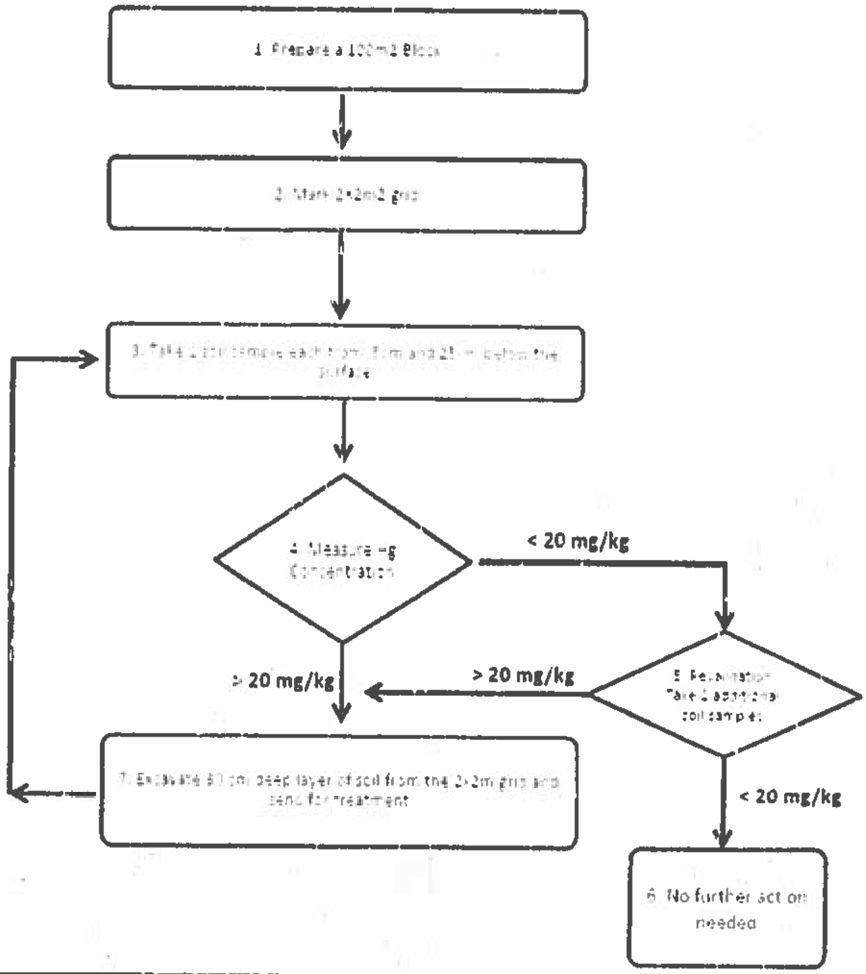
Excavation at Area C, which does not have steep slopes, will involve excavation using small mechanised excavator. Excavated soils will be loaded into a 4 wheel drive utility vehicle and transported directly to the main factory building for remediation. Backfilling will be done within Area C itself, once treated to the remediation criteria of 20 mg/kg.

4.2 EXCAVATION SOIL SAMPLING & SCREENING

Within each identified area, excavation shall proceed in 2x2 m grids. 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 analysis will 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 2 m grid. If the mercury concentrations are below 20 mg/kg, a revalidation of the pit shall be undertaken by collecting two additional soil samples within the excavation pit, and if concentrations are below 20 mg/kg, then then the grid can be reported as clean and shall not require further excavation and treatment.

If, however, mercury concentrations are above 20 mg/ kg, then the soil shall be excavated up to 60 cm below ground level (i.e. another 30 cm excavated). 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 in a similar manner. This process of excavation and screening/validation shall be continued until such a point where in all the sampling points within the 2 x 2 m grid report mercury concentrations below 20 mg/kg. In case rock is encountered, then excavation shall be ceased. Please refer to the decision matrix provided in Figure 10 below for sampling/ validation in the excavation areas.

Figure 10 ***Decision matrix for sampling/ validation in excavation areas.***



4.3 *EXCAVATION - DUST CONTROL*

If necessary, water spraying will be undertaken to minimise any airborne dust caused by the excavation or remediation work.

4.4 *SOIL EROSION CONTROL MEASURES*

Various erosion prevention measures shall be undertaken during the excavation work, as per the recommendations of the Indian Institute of Soil and Water Conservation (IISWC), Udhagamandalam. The general recommendations include:

- 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 proper thickness suited to the compaction equipment;

applying the necessary compaction to obtain the required densities; ensuring that compaction is of a nature that aeration to the root zone of surrounding trees is maintained. Proper bond shall be provided between each backfilled layer and also between the backfill and the sides of the excavation pits. 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.

- Use of sand bags around the excavated pits where required, to prevent water from entering the pits during rain events.

Specific recommendations for Area A (Steep slope area)

- Covering with geo-jute blankets and planting grass to avoid soil movement and erosion;
- For level areas (where available), soil will be excavated up to required depth, followed immediately grass turfing.
- Excavated soil in these areas will be treated and backfilled in Area C1 and C2;

Specific recommendations for Area B (Steep slope area)

- Near trees, it is recommended that the excavated areas be covered with non-woven geo jute before applying a grass turf ayer.
- Excavated soil in these areas will be treated and backfilled in Areas C1 and C2;

Specific recommendations for Area C1 (gentle slopes)

- Soil will be excavated and backfilled in terrace form with support walls;
- Root slips of the vegetative barriers, with appropriate species of plants as recommended by IISWC , will be planted on the terrace after backfilling;
- Close to the factory building, soil will be excavated at 1:1 riser slope ratio and turfing with appropriate species of plants as recommended by IISWC will be undertaken;
- Drainage lines passing through this area will be lined with loose boulders. The drainage lines will have silt sinks constructed along their paths.
- Treated soils from Area A and B will be refilled in this area by raising the lower level terraces.

Specific recommendations for Area C2 (gentle slopes)

- Soil will be excavated in horizontal and vertical slope near the factory building;
- Terrace walls with supporting walls to be developed as part of the backfilling activities
- Root slips of vegetative barriers with appropriate species of plants as recommended by IISWC, will be planted on the terrace after backfilling.

During heavy periods of rain, all excavation will be stopped and pits shall be covered with HDPE sheets, until a time when surface water runoff has ceased across the excavation area. Surface water runoff will be routed to the silt settling tank and silt traps.

4.5 TRANSPORTATION & HANDLING

Excavated soil will be transported to the main plant for treatment by use of a 4 wheel drive utility vehicle covered with tarpaulin. It is required that appropriate quantity of soil will be hauled to the main plant for processing and required quantity of treated soil will be moved from the main plant area back to be backfilled. Roads/path ways 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 treated soil be carried out simultaneously at different places. One or more 4 wheel drive utility vehicles are envisaged for transporting the soil from/ to excavated areas.

4.6 STOCKPILING OF MATERIAL

It may be required to stockpile the excavated soil prior to treatment or treated soil prior to backfilling. Excavated/ treated soil stockpiling will be done at separate locations within the main plant area or an alternatively identified area, where washed soil / retorted soil shall be stored for QC clearance / further treatment, if required. 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 stored in separate covered factory sheds or covered with a HDPE sheet.

4.7 PRESERVATION OF TREES DURING EXCAVATION

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, to the extent possible. Backfilling and provision of adequate soil cover after manual excavation will ensure that trees will be subjected to minimal stress, to the extent possible. 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, to ensure safety. For each tree that is felled or that falls down, two native species of trees will be replanted on site. The trees that are found at the site include the non-native eucalyptus trees, cypress and acacia trees, rhododendron and magnolia plants/ flowers.

5 CONTAMINATED SOIL TREATMENT PROCESSES

5.1 SOIL WASHING

Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes mercury from soils by concentrating the mercury into a smaller volume of fine soil (<1.0 mm) through particle size separation. The contaminated water generated from soil washing is treated in a process water treatment plant and thereafter reused in the soil washing process.

The Soil Washing process involves the following activities:

- Mechanical sieving of excavated soil to different particle sizes with the larger size fraction having been washed off with respect to the mercury.;
- Along with the sieving action, washing of soil with process water and separating the soil into a relatively clean coarse fraction, and a contaminated fine fraction is undertaken.

The washing process will be carried out in a series of vibratory screens with various sieve sizes. Each vibratory sieve has a mesh size and is powered by vibratory motors, which provide the mechanical sieving action. Forced water jets will be used to wash the input soil along the vibratory screens. Each oversize fraction from the respective sieves will be collected and analysed to verify the remediation criteria.

All oversize material from the sieves will be analysed for mercury concentrations and in case they exceed the remediation criteria will be sent back for washing.

All soil fractions that have been washed at the various stages, collected and found to contain mercury concentrations < 20 mg/kg, will be backfilled on site.

The final soil washing treatment train will be updated based on the final design.

5.2 VACUUM RETORTING

The fine grained, highly contaminated fraction (<1.0 mm), that is generated by the soil washing process is transferred to the vacuum retort unit. The vacuum-distillation process involves heating the contaminated fine fraction soil under vacuum and temperature high enough to volatilize mercury. Mercury vapours that are generated will be condensed and collected in an appropriate collection vessel that is under vacuum. Multiple activated carbons units will be placed post collection vessel.

After passing the vacuum-distillation unit, the treated soil if demonstrated to have mercury concentrations below 20 mg/kg, will be backfilled at the excavated areas.

5.3 SOLIDIFICATION & STABILIZATION OF WASTE

The contaminated soils and building material that cannot be treated in the soil washing and retort system having concentrations greater than 20 mg/kg, will be stabilized and solidified prior to disposal in an authorized TSDF following the regulatory procedures as stipulated under the Hazardous Waste Rules (2016). Mercury contaminated soil and building material will be stabilised on site to render the mercury into a non-leachable mercury form. Typical stabilizing agents used are sulphur compounds, furnace slag that has sulphur, sulphur impregnated Portland cement, etc. A further step of solidifying the stabilized contaminated soil into a composite matrix is followed prior to disposal to an authorised TSDF.

Non impacted building material that is documented as not containing mercury, will be reused at the site for construction of temporary roads, retaining walls, check dams etc.

Plant material from the excavation area, that has contaminated soil adhering to it will be containerised and sent to an authorised TSDF located in Virudhunagar District, Tamil Nadu, for disposal following the procedures as stipulated in the Hazardous Waste Rules (2016).

6 SOIL REMEDIATION EQUIPMENT UPSCALING PLAN

6.1 PILOT SCALE SOIL TRIALS

As directed by the TNPCB, remediation trials using the soil washing and retort was undertaken at the site between August 16th and Nov 18th 2017. The results of the trials and modifications identified were shared in the meeting with TNPCB and SEC on 21st November 2017 in Chennai. At the said meeting, TNPCB and SEC reviewed the data and report and made their recommendations as captured in the Minutes of Meeting. TNPCB has now asked HUL to submit the upscaling Remediation Plan, by incorporating the suggestions/ recommendations made by the TNPCB and SEC. The Soil Remediation Trials report as submitted to TNPCB is provided in Annex 2.

6.2 PROPOSED UPSCALED SOIL WASHING PLANT

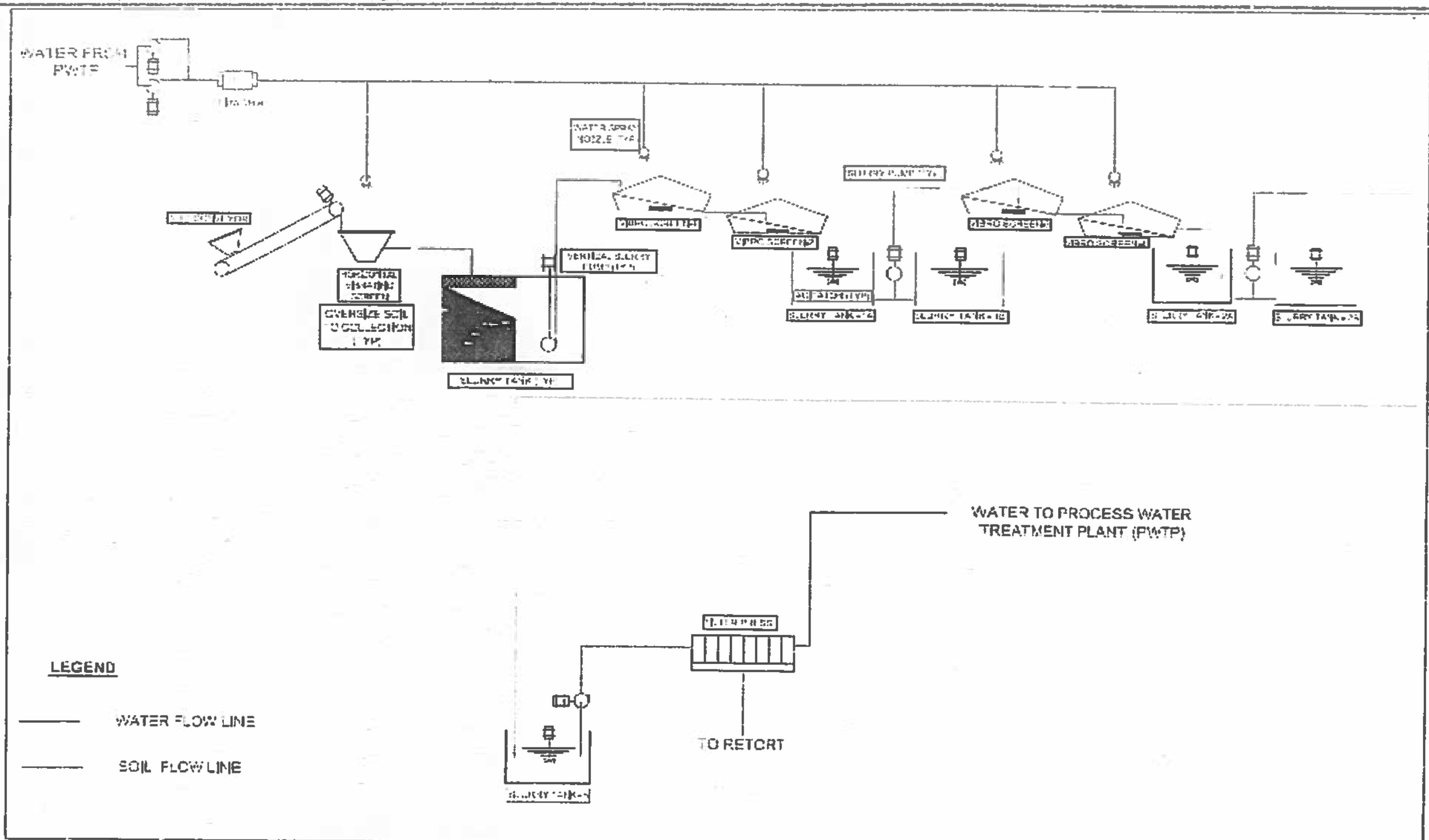
Based on the pilot scale studies undertaken at the site, it is planned to increase the throughput of the soil washing system to 20 tons per day. The following are the proposed design specifications, which may be subject to change during the final design stage which is currently ongoing. Please refer to the Figure 11 for the indicative schematic of the proposed upscaled soil washing plant.

Table 6.1 Throughput and proposed design specifications – soil washing

Soil Washing		
Objective: Soils at the site having mercury concentrations ranging from 20 to 1000+ mg/kg will be passed through the soil washing system to clean and recover the maximum quantity of soil with mercury concentration equal to or less than the remediation standard of 20 mg/kg . In the process, mercury will get concentrated into the fines fractions (i.e. < 1 mm). The fines fraction with concentrated mercury will be passed through a filter press or equivalent dewatering system to create a cake that has as little moisture as possible, whilst still retaining the mercury within the cake.		
Description	**Specifications**	**Additional Information**
Throughput	20 tons per day	Feed soil contaminated with mercury.
Mode of treatment	Soil Washing over vibratory screens with different mesh sizes and high pressure water jets	Includes automation and all precautions for safety (including but not limited to tanks covers, guards, interlocks, etc.)
Mode of transfer	Apron conveyor at feed point, followed by slurry transfer using slurry pumps	Includes management of oversize material to avoid any manual handling
Equipment		
Vibratory Screens	Either in series or multi-deck configuration with multiple water jet spray nozzles	Vibratory screens will have battery of soil washing jet sprays along the length of vibratory screens
Horizontal Vibratory Screens	mesh size ranging from 25 mm to 1 mm	

Transfer pumps	Capable of transferring slurry of soil with density varying between 1.1 and 1.5	compatible with abrasive nature of soil slurry and also mercury
Slurry holding tanks	Multiple as required	
Filter press or alternate dewatering equipment	To generate mercury enriched filter press cake with minimum moisture content.	

Figure 11 Proposed upscaled soil washing plant



6.3 VACUUM RETORTING

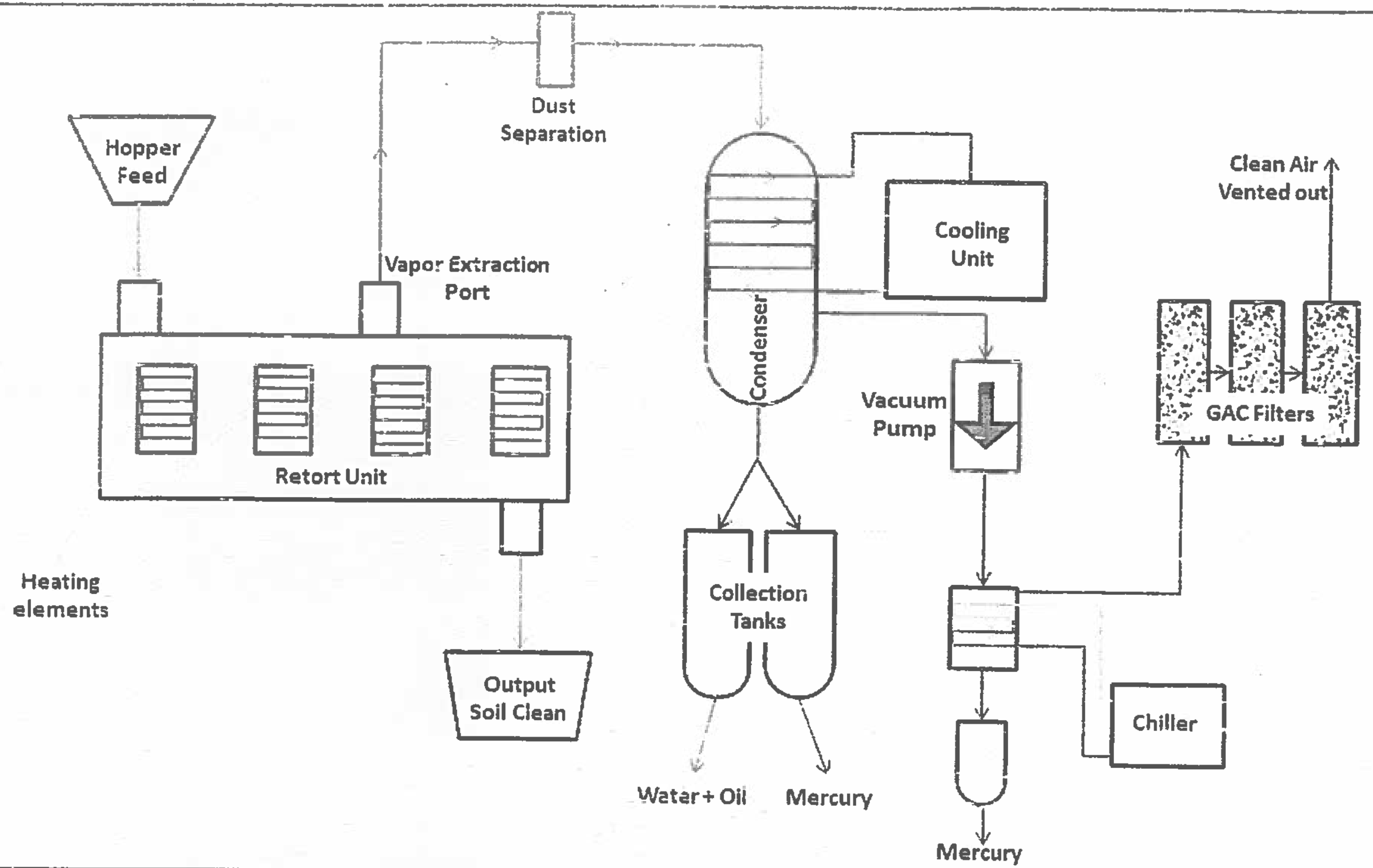
Based on the pilot scale studies undertaken at the site, it is planned to increase the throughput of the vacuum retort system to 5-6 tons per day.
The following are the proposed design specifications, which may be subject to change during the final design stage which is ongoing. Please refer to Figure 12 for indicative schematic of the proposed vacuum retort.

Table 6.2 Throughput and indicative design specifications – vacuum retort

Thermal Retort		
Objective: Intent of the thermal retorting system is to remove mercury from the fines fractions which are separated by means of the soil washing system. The mercury will be volatilized in the retort and will be re-condensed within an appropriately designed condenser. Ancillary process equipment like vacuum pump and activated carbon columns will also be installed to capture all the mercury vapours, if any. Other equipment's will be installed for movement of the soil .		
Description	**Specifications**	**Additional Information**
Throughput	5-6 tons per day	Feed material for retort will be fines contaminated with mercury.
Mode of treatment	Thermal retorting, condensation, and polishing using activated carbon columns	Thermal treatment will be conducted under vacuum and elevated temperature. The equipment will include all provisions from safety and interlocking point of view.
Mode of transfer	Conveyor systems for transfer of fines to and from thermal retort.	Includes provision of valves to control flow and hold vacuum in the retort.
Equipment		
Conveyor for feed and discharge	For transferring mercury containing cake to retort. To transfer dry material from retort discharge to handling area.	Feed will contain approximately 30-40% moisture with grain size less than 1mm. The material will within the silt-sand range and sticky in nature
Thermal Retort	Retort to be operated under vacuum and elevated temperature with appropriate residence time.	Will be able to withstand required temperature and vacuum without any leaks.
Condenser & Chiller	Individual or combined system to condense Hg and water vapour from the retort	Temperature to be reduced to condense all the mercury and water from the gas stream originating from the retort
Vacuum System	Pumps to provide sufficient vacuum (considering all losses) to transfer Hg and water vapour from retort through the condenser and activated carbon columns	Will include water entrapment system to remove any water (seal or from retort) escaping into the discharge

Granular Activated Carbon Columns	System of Granular Activated Carbon columns (set of 3 with 2 in operation and one standby) operating in sequence with provision to switch in case of breakthrough will be installed	

Figure 12 Proposed retort plant



6.4 PROCESS WATER TREATMENT PLANT

Process water will be generated from the washing activities. Please refer to Figure 13 for indicative schematic of the proposed process water treatment plant.

The process water is collected in the collection cum equalisation tanks after grit removing chamber. From collection tank, the water is pumped to the mixing tank where chemicals are dosed for PH correction, coagulant and polymer for precipitation and flocculation and mixed using flash mixer.

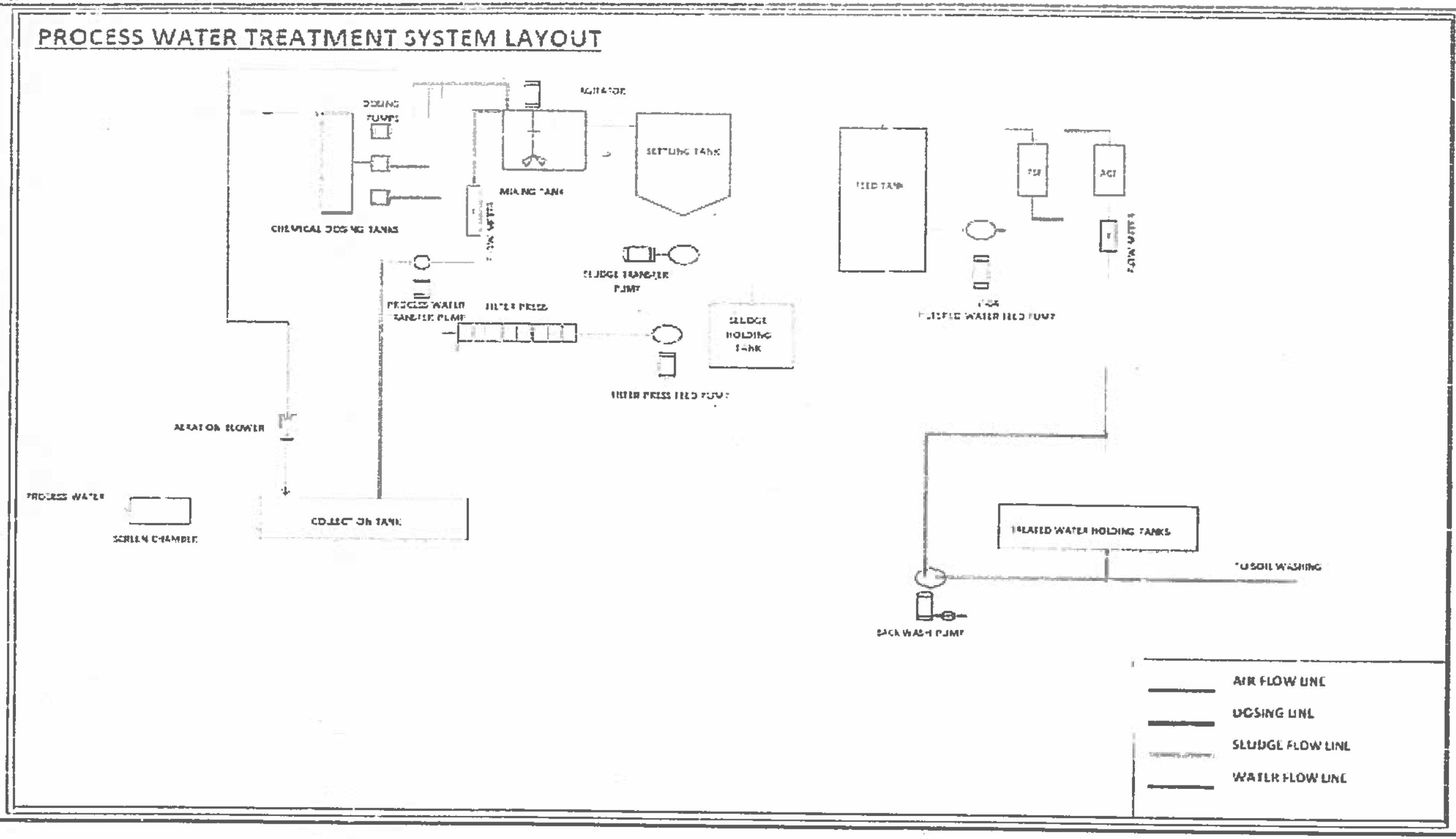
The flocs are allowed to settle by gravity where the sludge gets settled on the bottom and the supernatant water flows to filter fed tank. The sludge settled is passed through filter press for water separation.
The process water is then passed through pressure sand filters and activated carbon filters. The final treated water will be pumped to process feed tank for reusing in soil washing process and dust suppression/gardening, post quality clearance from the analytical laboratory with repect to the relevant discharge criteria parameters.

Table 6.3 ***Throughput and indicative design specifications – process water treatment plant***

Process Water Treatment Plant (PWTP)		
Objective: The water from the different streams including but not limited to soil washing, retort, laboratory wastewater, floor washing, and condenser will be treated in an on-site process water treatment facility. The treatment system will be required to remove all mercury from the water and recycle it back to the soil washing system. The PWTP will consist of processes necessary to remove any soil fines that may have been discharged from the soil washing or during floor washing. The treatment system will involve flocculation and settling of soil fines containing mercury followed by absorption of mercury onto the activated carbon columns		
Description	**Specifications**	**Additional Information**
Throughput	As per soil remediation trials, the treatment was undertaken with approximately 6L process water/Kg of soil, which gives an approximate capacity of 150 cubic meters per shift	Process water from filter press, floor washing, condenser, vacuum seal, etc. will be routed through the PWTP
Mode of treatment	Settling and mechanical separation by use of polyelectrolyte, alum, and lime to balance and settle the solids from the different streams in order to remove mercury in water.	The discharge from the PWTP will meet the CPCB/TNPCB prescribed limits (i.e. pH – 5.5 to 9.0, Total Suspended Solids - 100 mg/l, Total Dissolved Solids - 2100 mg/l, BOD - 30 mg/l, COD - 250 mg/l, Chlorides - 1000 mg/l, Sulphates - 1000 mg/l, Oil & Grease - 10 mg/l, and Mercury (as Hg) - 0.001 mg/l).

Mode of transfer	Interconnected piping and pumps for water and slurry transfer	Provision of appropriate sized tanks and appropriate Material of Construction (MOC) of valves
Equipment		
Screen Chamber	Appropriately sized chamber for screening out any large foreign objects	
Collection Tank	Collection tank with a minimum of 2 day storage capacity with provision to not let soil settle at the bottom and even out variation in flow and quality from different streams	Use of blowers/aerators to keep the fine soil/Hg in suspension
Chemical Dosing System	Appropriate mix of chemicals (lime, alum, and polyelectrolyte) storage and dosing systems	
Mixing Tank	Mixing of chemicals at pre-determined dosage to remove fine soil and mercury	
Settling Tank	Appropriately sized and type of settler to remove fine suspended soils by gravitational settling	
Dewatering System	Dewatering of wet sludge obtained from the settling tanks via sludge holding tanks and filer press	
Clarified Water Tanks	Holding tank for water from settling tank prior to be polished by filtration	
Pressure Sand Filters and Activated Carbon Filter	Removal of any suspended solids and mercury that did not get removed in settling tank	

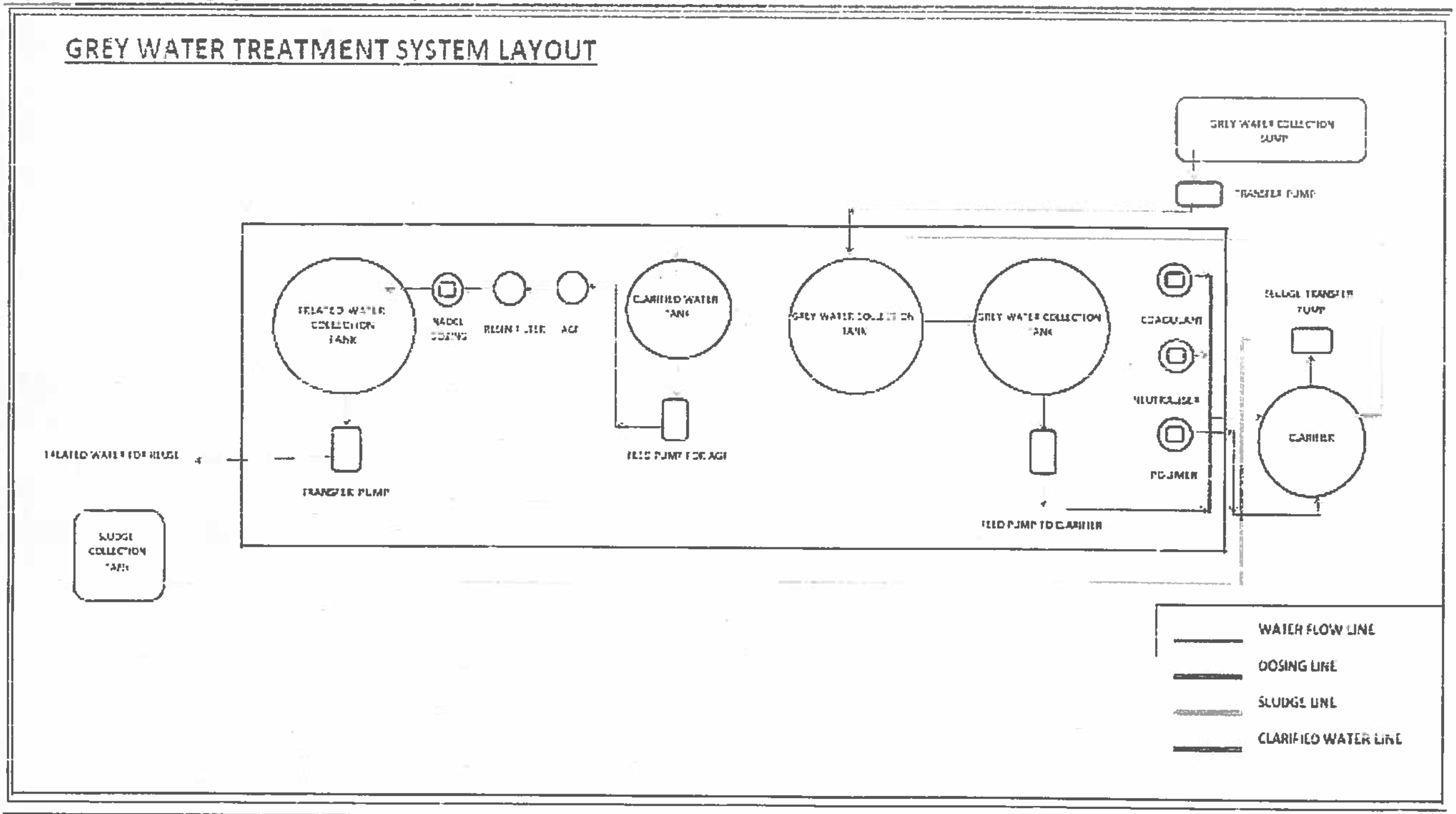
Figure 13 Proposed process water treatment plant



6.5 GREY WATER TREATMENT PLANT

Effluents from multiple sources (hand wash, cloth wash, and bathing) will be collected in the sumps. Collected water will be pumped in to the Treatment plant collection and equalisation tank. From the collection and equalisation tank, water will be pumped in to the clarifier and a polymer, coagulant, and neutralizer will be dosed. In the clarifier tank, water will be purified by settling and clear water will be decanted in to the clarified water tank. From the clarified water tank, water will be pumped to the treated water tank through a multi grade sand filter, activated carbon filter and resin filter with sodium hypo dosing in between. Treated water will be recycled either to factory toilet flush use or soil wash processes, as needed. Please refer to Figure 14 for indicative schematic of the proposed grey water treatment plant.

Figure 14 Proposed grey water treatment plant

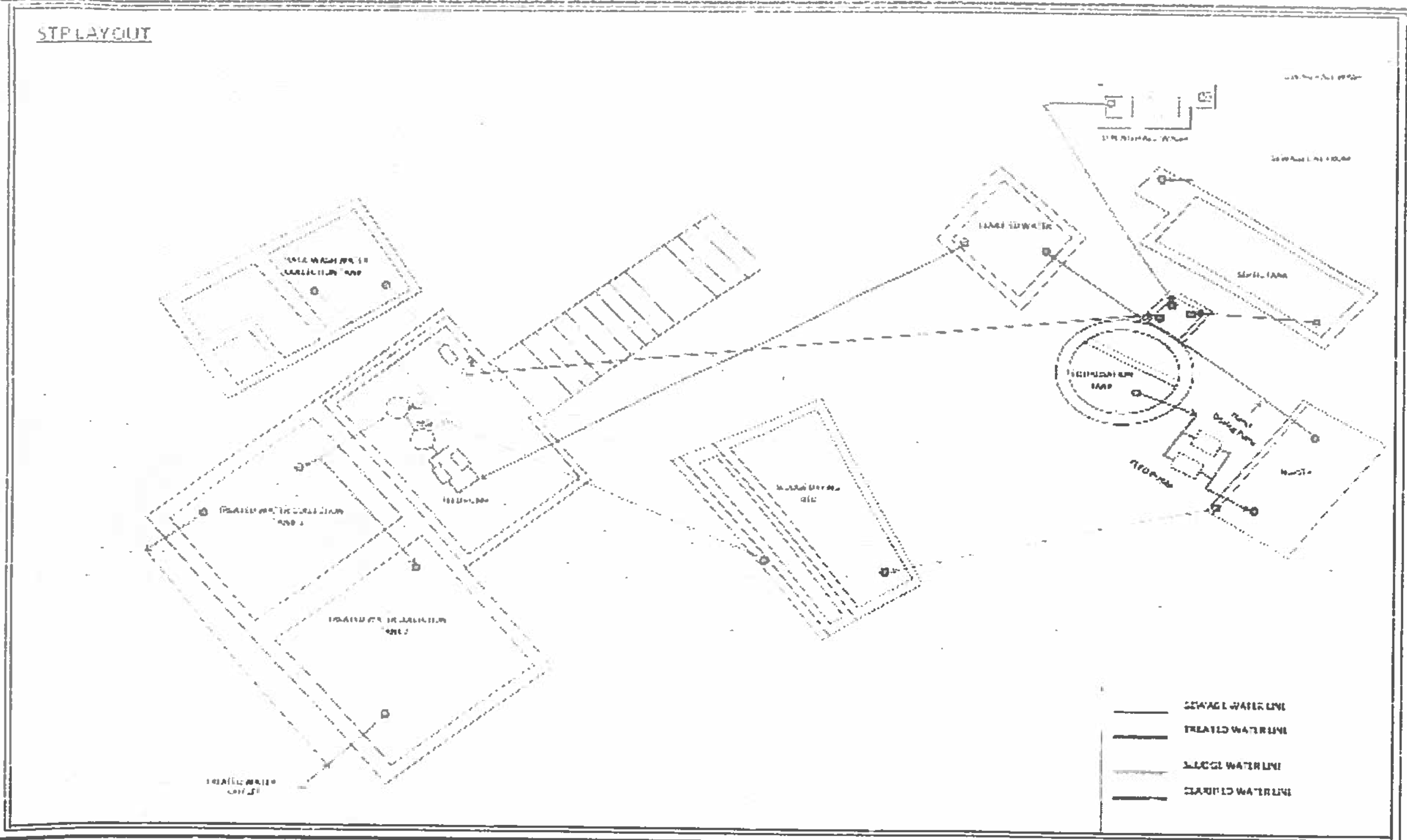


6.6 SEWAGE WATER TREATMENT PLANT

Effluents from toilet will be collected in the septic tank. Effluents from canteen hand wash and utensils wash will be collected in an equalisation tank via oil trap. Water in the equalisation tank will be pumped in to the on-site sewage treatment plant. MLSS will be grown in the sewage treatment plant. Aeration will be carried out and the effluent will be treated by biological method.

Clarified water from sewage treatment plant will be decanted in to the clarified water collection tank and will be pumped to the treated water tank via multi grade sand filter and activated carbon filter with sodium hypo dosing. Treated water will be used for gardening and soil dust suppression. Please refer to Figure 15 for indicative schematic of the proposed sewage treatment plant.

Figure 15 Proposed sewage treatment plant



6.7 AIR HANDLING UNITS

The ambient air in the soil treatment and retort area will be treated using air handling units equipped with particulate filter and carbon filter to capture any fugitive mercy emissions. The details of these units are provided below.

Table 6.4 ***Throughput and indicative design specifications – Air handling units***

Air Handling Units (AHU)		
Objective: The mercury vapours in air in the treatment area are to be captured with the air handling units. The AHUs are used to maintain sufficient air changes (10-15 changes per hour) within the work area so as capture any potential mercury vapours.		
Description	**Specifications**	**Comments**
Throughput	A minimum of 10 air changes per hour to be maintained in the work area	
Mode of treatment	Use of appropriately sized particulate filter, and carbon filter to control any emissions escape into the surroundings.	The discharge from the AHUs will meet standards prescribed by TNPCB.
Mode of transfer	Use of appropriately sized blowers and filters to maintain the air exchange rates	
Equipment		
Blower	Appropriately sized blowers based on required air exchanges and overcome any losses due to various filters will be provided	
Filters	Particulate and carbon filters will be installed to avoid an emission to escape	

7 ENVIRONMENTAL PARAMETERS MONITORING FRAMEWORK

7.1 ON-SITE LABORATORY FOR ANALYSIS

The onsite analytical laboratory is a state-of-the-art setup with imported Zeeman analysers from Russia exclusively for analysing mercury from various matrices such as solids and liquids. The laboratory can also analyse for Effluent Treatment Plant (ETP) parameters. The laboratory is resourced with experienced analytical chemists who are subcontracted from a NABL approved laboratory.

The following equipment's are available during the full scale remediation.

Table 7.1 List of analytical instruments in the laboratory

S.No	Instrument	Analysis
1	Zeeman Mercury Analyser with Pyro attachment	Analysis of mercury in soil, and sediment samples
2	Zeeman Mercury Analyser with RP-91 attachment	Analysis of mercury in water and urine by Cold Vapour technique
3	XMET 3000 XRF(X-ray Fluorescence) Analyser	Field screening for mercury in soil and sediment samples
4	Sieve Shaker	For determining the particle size distribution of the soil samples and various outputs from soil washing area
5	Instant Moisture Analyser	For instant moisture measurement
6	Instant Moisture Meter	Field screening for determining the moisture content (%) of the soil
7	Hydrometer	For instant measurement of the specific gravity of slurry
8	Jar Test	For determining the dosing level of coagulants/flocculants for process water treatment requirements
9	pH meter	For measuring pH of water and soil samples
10	Hot-Air Oven	For determining the percentage moisture content in soils by ASTM Method
11	Infrared Thermometer	For instant measurement of temperature across various surfaces especially the retort
12	Digital Anemometer	For aiding in calculation of air exchange rates for the AHU's(Air Handling Units) and undertake maintenance activities
13	Digital Manometer	For cross checking pressure
14	Laser Distance meter	For instant measurement of the distance between two point
15	Handheld GPS	For georeferencing sampling location with 3m accuracy, onsite and offsite
16	Total Suspended Solids (TSS) Measurement	For determining the TSS in the soil slurry and water samples
17	Mortar and Pestle	For crushing and homogenising soil samples as a preparatory step for soil analysis by Zeeman Analyser

7.2 ANALYTICAL PROTOCOLS

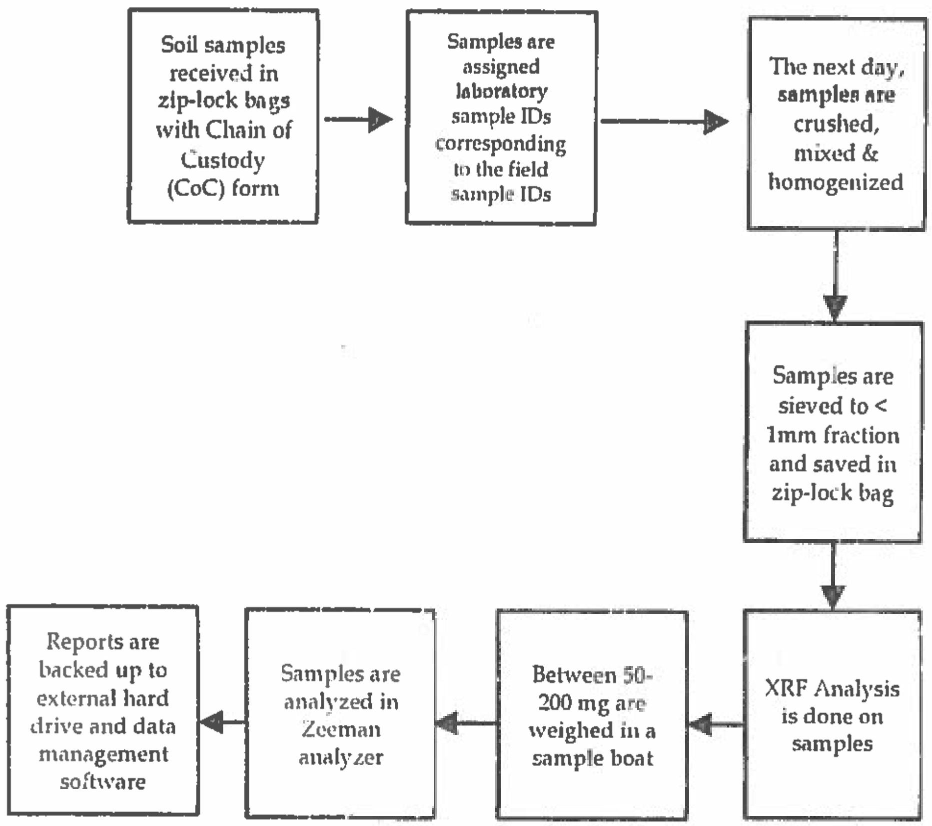
7.2.1 Soil

The XMET 3000 XRF will be used for field screening of soil samples. Ohio Lumex analyser will be used for onsite laboratory analysis of mercury in soil samples. The soil samples from the process area or excavation area will be received in the ziplock bags along with a Chain of Custody (CoC) form wherein the sampler will fill in information regarding the sample ID, type of analysis required, sample type, date and time of sampling and GPS coordinates, (for field samples). After cross checking the CoC with the samples, the laboratory chemists will allot a laboratory sample ID corresponding to the sample ID indicated in the CoC. This sample ID will be used for all analytical procedures in the laboratory. A butter paper (1 ft by 0.5 ft) will be labelled with the laboratory sample ID and approximately 300-500 g of well mixed soil will be allowed to air dry in the 'soil preparation' room. The soil samples are thoroughly ground and homogenized with a mortar and pestle. This is to minimize the spatial heterogeneity of mercury in the soil samples to the extent possible. Finally, the samples are mixed again and sieved through an 18 mesh (< 1mm) brass sieve by hand. The soil samples passing through this sieve are collected in a small zip lock bag labelled and saved for XRF Analysis. After noting down the XRF value of the sample, between 50-200 mg of the processed soil sample will be weighed in a sample boat and analysed in the Zeeman Analyser in triplicates for mercury concentration. The concentration of mercury in the soil sample is calculated using the proprietary Lumex Rapid Software (Ver 1.00.442).

Analysis will be carried out for soil samples with a maximum allowable Relative Percent Difference (RPD) variation of 35% as per norms followed by USEPA. After the sample are analysed, the laboratory report called the laboratory Certificate of Analysis (CoA) will be generated. Before issuing the CoA, a thorough Quality Control (QC) check will be done to ensure the correct data is reported. This includes rechecking the CoC for correlation between laboratory and field sample ID's, cross checking and cross verifying the raw data from Lumex Rapid Software and spot QC check of the XRF values of random samples. The CoA Reports will then be signed by the laboratory chemists and laboratory manager. The analytical reports will then be backed up in an external hard drive and uploaded to cloud-based laboratory data management software, Equis.

The summary of flowchart for soil mercury analysis is given below in Figure 16.

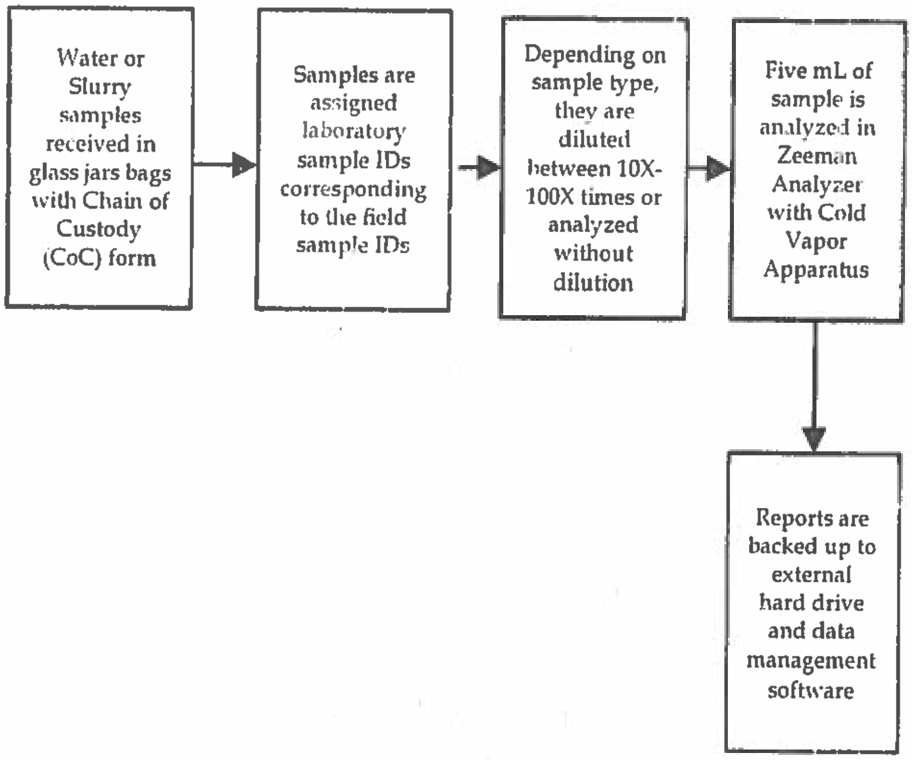
Figure 16: ***Flowchart for soil mercury analysis***



7.2.2 *Water*

Similar to the soil sample, after labelling the laboratory sample ID, the water samples will be immediately analysed in Zeeman Analyzer attached to Cold Vapour setup (RP-91 attachment). Depending on the location where the samples were taken, the water or slurry samples will be diluted or analysed as is. For e.g. if the samples are PWTP effluents they are directly analysed undiluted, but if they are taken from the condensate of the retort they are diluted 100X in a standard measuring flask before analysis. The concentration of mercury is calculated by the Lumex Rapid software. Analysis is carried out for water samples with a maximum allowable RPD variation of 20%. Similar to the soil samples, the CoA reports are generated after doing a QC check of the results with CoA and manually checking the Lumex Rapid software for discrepancies. After the CoA reports are finalized, they are backed up in an external hard drive and uploaded to cloud-based laboratory data management software, Equips. A flowchart of the entire steps for water analysis is given below in Figure 17.

Figure 17 *Flowchart of water/slurry analysis*



7.2.3 *Air*

Air will be monitored routinely at process specific locations and across the site, including along the site perimeter. The handheld Jerome 431/405 Mercury vapour analyser will be used to monitor mercury vapour readings at the specific process locations and other locations across the site. In addition, a real time 24 hour Jerome 451-X monitoring station will be placed in the centre of the excavation area to monitor for any potential mercury vapours during the excavation work. In the process area /retort area, one Jerome 451-X for continuous air monitoring will be installed for detecting elevated level of mercury in workplace air.

7.3 DATA QUALITY OBJECTIVES: QA/QC PROTOCOLS

The onsite laboratory follows stringent quality checks and laboratory protocols in order to ensure that the results generated are reliable, repeatable and defendable. For this, a series of Quality Control procedures have been devised at every step; right from the time the samples are received by the laboratory until the final reports (CoA) are issued. The quality control parameters are classified into three levels: Method level, Batch level and Sample level. These will be undertaken on a daily basis for all samples that were received by the laboratory.

7.3.1 *Quality Control at Method Level*

It is important that an appropriate and reliable method which matches the Data Quality Objectives (DQO) and the analytical requirement for the matrix of interest are selected for the project. USEPA Method 7473 for determining mercury in solids by thermal decomposition and USEPA Method 245.1 for determination of mercury in water by Cold Vapour Atomic Absorption Spectrometry has been selected for the purpose of analysing samples at the on-site laboratory.

Consequently, the following QA/QC methods are followed which include:

1. Quantifying the Method Reporting Limit and qualitatively estimating the Method Detection Limit (MDL) as per the USEPA Protocol. The MDL for soil has been determined to be 0.02 mg/kg and liquids are 1 ug/L for the instruments.
2. Calibrate using only Certified Reference Material (CRM) standards for the range of concentrations encountered onsite. The CRM standards are commercially prepared standards that have been extensively analyzed and reported by peer commercial environmental laboratories and subsequently been classified as "Certified Reference Materials".
3. The calibration is accepted and deemed valid if it passes the following criteria:
   3.1. The correlation coefficient of the calibration standards is ≥ 0.998
   3.2. The Relative Standard Deviation(RSD) of a Standard Reference Material (SRM) analyzed with calibration curve is $\leq 10\%$
   3.3. The Initial Calibration Verification (ICV) standard falls within 10% of RSD
4. Calibrating the Mercury Zeeman Analyzers once a week with freshly prepared stock solutions and standards
5. Carry out a Continuous Calibration Verification (CCV) standard as required on a daily basis.

7.3.2 *Quality Control at Batch Level*

In order to ensure the data is accurate and repeatable across various batches, the following test procedures are to be followed:

1. Checks to ensure that that CoC match the sample ID, batch, date indicated on the ziplock bags.
2. Assign laboratory sample IDs corresponding to field sample IDs.
3. Undertaking at least one Laboratory Control Spike (LCS) analysis to each batch analyzed and mandate the recovery is within the acceptable range of criteria set by the corresponding method (80-120%) to avoid data bias.
4. Carry out random method blank tests after analyzing high concentration samples

7.3.3 *Quality Control at Sample Level*

The Quality Control checks at a sample level to be followed are:

1. The RPD for soil and water was set to be 35% and 20% respectively. If either the duplicate or triplicate samples fail the RPD test, the analysis will be repeated.
2. External QC will be carried out by sending a fixed percentage of split samples as required to a third party laboratory to validate the in-house laboratory results.
3. Using dedicated sample preparation tools and sample containers for the three range of concentrations encountered on site.
4. Ensure running blanks after measuring soil samples with high concentration
5. Creating a sample ID that clearly indicates detailed sampling information.

7.4 INTERNATIONAL STANDARDS

In order to ensure that the data generated from the laboratory is a true reflection of the sample analysed and because critical remedial decisions are entirely based on the laboratory results, we shall follow a tried and tested protocol which has been verified by reputable community and pass international quality standards. The following is the list of recognized and accepted standards to be followed for testing soil, water, urine, slurry and sediments

Table 7.2 *List of standards followed for analytical protocol*

S.No	Analysis	International Standard followed
1	Soil, Sediments	USEPA Method 7473 for Mercury in Solids by Thermal Decomposition and Atomic Absorption Spectrophotometry
2	Water, Slurry	USEPA Method 245.1 for Mercury Analysis by Cold Vapour Atomic Absorption (CVAA)
3	Moisture	Determination of Moisture Content of Soil by ASTM Method D2216
4	TSS	Standard Method of Determination of Suspended Solids in Water and Wastewater by APHA Method 2540D

7.5 REMEDIATION MONITORING FRAMEWORK

The following process and environmental parameters monitoring framework will be followed for the full scale soil remediation.

7.5.1 *Excavation and Process Area Soil Monitoring Framework*

The excavation and process area soil monitoring frame work is provided below and will be followed during the full scale remediation at the site.

Table 7.3 *Excavation and Process Area soil monitoring framework*

Sampling location	Number of samples
Sampling and analysis of soils from excavation areas and feed soil into soil washing plant	2 samples per excavation grid of 2mX 2 m and 3 samples from feed soil at soil washing plant loading area. Corresponds to approximating 5 samples per 2 tons of soil.
Sampling and analysis of output soil of the remediation equipment	Three soil samples collected per drum (~200 kg, one from the bottom, middle and top of the drum) and composited into one sample for analysis.
Sampling and analysis of soil from the silt traps.	Weekly sampling and analysis from one sample from every slit trap.
Fence line monitoring - soil sample from the southern boundary of the site, at the point where the onsite stream and at Levinge path meet	Weekly sampling and analysis of one soil sample from Levinge Path.

7.5.2 *Water Quality Monitoring Framework*

The inlet and outlet of the process water treatment plants will be sampled and analysed for mercury. Discharge criteria as per the Environment (Protection) Rules, 1986 (Fifth Amendment, 2014), "General standards for discharge of mercury as (Hg) in effluents" will be followed. Treated water will be predominantly reused in the soil washing train.

Table 7.4 *Process Water Monitoring framework*

Sampling location	Number of samples
Sampling and analysis of raw water used for soil washing.	One sample for every tanker brought in (or) daily sampling of in-house well water used.
Sampling and analysis of inlet and outlet water to process/grey/sewage water treatment plant.	Hourly samples from inlet and outlet of the process water treatment plant. Daily sample from inlet and outlet of the grey water treatment plant. Weekly sample from inlet and outlet of the sewage treatment plant.
Sampling and analysis of bleed water (when applicable) from the treatment process for soil reconditioning etc.	One sample of bleed water prior to being used for soil re-conditioning etc.
Sampling and analysis of water from the silt traps.	Weekly sampling and analysis of one sample from every slit trap
Fence line monitoring - surface water from the stream at Levinge path, located at the southern boundary of the factory	One sample per week

7.5.3 *Air Quality Monitoring Framework*

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) is 0.05 mg/m^3 for mercury compounds (except (organo) alkyls). For human safety, workplace mercury vapour will not exceed 0.05 mg/m^3 as per Indian Factories Act.

For the full scale remediation project at the site, a conservative approach is being adopted where half the acceptable concentration limit (of 0.05 mg/m3) for half the designated period (8 hour exposure period) is being used as a stop work trigger.

The Jerome Mercury Vapour Analyser will be used throughout the duration of onsite work to monitor the surrounding air quality with respect to mercury. The following levels of PPE will be applicable;

- Level D - Safety shoes, lab coats, safety glasses, helmet and 3M dust masks: During non-operational (ie excavation, treatment, operation & maintenance etc) periods at the site, and in other areas like security cabins, administrative building etc.
- Level C- Safety shoes, overalls, safety glasses, helmet and half face respirators with 3M Mercury Catridges: During and in excavation and soil treatment areas at all times.
- Level B - Safety shoes, overalls, safety glasses, helmet and Positive Air Purifying Respirator (PAPR): During exceedances of mercury vapor as indicated below.

If the vapour readings in the breathing zone exceed 0.025 mg/m3, readings will be collected every 15 min for a duration of 1 hour. If the readings still exceed 0.025 mg/m3, then work will be stopped and the work force will be moved out of that particular area until the vapour concentrations reduce to below 0.025 mg/m3.

Air monitoring for mercury vapor will be carried out using a Jerome 431-X /405Mercury 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.

A Mercury environmental Monitoring station (Jerome 451) will be installed in the centre of the site to monitor mercury vapours within the site during the excavation activities. The excavation areas themselves will be within an enclosed tent with appropriate Air Handling Units to capture any mercury vapours, if any, that may be present. 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/m³. The monitoring station downloads the mercury vapour concentrations collected every half an hour over a 24 hour period directly onto a computer where the data will be archived and stored.

One more continuous monitoring (Jerome 451) station in retort area will be installed for monitoring the mercury vapour concentrations.

Table 7.5 *Air quality monitoring framework*

Sampling location	Number of samples
Sampling and analysis of mercury in air at the middle of the contaminated area.	Continuous monitoring station (Jerome 451-X Real Time Monitoring Station) - every half an hour.
Sampling and analysis of mercury in air in the retort area.	Continuous monitoring station (Jerome 451-X Real Time Monitoring Station) - every half an hour.
Work area - soil excavation area, soil treatment area, water treatment plant, analytical laboratory, office and other areas where workers are deployed.	Hourly monitoring at process area locations using the handheld Jerome 431 Mercury Analyser.
Outlet from the air handling units	Hourly monitoring using the handheld Jerome 431 Mercury Analyser.
Fence line monitoring along the factory boundary	Hourly monitoring at 8 locations along the factory boundary

7.5.4 *Noise Monitoring Framework*

Noise exposure will be maintained below 85 dB(A) $L_{EX,8h}$ as the Factories Act. Monitoring of the noise at workplace and factory boundaries will also be undertaken as per standard. In certain process areas where noise may exceed the prescribed limits, appropriate ear protection/ ear plugs will be issued to the workers.

8 BACKFILLING

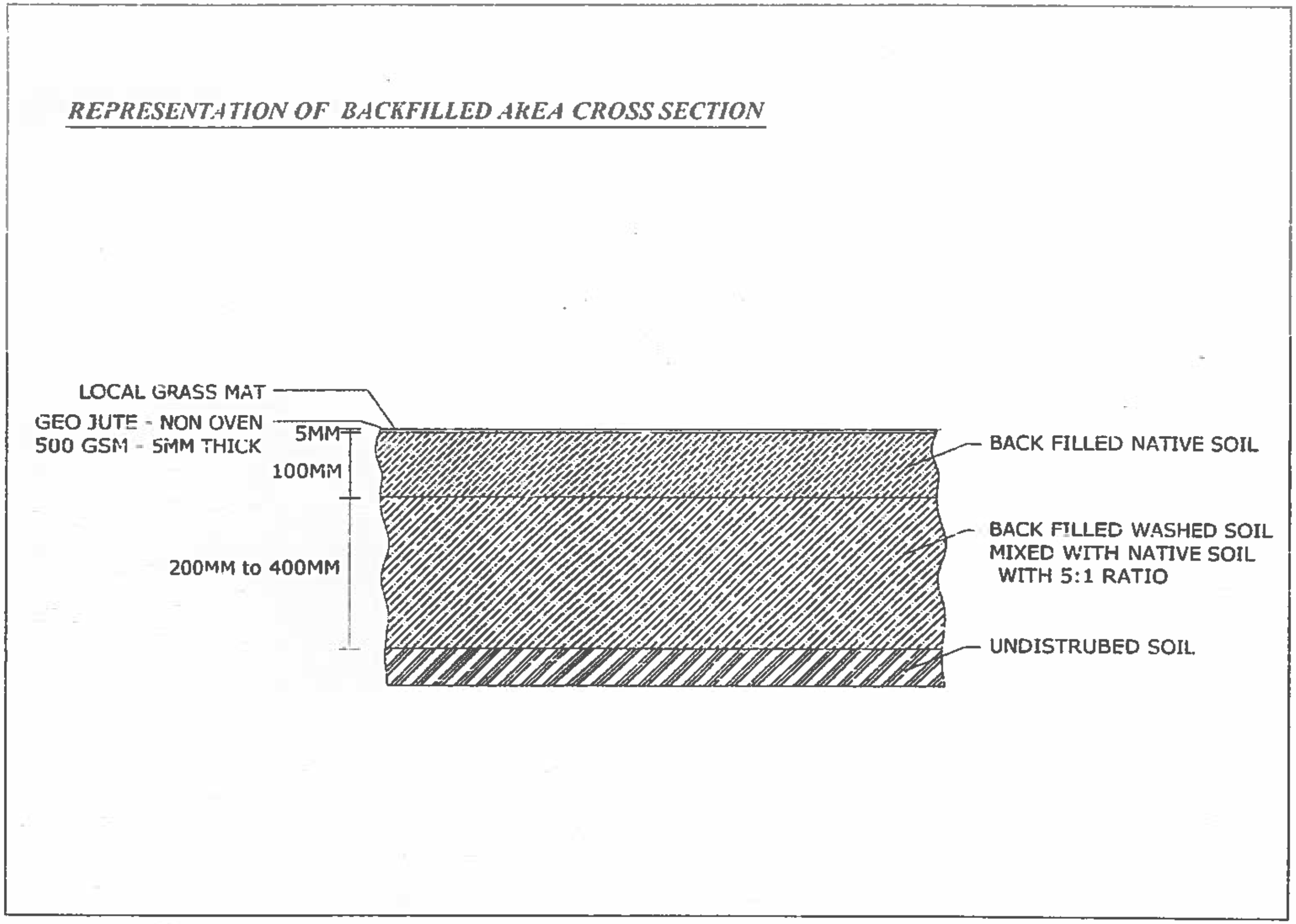
8.1 BACKFILLING OF TREATED SOIL

Treated soil which contains less than 20 mg/kg mercury after soil washing / retorting will be duly checked and certified by Quality Control before backfilling on site.

The treated soil will be loaded in 4 wheel drive utility vehicle covered with tarpaulin to prevent the loose soil/dust escaping in to the atmosphere. The utility vehicle will move through the designated road to the back fill points in Area C. No back filling operation will be carried out in Area A & B. Tied Tarpaulin will be removed from the utility vehicle and treated soil will be filled back in the designated previous excavated area by adding/spraying water to prevent dust escape in to the atmosphere.

As per the recommendations of the IISWC, native uncontaminated soil will be mixed with the remediated soil in a ratio of 1:5 during backfilling. Mixture of treated soil and native soil will be filled to the level less than 10 cm from the top of the ground level. Native soil will then be further backfilled above the remediated mixed soil. The backfill will be appropriately compacted. Geo-Jute will be spread over the compacted soil and appropriately overlapped. Grass mat will be placed above the geo-jute and grass will be watered by using treated or fresh water from on-site treatment system. Please refer to Figure 18 for a cross section representation of the proposed backfill at the site.

Figure 18 Backfilled areas cross section



8.2 GRADING & LANDSCAPING

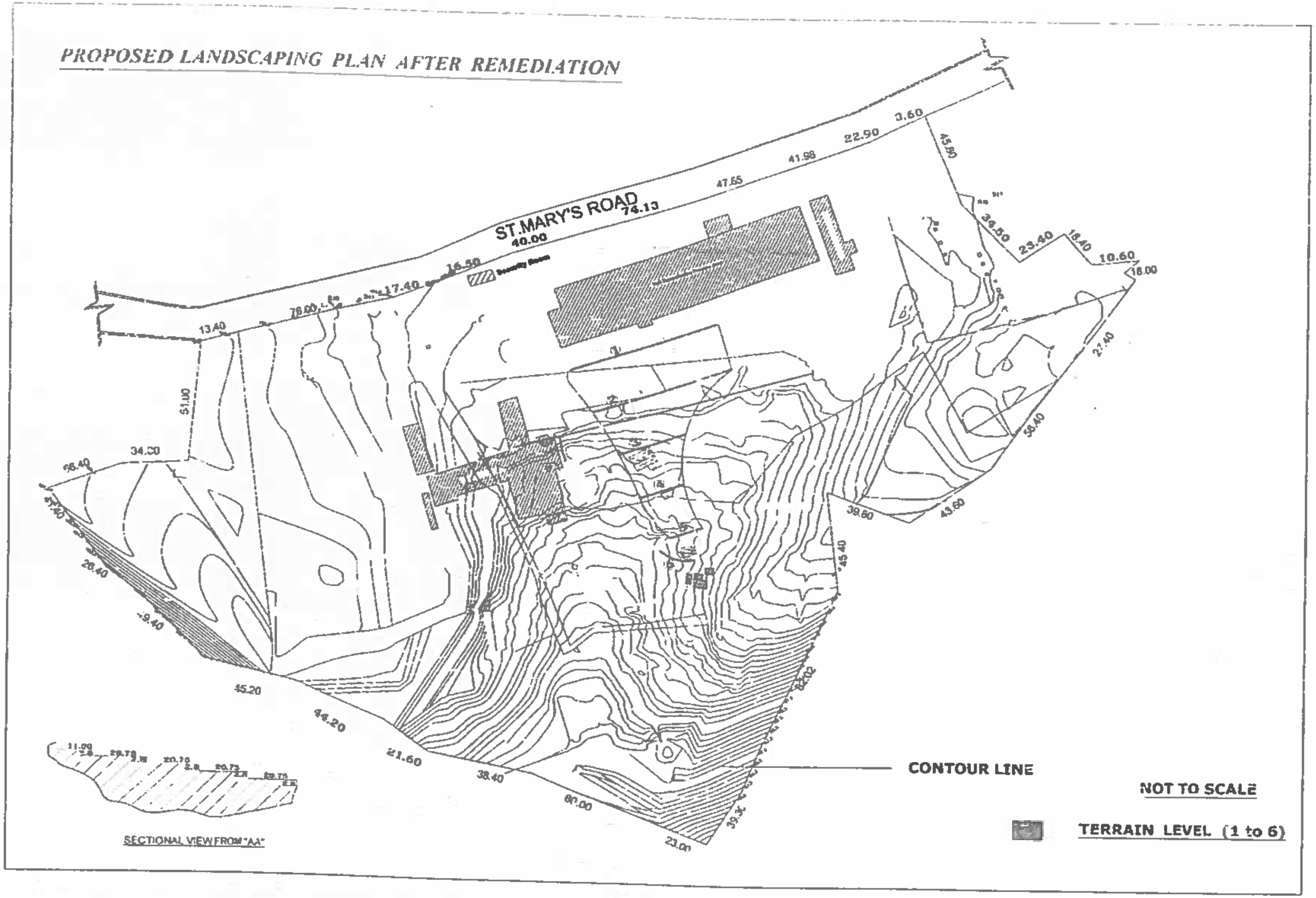
Treated soils that meet all cleanup criteria will be used on-site as backfill. Grading of treated backfilled soil will be done using excavators and compactors, in order to compact the soil and reduce the potential for erosion. Compaction of soil will be done in layers, to the extent that the natural porosity is not altered, thereby hindering natural growth of vegetation. A landscaping plan will be followed while the backfilling activities with treated soils.

8.3 EROSION CONTROL MECHANISMS

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. 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. Please refer to Figure 19 for the proposed landscaping after the completion of remediation and backfilling.

All grading, landscaping and erosion control measures will be undertaken under the guidance of IISWC.

Figure 19 Proposed landscaping plan after remediation



8.4 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 native species of trees shall be replanted at the site. The trees shall be of the local variety and preferably fast growing.

8.5 TREATED SOIL REHABILITATION

This activity will be undertaken under the guidance of IISWC. Blending of the washed and retorted fractions, will to some extent maintain the original soil characteristics. If on analysis, it is found that these soil properties are lacking or diluted, then soil amendments will be appropriately added. Soils may be mixed, if required, with compost and nutritional supplements and virgin soil from other areas within the site that are not contaminated.

9 BUILDING AND EQUIPMENT DECONTAMINATION

9.1 BUILDING DEMOLITION AND RUBBLE DISPOSAL

Prior to soil remediation commences (i.e. prior to excavation) the following buildings will be demolished at the site:

- Mercury distillation room;
- Mercury recovery and extension room; and
- Scrap storage room (Old bakery room)

When post remediation activities have been completed and the remediated area at the site has been validated, the main plant building and utilities building shall be demolished. All other remaining structures such as ETP, STP, etc. at the site will also be demolished. However, the check dam and slit traps and retaining walls etc. will not be demolished.

For the building demolition, specifically for those that are known to be impacted with mercury, the following steps will be undertaken:

- scraping the contaminated interior wall surface and filling into polywoven bags for disposal;
- re-testing the wall / structure for mercury after initial scraping;
- Demolishing the building structure ensuring safety.

Based on the results of mercury analysis from the building surfaces, rubble from the demolition will be segregated into contaminated and non-contaminated material.

Any building materials / debris and soil beneath the main building which contain above 20 mg/kg mercury will be disposed of in approved Treatment, Storage and Disposal Facility located in Virudhunagar District, Tamil Nadu, as per the Hazardous Waste Rules (2016). Remaining material that has been classified as non-contaminated will be utilized on site for construction of retaining walls, pathways, filling materials for landscape and other constructions at the site.

Roofing sheets will be collected prior to building demolition, bundled in plastic sheets and disposed off at a Treatment Storage and Disposal Facility.

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 approved by TNPCB and followed during Plant Machinery and Materials decontamination phase at the site. The decontaminated scrap will be tested and disposed off as scrap to approved recyclers.

9.2 DECONTAMINATION AND DISPOSAL OF MATERIALS AND EQUIPMENT

The decontamination protocol that was developed by the Indian Institute of Technology, Mumbai, and approved by the SEC and TNPCB will be used for all equipment decontamination process. Materials/ pilot plant equipment that is not intended to be used in the full scale remediation at the site as well as the some of the material/equipment leftover after soil remediation will be decontaminated prior to disposal as scrap metal. This is to clarify that some of the soil remediation equipment/utilities will be put to use by transferring to other sites for any other productive use. A detailed list of all the equipment's to be decontaminated will be maintained on site as records. Appropriate validation of the decontaminated equipment's will be undertaken as per the decontamination protocol. Please refer to Annexure 3 for the decontamination protocol.

10 WASTE MANAGEMENT AND DISPOSAL

10.1 HAZARDOUS WASTE

The following Hazardous Wastes will be generated during the remediation at the site. These wastes will be appropriately containerised, labelled and transported through a manifest system, as per the Hazardous Waste Rules (2016) to an authorised Treatment, Storage and Disposal Facility located in Virudhunagar District, Tamil Nadu or TNPCB approved recyclers.

- Spent activated carbon
- Sludge from the process water and grey water treatment plant
- Corrugated sheets
- Spent oil
- E-waste

10.2 CONTAMINATED WASTE

In addition to the regulated Hazardous Wastes that will be disposed to an authorised TSDF, other wastes that are contaminated but not designated as Hazardous Wastes as per the Hazardous Waste Rules (2016), will also be appropriately containerised, labelled and transported through a manifest system to an authorised Treatment, Storage and Disposal Facility located in Virudhunagar District, Tamil Nadu.

- Non-recyclable contaminated building material
- Used PPE
- Waste Cloth
- Insulation material
- Vegetation from the excavated areas; and
- Contaminated soils above 20 mg/Kg.

10.3 NON HAZARDOUS MATERIALS/WASTE

The following non-hazardous materials / wastes will also be generated during the remediation at the site. These materials / wastes will be tested in test chamber following decontamination, testing and clearance protocol and sent to approved recyclers.

- Metal scrap
- Paper
- Glass
- Plastic
- Empty bottles

11 HEALTH & SAFETY PRACTICES

11.1 OCCUPATION HEALTH MEASURES

The site has set up an exclusive Occupational Health Centre (OHC), with fulltime doctor, equipped with following medical equipment/ accessories;

- Defibrillator
- Bloor Pressure monitor
- Gluco Meter
- Digital Electro Cardio Graph
- Portable Phlegm Suction Unit
- Oxy watch - Pulse Oximeter
- Nebulizer
- Digital Thermometer
- Oxygen cylinder
- Valve with JFM & Humidifier set
- Folding stretcher
- Wheel chair
- Steriliser

Medical facilities include OHC 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 necessary emergency drugs, including anti snake venom, etc. will be made available.

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.

All workers and employees will be monitored in a systematic program of medical surveillance that is intended to prevent occupational exposure. The program will include education of contractors 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 employment (b) on a quarterly basis during the term of employment; and (c) at the time of closure of remediation work or exit of the worker from work.

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 analysed during the pre-employment phase on all employees who will be working on site.

The following urine monitoring framework will be put in place during the remediation phase at the site:

Table 11.1 ***Urine monitoring schedule***

Category of employee	Schedule
Employees working in retort section	Daily urine analysis
Employees in treatment process	Twice a week urine analysis
Employees in excavation area and all other areas	Weekly once urine analysis
Security personnel	Monthly once urine analysis
Additional monitoring	Prior to employment and following employment.

All employees have to follow hygiene practices such as hand wash before leaving the workplace. 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.

11.2 PERMIT TO WORK

Permit to work (PTW) shall be required for all non-routine activities carried out at site. Three types of permits formats shall be used namely general work permit, Height work permit and confined space permit. PTWs will be issued by respective area in-charge and authorised by project Executive. All high risk permits (height and confined space) shall be authorised by Safety officer and Project Manager.

For Routine activities work instructions/SOPs to be prepared and approved considering the risk, control measures and PPEs requirement etc.

11.3 PERSONAL PROTECTIVE EQUIPMENT

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

- Hard hat
- During any excavation and/ or treatment activities being undertaken, 3M Half Face Mask respirators with twin mercury vapour cartridge filters will be used.
- Safety glasses;
- Hearing protection in areas where noise decibel exceeds 85 decibels;
- Full sleeve coveralls;

- High visibility vests vest, if working in an area where there is vehicle movement, like excavation area;
- 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 life line, safety belt and safety net etc.

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

- Upon leaving the process area/excavation area 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 in the PPE;
- Contaminated personal protective equipment, i.e., suits, gloves, respirator cartridges, etc., will be placed into plastic bags and/or barrels and prepared for disposal
- Every person must wash their hands before leaving the work area;
- Personnel will thoroughly wash their hands before eating, drinking and using wash room.
- Smoking is prohibited in the factory premises.
- Mobile phone usage is not permitted in the work areas other than office areas.
- 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. All wash water will be routed to the 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.

11.4 *PREVENTION OF POTENTIAL EXPOSURE TO MERCURY*

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.

Potential exposure may also occur through incidental inhalation of contaminated soil as dusts or through incidental ingestion of contaminated soil.

The proper use of personal protective equipment and good personal hygiene practices are a must.

Appropriate Health and Safety procedures shall be in place in the treatment plant area and excavation area.

In case of accidental mercury spillage, evacuate the people inside the room, ensure proper ventilation, wear PPE including PAPR, 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 will be avoided. All instances of such incidents and measures that were taken shall be documented.

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.

11.5 *SAFETY TRAINING*

All personnel will be inducted into the Health & Safety program of the site and remediation activities. All contractors and their equipment will be vetted before employment to ensure that they can meet requirements. All Standard Operating Procedures, work instructions, Do's and Don'ts will be communicated to workers prior to initiation of the remediation phase.

11.6 *EMERGENCY RESPONSE PLAN*

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 section in-charge.

An assembly point near factory main gate located in an upwind area will be designated and all employees shall be notified of the area. A bell/ horn will be used to signal an evacuation in the event of an emergency. Continuous ringing of the bell/ 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.

11.6.1 *Emergency Information*

Fire Brigade	Phone # 240785
Ambulance (Van Allen Hospital)	Phone # 241273
Police Department	Phone # 242200
Local Electrical Utility	Assistant Engineer,TNEB,Phone # 240300, 240700
Local Telephone Utility	Assistant Engineer Office, Phone # 245500;
Local Water/Sewer Utility	Kodaikanal Municipality, Phone # 241253
District Forest Officer	Phone # 240287

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.

11.6.2 *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. Work must be stopped and corrective action to be taken. Work shall re-commence only after clearance from the Project Manager.

Table 11.2 ***Corrective action plans***

Anticipated Problem	Corrective Action
Excessive Rain	a) Suspend operations, b) Cover Excavation area with HDPE/Tarpauling sheet, c) Ensure soil erosion preparatory measures like Sand bags bunds are intact.
Unmanageable mud in excavation zone	a) Improve the drain arrangements around the area, b) Cover the problematic area with Geo texture/ HDPE liners, c) Strip off mud and shift to process area.
Excessive dust	Use water sprays or cease dust-generating activity until better dust control can be achieved.
Excessively wet materials	Stockpile and dewater onsite.
Springs/seeps	Isolate and re-route the water to silt settling tanks or silt traps.

12 SITE VALIDATION & CLEARANCE

12.1 SITE VALIDATION PROCEDURE

After the completion of excavation, treatment and backfilling of impacted soils a thorough site validation procedure shall be implemented. The National Environmental Engineering Research Institute (NEERI), Nagpur, will be the focal agency undertaking this operation.

Soils that have been treated to levels below 20 mg/kg mercury will be mixed with other treated soil fractions and native soil and has been appropriately rendered nutritionally active.

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, including along Levinge pathway
- Review of all remediation/decontamination procedures carried out on site, to determine that all standards and practices have been carried out.

12.2 POST REMEDIATION MANAGEMENT PROGRAM

A post remediation monitoring program will be required to monitor the effectiveness of soil remediation. This monitoring program will also evaluate the vegetative regeneration at the remediated areas. If it is found that the areas do not promote growth of plants and trees, adequate measures such as additional seeding and nutrient enhancement shall be undertaken. Evaluation of soil erosion prevention measures will also be undertaken regularly. Geo jute that has been installed will be checked and replaced on a regular basis.

A quarterly monitoring program, covering one year period, is proposed wherein soil sampling and analysis for mercury shall be undertaken within the treated soil area, and, silt traps, and at the point where the stream meets the Levinge pathway, to monitor whether any mercury is encountered on and off site, post remediation. Soil shall also be tested for biological activity of the treated and backfilled soil. An inventory and general assessment of all trees that have been planted on site will also be conducted.

13 PROJECT SUMMARY

13.1 SCHEDULE OF ACTIVITIES

The indicative project schedule is provided in Figure 20 below. The total project duration is anticipated to be 32 months from the date of receipt of TNPCB and all other Statutory Permits. The schedule is broken into three phases:

- Remediation equipment procurement, installation and commissioning
- Full scale remediation
- Reporting and site closure

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Equipment procuring & Installation	TNPCB and Statutory permits	■	■	■	■	■	■																										
Site preparation, terrace wall, rerouting of drains, access roads, check dams		■	■	■	■	■	■																										
Commissioning and testing of Remediation Equipment								■	■																								
Full scale Remediation									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Factory building demolition and disposal of underlying soils to TSDF																													■	■	■		
Disposal of residuall material/ waste to TSDF upon completion of soil remediation																														■	■	■	
Valildation of site																															■	■	
Remediation/ Site Closure Report																																■	■

Assumptions:
Schedule of activities starts from the obtaining necessary TNPCB and other statutory permits
Estimated Soil Quanity is 7,000 to 8,000 MT, treatment rate of 20 tons per day
3 months considered in full scale remediation timeline, for interruptions on account of rain
Post remediation monitoring of the site will be for one year after the remediation closure report

13.2

13.3 PROJECT PROGRESS REPORTING

The following project progress reports will be made available and shared appropriately:

- Weekly information on environmental monitoring shared at the factory gate for information to the public.
- Weekly soil remediation report to TNPCB.
- Monthly soil remediation progress report to TNPCB.
- Soil remediation and closure report at completion of remediation.

The above reports will be maintained at the site and will be available to the relevant authorities for review during project reviews.

13.2

13.3 PROJECT PROGRESS REPORTING

The following project progress reports will be made available and shared appropriately:

- Weekly information on environmental monitoring shared at the factory gate for information to the public.
- Weekly soil remediation report to TNPCB.
- Monthly soil remediation progress report to TNPCB.
- Soil remediation and closure report at completion of remediation.

The above reports will be maintained at the site and will be available to the relevant authorities for review during project reviews.

Annexure 1: List of Studies

List of studies

Description	Institution	Dated
Environmental Site Assessment and Risk Assessment for Mercury	URS Dames & Moore	May 2002
Remedial Action Plan - Site Remediation	URS Dames & Moore	May 2002
Health & Safety Plan - Site Remediation	URS Dames & Moore	May 2002
Total Mercury content in sediment, surface water & Fish samples drawn from area surrounding Kodaikanal	URS Dames & Moore	June 2005
Site Specific Target Level determination	NEERI & ERM	September 2006
Protocol for remediation of mercury contaminate site	NEERI	February 2007
Detailed project Report - Soil Remediation	NEERI & ERM	May 2008
Detailed mercury delineation of impacted soils	ERM	2009 / 2010
Report on Site Specific Cleanup Standards for HUL's mercury thermometer manufacturing factory at Kodaikanal, Tamil Nadu	Indian Institute of Technology, Delhi	October 2010
Report on Study soil conservation while undertaking and soil remediation process in mercury contaminated site of Hindustan Unilever Ltd., Kodaikanal	Central Soil and Water Conservation Research & Training Institute, Ooty	October 2010
Plant protection measures during decontamination process of mercury polluted soil at HUL, Kodaikanal	National Botanical Research Institute, Lucknow	May 2010
Detailed project Report - Soil Remediation	NEERI & ERM	August 2015
Assessment of Mercury Levels in Soil, Sediment and water samples from the Off-site Area of Hindustan Unilever Limited Factory (HUL), Kodaikanal, Tamil Nadu	NEERI	October 2015

Annexure 2: Soil Remediation Trials report

Report of Soil Remediation Trials undertaken at Hindustan Unilever Limited site, Kodaikanal.

The former HUL Mercury thermometer facility located in Kodaikanal needs to be remediated to bring down the mercury concentrations in soils to a safe and acceptable level as mandated by the Tamilnadu Pollution Control Board (TNPCB) and Scientific Experts Committee (SEC). Based on the recommendations of the Scientific Experts Committee (SEC), the TNPCB granted permission vide the letter dated 30th Dec 2016 to conduct soil remediation trial at the site, using the remediation equipment that had previously been installed at the site. HUL obtained the necessary statutory approvals between the period of 9th Jan 2017 and 6th Jun 2017 and thereafter completed the preparatory works at the site i.e. facilities required for soil remediation trials and upgraded /repaired remediation equipments between 7th Jun 2017 to 14th Aug 2017.

Soil remediation trials started at the site from 16th Aug 2017. The trials undertaken during this three month period were as per the Detailed Project Report and the Design of Experiments submitted and approved by the Tamil Nadu Pollution Control Board. The trials were undertaken under the directions of TNPCB and also following the SEC recommendations. National Environmental Engineering Research Institute (NEERI) deputed a project associate during the remediation trials as per TNPCB monitoring framework to oversee the remediation trials being undertaken at the site. The Kodaikanal Municipality and Local Area Environment Committee were associated during the soil remediation trials undertaken at the site.

The trials were undertaken in two phases, with the first phase using non-contaminated soil to stabilize the remediation equipment and set the preliminary operating parameters, followed by contaminated soil trials in the second phase. The objectives of the soil remediation trials were to test the efficacy of the remediation equipment installed at the site and test the treatability of contaminated soils from the site.

The following sections provide the details of the uncontaminated soil trials undertaken between 16th Aug 2017 and 29th Sept 2017 and the subsequent contaminated soil trials undertaken between 4th Oct 2017 and 18th Nov 2017.

Uncontaminated soil trials:

- A meeting with the Local Area Environmental Committee (LAEC) and Local Government Body was held at the Kodaikanal Sub-Collector's office on 9th Jul During this meeting, HUL appraised the members of the status of permits received and the progress of work being undertaken at the site. Another meeting was held on 10th th Aug 2017 followed by factory visit. The site visit included a walkthrough with all the members showing them the contaminated areas, plans around excavation, the remediation equipment set up at the site and ancillary services made available at the site.
- Between 16th Aug 2017 and 29th Sep 2017, trials with uncontaminated soils were undertaken at the site. Soil from uncontaminated areas at the site (near the old

security shed area) were excavated and used as feed soil for the uncontaminated trials.

- Environmental monitoring data was displayed on the notice board at the factory gate for information to public and the same reports were also sent to the TNPCB.
- A total of twenty nine (29) batches of uncontaminated soil totaling 95 tons, were processed as part of the uncontaminated soil trials.
- Equipment performance related settings such as screen configuration, selection spray nozzle arrangement, material conveying, vibration of the sieves, filter press slurry pump selection etc. were tested and operational settings were determined .
- Operating parameters achieved:
  - Soil feed rate achieved : 1 ton per hour
  - Water wash rate optimized to 5.9 KL per ton of soil
- Sieve sizes evaluated: 25 mm, 10 mm, 6 mm, 3 mm, 2 mm, and 1 mm sieve sizes were chosen for further contaminated soil trials.
- The distribution of the uncontaminated soils over the various mesh size configurations are given in the tables presented in the Annexures to this report. On an average approximately 30% of the feed soil was generated into a slurry which was ultimately converted into a filter press cake which was then to be tested in the retort.

The data sheets for the uncontaminated soil trials are provided in **Annexure A1 and A2.**

Contaminated soil trials:

- The Local Area Environment Committee meeting was held on 14th Nov 2017 and included a site visit with the members.
- In addition, NEERI visited the site to review the soil washing and retort operations during the contaminated soil trials.
- SEC members also visited the site and reviewed the progress of the soil washing and retort operations on 9th, 10th and 11th Nov 2017.
- TNPCB officials visited the site routinely during the trials.
- A total of 70 batches of contaminated soils trials were undertaken as part of the contaminated soil trials.
- A total of 87 tons of mercury contaminated soils were subjected to soil washing trials with concentrations ranging between 8.0 and 1,010 mg/kg.
- Three batches had input mercury concentrations less than 20 mg/kg.
- Twenty seven batches had input mercury concentrations ranging between 20 and 100 mg/kg.
- Twenty four batches had input mercury concentrations ranging between 100 and 250 mg/kg.
- Sixteen batches had input mercury concentrations ranging between 250 and 1,010 mg/kg,
- During the trials, and based on the operating parameters from the uncontaminated soil trials, a single feed point with contaminated soils was fed into the system and 6 oversize fractions were subsequently collected. These oversize fractions

corresponded to 25 mm, 10mm, 6mm, 3mm, 2mm, and 1mm in most cases. Towards the end of the contaminated soil trials the mesh sizes were changed to obtain better separation at the various vibratory screens. The slurry of the 1mm undersize fraction was passed through a filter press to generate cakes.

- The trials were undertaken with different feed rate of soil ranging from 210 kg/hr. to 2,317 kg/hr. (average of 1,039 kg/hr.) and the water to soil ratio of 1 to 14 L/ Kg soil (average of 5.5 L/ kg).
- A total of 70 contaminated soil trials generated a slurry of fines with particle size less than 1 mm and enriched in the elemental mercury. This slurry was pumped into a filter press and generated 12 batches of filter press cakes, some of which was subsequently introduced into vacuum retort.
- The indicative soil washing process parameters established based on the contaminated soil washing trials were
    - ~ 1.23 tons/hr. feed rate for low to medium contaminated soils
    - ~5.5 KL of fresh water per ton of contaminated soils required
    - *A slower soil feed rate and higher wash rate would be required for higher* contaminated soils or soils requiring a second round of washing.
- 11 Retort trials were undertaken with the existing retort. .
- One retort trial on uncontaminated filter press cake, and 10 retort trials for contaminated filter press cake were undertaken.
- Environmental monitoring data was displayed on the notice board at the factory gate for information to public and the same reports were also sent to the TNPCB. Summary of environmental parameters on water and air is enclosed as **Annexures B1 to B2**

The data sheets for the contaminated soil trials are provided in **Annexures C1 to C6**

Analysis of Soil Remediation Trials:

Following the soil remediation trials, the data was analysed to help in interpreting the data and determine whether the objectives of the trials were met.
The soil washing data was split according to various concentrations bands and statistical analysis undertaken on the data generated during the analysis of samples at the on-site laboratory. Please refer to **Annexure D1** for the table that captures the mean, variance and standard deviation data for the various oversized soil washed fractions. A chart in **Annexure D2** is showing 3 examples of treated soil variation in mercury concentration.

Based on the detailed analysis, the following are the findings:

- For soils with concentrations less than 100 mg/kg: ~ 70% of the total soil will pass the 20 mg/kg remediation criteria.
- For soils with concentrations ranging between 100 and 250 mg/kg: ~ 50- to 60% of the total soil will pass the 20 mg/kg remediation criteria.

- Soils with Hg concentrations ranging between 100 and 250 mg/kg may require a second wash to achieve the 20 mg/kg remediation criteria
- It is estimated that 50 to 60% of the total contaminated soils at the site can be treated using soil washing and achieve the 20 mg/kg remediation criteria. The remaining soil with higher concentration may have to go for further treatment, like retorting or other processes to achieve the remediation standard.
- The principle of retorting has been demonstrated and desired result of remediation standard of 20 mg/kg was obtained in 2 batches. Through the learnings of the operation of the pilot retort unit at the plant, it is planned that a higher throughput retort will be designed and erected/commissioned at the site for the full scale remediation activities.

Meeting of SEC on 21 Nov 2017

The findings of the soil washing and retort trials were shared with the Tamil Nadu Pollution Control Board, Central Pollution control Board and Scientific Experts Committee Members on 21st Nov 2017 at the meeting in Chennai. Scientists from National Environment Engineering Research Institute and Indian Institute of Soil and Water Conservation were also present.

Based on the results of the soil remediation trials, the SEC members have asked HUL to submit an upscaling plan for the soil washing and retort remediation equipment. The improvement and upscaling plan taking into account the views and suggestions of NEERI and SEC, to ensure safety during operations and achieve the remediation standard of 20 mg/kg along with timeline and throughput will be submitted to SEC and TNPCB for soil remediation of the contaminated site at Kodaikanal.

Annexure - A 1

[illegible]
Uncontaminated Soil T[illegible]
Soil Washing - Process Parameters
16 August 2017 - 27 September 2017

Sr. No	Date	SW Ref. No.	*Input Soil - Weight	Soil Feed Rate (Kg/hr)	Water to Soil (L/Kg)
1	16-08-2017	SW-01	1350.00	338	5
2	18-08-2017	SW-02	1275.00	319	NA
3	19-08-2017	SW-03	2415.00	604	NA
4	21-08-2017	SW-04	1181.00	295	NA
5	22-08-2017	SW-05	1478.00	370	NA
6	23-08-2017	SW-06	375.00	375	16
7	24-08-2017	SW-07	450.00	450	3
8	26-08-2017	SW-07	630.00	630	NA
9	29-08-2017	SW-08	578.00	578	NA
10	30-08-2017	SW-09	1215.00	304	NA
11	31-08-2017	SW-10	1688.00	422	NA
12	01-09-2017	SW-11	900.00	225	NA
13	02-09-2017	SW-11	338.00	338	NA
14	04-09-2017	SW-12	2813.00	703	NA
15	05-09-2017	SW-13	4500.00	1125	NA
16	06-09-2017	SW-14	4500.00	1125	10
17	07-09-2017	SW-15	4500.00	1125	8
18	08-09-2017	SW-16	5558.00	1390	5
19	09-09-2017	SW-17	6300.00	1575	4
20	11-09-2017	SW-18	6300.00	1575	3
21	12-09-2017	SW-19	3938.00	985	4
22	13-09-2017	SW-20	6075.00	1519	5
23	14-09-2017	SW-21	6075.00	1519	3
24	15-09-2017	SW-22	5850.00	1463	4
25	16-09-2017	SW-23	3255.00	814	5
26	18-09-2017	SW-24	2949.00	737	4
27	19-09-2017	SW-25	6038.00	1510	3
28*	23-09-2017	SW-26	2700.00	675	4
29*	25-09-2017	SW-27	3360.00	840	10
30**	26-09-2017	SW-28	3300.00	825	9
31**	29-09-2017	SW-29	2783.00	696	4
Average			3053.77	821	5.88

Note:
All weights are in Kg
All weights are normalized to 25% mositure contenct
Soil washing screen mesh configration was 25, 10, 6, 3, 2, and 1 mm
Output 1 is sum of oversize from 25 and 10 mm screens
* Soil washing screen mesh configration was 25, 10, 6, 2, 2, and 1 mm
**Soil washing screen mesh configration was 25, 10,3, 2, 2, and 1 mm
NA - Data not available

Annexure – A 2

Soil Washing - Weight Distribution
16 August 2017 - 29 September 2017

Sr. No	Date	SW Ref. No.	Input Soil - Weight	Feed Oversize - HVS&Feed Oversize	VS-1 Oversize - Output 3	VS-2 Oversize - Output 4	VS-3 Oversize - Output 5	VS-4 Oversize - Output 6
1	16-08-2017	SW-01	1350.00	278.00	38.00	525.00	8.00	8.00
2	18-08-2017	SW-02	1275.00	548.00	53.00	203.00	8.00	11.00
3	19-08-2017	SW-03	2415.00	863.00	143.00	1013.00	38.00	53.00
4	21-08-2017	SW-04	1181.00	555.00	30.00	255.00	45.00	45.00
5	22-08-2017	SW-05	1478.00	683.00	210.00	353.00	15.00	23.00
6	23-08-2017	SW-06	375.00	225.00	105.00	23.00	1.00	1.00
7	24-08-2017	SW-07	450.00	300.00	30.00	75.00	4.00	4.00
8	26-08-2017	SW-07	630.00	263.00	30.00	150.00	8.00	8.00
9	29-08-2017	SW-08	578.00	360.00	53.00	38.00	45.00	83.00
10	30-08-2017	SW-09	1215.00	525.00	150.00	420.00	225.00	128.00
11	31-08-2017	SW-10	1688.00	450.00	188.00	405.00	113.00	113.00
12	01-09-2017	SW-11	900.00	128.00	113.00	165.00	113.00	218.00
13	02-09-2017	SW-11	338.00	90.00	38.00	158.00	15.00	0.00
14	04-09-2017	SW-12	2813.00	495.00	113.00	960.00	263.00	120.00
15	05-09-2017	SW-13	4500.00	750.00	188.00	1800.00	131.00	120.00
16	06-09-2017	SW-14	4500.00	563.00	720.00	1560.00	263.00	120.00
17	07-09-2017	SW-15	4500.00	638.00	168.00	1440.00	131.00	79.00
18	08-09-2017	SW-16	5558.00	834.00	120.00	1800.00	53.00	79.00
19	09-09-2017	SW-17	6300.00	1020.00	195.00	1515.00	120.00	60.00
20	11-09-2017	SW-18	6300.00	960.00	188.00	1965.00	135.00	135.00
21	12-09-2017	SW-19	3938.00	758.00	128.00	1403.00	128.00	128.00
22	13-09-2017	SW-20	6075.00	1313.00	210.00	2805.00	135.00	135.00
23	14-09-2017	SW-21	6075.00	1313.00	203.00	2295.00	150.00	150.00
24	15-09-2017	SW-22	5850.00	1200.00	203.00	2295.00	150.00	150.00
25	16-09-2017	SW-23	3255.00	720.00	113.00	1275.00	113.00	113.00
26	18-09-2017	SW-24	2949.00	480.00	90.00	765.00	90.00	90.00
27	19-09-2017	SW-25	6038.00	1305.00	225.00	2040.00	135.00	135.00
28	23-09-2017	SW-26	2700.00	518.00	90.00	540.00	338.00	53.00
29	25-09-2017	SW-27	3360.00	563.00	90.00	525.00	675.00	60.00
30	26-09-2017	SW-28	3300.00	480.00	105.00	510.00	750.00	90.00
31	29-09-2017	SW-29	2783.00	450.00	675.00	698.00	38.00	38.00
			94667.00 Total	21%	5%	32%	5%	3%

Note:
All weights are in Kg
All weights are normalized to 25% mositure contenct
Soil washing screen mesh configration was 25, 10, 6, 3, 2, and 1 mm
Output 1 is sum of oversize from 25 and 10 mm screens
* Soil washing screen mesh configration was 25, 10, 6, 2, 2, and 1 mm
**Soil washing screen mesh configration was 25, 10,3, 2, 2, and 1 mm

Annexure – B 1

Environmental Parameters Monitoring (Air)

Location	No of Obs	Mean Value (mg/m3)	Min Value (mg/m3)	Max Value (mg/m3)	Std Dev
Fence line & Continuous	3,070	BDL	BDL	BDL	-
Excavation area	240	0.002	BDL	0.067	0.009
Soil Wash Area	1317	0.007	BDL	0.100	0.007
Retort Room	1,032	0.007	BDL	0.031	0.004
Air Handling Units	2,742	0.002	BDL	0.067	0.004
Laboratory	563	0.001	BDL	0.013	0.002
Other Work areas	1458	BDL	BDL	BDL	-

Trigger Limit- 0.01 mg/m3
PPE upgrade- 0.025 mg/m3
Stop Work- 0.05 mg/m3
BDL- Below Instrument Detection Limit

Environmental Parameters Monitoring (Water)

Stream	Inlet		Outlet	
	No of Observations	Avg concentration (ug/L)	No of Observations	Avg Concentration (ug/L)
Process Water	49	90.3	54	1.9
Grey Water	30	1.73	27	0.09
STP Water	25	0.12	-	-
Well Water	5	BDL	-	-
Tanker Water	19	BDL	-	-

Discharge Limit is 10 ug/L

BDL- Below Laboratory Detection Limit

Annexure – C 1

HUL Kodaikanal
Contaminated Soil Trials
Soil Washing - Process Parameters
04 October 2017 - 18 November 2017

Sr. No	Date	SW Ref. No.	Input Soil Weight	Soil Feed Rate (Kg/hr)	Water to Soil Ratio
	04-10-2017	SW-01	3603.50	667.00	
2	05-10-2017	SW-02	2014.25	760.00	2
3	06-10-2017	SW-03	1824.00	667	2
4	07-10-2017	SW-04	1600.25	333	2
5	10-10-2017	SW-05	1433.75	650	5
6	12-10-2017	SW-06	1968.20	210	
7	14-10-2017	SW-07	1859.96	731	11
8	14-10-2017	SW-08	1151.87	477	8
9	21-10-2017	SW-09	1593.42	540	6
10	21-10-2017	SW-10	1667.79	477	5
11	22-10-2017	SW-11	1888.20	384	7
12	23-10-2017	SW-12	1002.82	486	4
13	24-10-2017	SW-13	809.31	600	14
14	24-10-2017	SW-14	989.10	576	6
15	24-10-2017	SW-15	1036.94	903	10
16	14-10-2017	SW-16	1335.09	1462	4
17	26-10-2017	SW-17	932.21	480	4
18	27-10-2017	SW-18	794.16	340	12
19	27-10-2017	SW-19	669.81	1324	12
20	27-10-2017	SW-20	921.34	595	7
21	28-10-2017	SW-21	1083.28	385	8
22	28-10-2017	SW-22	1029.71	520	7
23	30-10-2017	SW-23	946.53	976	11
24	30-10-2017	SW-24	876.81	281	8
25	31-10-2017	SW-25	1122.00	281	13
26	01-11-2017	SW-26	948.07	518	14
27	02-11-2017	SW-27	920.32	994	10
28	03-11-2017	SW-28	909.07	488	11
29	03-11-2017	SW-29	784.88	660	6
30	03-11-2017	SW-30	817.80	700	8
31	04-11-2017	SW-31	1008.98	896	5
32	07-11-2017	SW-31R	2444.44	2317	4
33	01-11-2017	SW-32	1256.31	1015	5
34	07-11-2017	SW-32R	1285.73	1755	3
35	06-11-2017	SW-33	1107.35	1176	5
36	07-11-2017	SW-33F	1131.46	1176	4
37	06-11-2017	SW-34	1163.84	1280	5
38	08-11-2017	SW-34R	1453.60	1600	4
39	06-11-2017	SW-35	1500.00	1600	4
40	06-11-2017	SW 36	1024.13	1147	4
41	06-11-2017	SW 37	801.23	900	2
42	09-11-2017	SW-38	1149.34	1302	3
43	09-11-2017	SW-39	1549.18	2219	3
44	09-11-2017	SW-40	1614.17	1728	4
45	07-11-2017	SW-41	991.28	1717	4
46	08-11-2017	SW-42	1189.94	1344	5
47	10-11-2017	SW-43	911.77	980	4
48	11-11-2017	SW-44	865.38	1363	5
49	11-11-2017	SW-45	1022.65	1605	3
50	11-11-2017	SW-46	962.98	1443	4
51	11-11-2017	SW-47	1170.54	1729	3
52	13-11-2017	SW-48	1242.70	1360	3
53	13-11-2017	SW-49	1245.78	1833	3
54	13-11-2017	SW-50	1209.29	1387	4
55	13-11-2017	SW-51	1169.97	1831	2
56	14-11-2017	SW-52	1122.35	1260	5
57	15-11-2017	SW-53	1179.79	1277	5
58	15-11-2017	SW-54	870.98	1050	6
59	16-11-2017	SW-55	1168.87	651	4
60	16-11-2017	SW-56	1285.19	1872	4
61	16-11-2017	SW-57	958.99	1032	5
62	17-11-2017	SW-58	1199.12	1296	5
63	17-11-2017	SW-59	969.84	1080	6
64	17-11-2017	SW-60	1216.86	1360	4
65	18-11-2017	SW-61	1167.74	638	4
66	18-11-2017	SW-62	1505.78	2220	3
67	18-11-2017	SW-63	1560.03	1662	4
68	18-11-2017	SW-07RW	1062.95	1319	3
69	18-11-2017	SW-40RW	770.00	616	
70	02-11-2017	SW-61 (SW-9 rewash)	1027.69	562	8
Average			1232.52	1039.47	5.45

Note:
All weights are in Kg
Soil washing screen mesh configration from 04/10/17 to 03/11/17 was 25, 10, 6, 3, 2, and 1 mm
Soil washing screen mesh configration from 04/11/17 to 18/11/17 was 25, 10, 5, 3, and 1 mm
VS-3 data is unavialable for soil washing trials post 04/11/17 as the screen was kept blank

HUL Kodaikanal
Contaminated Soil Trials
Soil Washing - Weight Distribution
04 October 2017 - 18 November 2017

Sr. No.	Date	SW Ref. No.	Input Soil - Weight	Fines Overflow - Output 1	HVS Oversize - Output 2	VS-1 Oversize - Output 3	VS-2 Oversize - Output 4	VS-3 Oversize - Output 5	VS-4 Oversize - Output 6
1	04-10-2017	SW-01	3603.50	745.02	768.27	952.71	640.28	8.47	6.98
	05-10-2017	SW-02	2014.25	39.08	628.33	39.03	707.49	0.00	281.67
3	06-10-2017	SW-03	1844.00	469.22	683.35	47.34	475.95	0.00	[illegible]
4	07-10-2017	SW-04	1600.75	130.92	224.83	40.23	324.47	20.05	[illegible]
5	10-10-2017	SW-05	1433.75	63.87	470.28	41.60	474.91	0.57	[illegible]
6	12-10-2017	SW-06	1968.20	247.18	710.15	57.11	437.73	10.76	[illegible]
7	14-10-2017	SW-07	1859.94	190.03	400.06	23.75	[illegible]	1.00	460.12
8	14-10-2017	SW-08	1151.87	[illegible]	99.85	14.18	155.59	21.78	216.40
9	21-10-2017	SW-09	1593.42	17.44	181.48	37.77	400.21	22.60	308.13
10	21-10-2017	SW-10	1667.79	79.84	328.51	41.73	406.45	0.68	258.69
11	22-10-2017	SW-11	1888.20	220.64	320.98	61.75	611.75	18.71	308.01
12	23-10-2017	SW-12	1002.82	104.83	233.37	50.77	355.68	0.53	78.93
13	24-10-2017	SW-13	809.31	68.13	195.38	48.65	269.11	0.89	271.36
14	24-10-2017	SW-14	939.10	85.01	179.27	132.43	151.12	0.92	133.01
15	24-10-2017	SW-15	1036.94	50.06	216.40	98.33	258.33	1.04	192.11
16	14-10-2017	SW-16	1335.09	81.76	134.70	20.81	146.45	0.88	100.98
17	26-10-2017	SW-17	972.21	117.91	137.58	8.73	118.30	0.91	147.44
18	27-10-2017	SW-18	794.16	48.53	104.92	25.51	170.98	0.85	191.43
19	27-10-2017	SW-19	869.81	112.32	134.36	13.41	107.76	0.92	[illegible]
20	27-10-2017	SW-20	921.34	33.18	122.78	13.26	145.08	0.83	0.81
21	26-10-2017	SW-21	1085.28	7.12	91.43	25.56	173.66	8.68	150.22
22	28-10-2017	SW-22	1029.71	1.08	82.25	35.39	128.95	1.07	[illegible]
23	30-10-2017	SW-23	946.53	11.05	85.64	22.21	159.12	0.94	241.88
24	30-10-2017	SW-24	876.81	9.34	75.02	42.24	43.06	11.34	219.97
25	31-10-2017	SW-25	1122.00	17.00	95.00	15.00	134.00	1.00	224.00
26	01-11-2017	SW-26	948.07	9.81	111.61	18.47	153.25	9.89	192.96
27	02-11-2017	SW-27	920.32	12.66	117.33	17.90	143.78	11.88	234.83
28	03-11-2017	SW-28	909.07	143.14	160.74	32.44	145.58	16.21	165.07
29	01-11-2017	SW-29	784.80	19.32	168.91	42.09	145.87	15.33	122.26
30	03-11-2017	SW-30	817.80	12.53	186.36	32.52	155.72	6.94	97.84
31	04-11-2017	SW-31	1008.98	32.31	191.90	38.28	244.18	18.76	191.84
32	07-11-2017	SW-31R	2444.44	96.88	609.03	86.54	303.97	0.00	318.90
33	04-11-2017	SW-32	1254.31	23.67	191.77	18.71	199.47	11.55	83.21
34	07-11-2017	SW-32R	[illegible]	26.31	256.00	334.16	124.45	0.00	162.51
35	06-11-2017	SW-33	1107.35	4.36	185.65	54.15	111.64	0.00	38.22
36	07-11-2017	SW-33R	1131.46	51.85	331.07	377.90	229.38	0.00	107.51
37	06-11-2017	SW-34	1163.84	84.15	374.16	214.88	312.47	0.00	402.48
38	08-11-2017	SW-34R	[illegible]	148.44	233.75	134.17	122.66	0.00	221.94
39	06-11-2017	SW-35	1500.00	86.95	317.31	61.66	126.95	0.00	154.25
40	[illegible]-11-2017	SW-36	1024.13	30.27	257.29	123.44	291.14	0.00	159.42
41	06-11-2017	SW-37	901.23	105.17	213.57	49.98	131.11	0.00	123.35
42	09-11-2017	SW-38	1149.34	153.43	243.40	65.25	104.91	0.00	125.32
43	09-11-2017	SW-39	[illegible]	111.88	215.11	73.81	151.73	0.00	186.94
44	09-11-2017	SW-40	1614.37	41.81	250.87	54.03	141.97	0.00	141.61
45	07-11-2017	SW-41	991.28	17.34	126.23	250.14	113.17	0.00	124.91
46	08-11-2017	SW-42	1189.94	37.94	139.99	37.00	98.16	0.00	153.94
47	10-11-2017	SW-43	911.77	51.04	208.83	[illegible]	139.78	0.00	155.84
48	11-11-2017	SW-44	865.38	64.22	126.77	34.23	142.28	0.00	152.26
49	11-11-2017	SW-45	1022.65	115.36	161.36	37.60	111.19	0.00	101.78
50	11-11-2017	SW-46	962.98	65.65	233.22	79.59	146.77	0.00	146.43
51	11-11-2017	SW-47	1170.54	39.19	138.54	49.76	208.39	0.00	133.26
52	13-11-2017	SW-48	1242.70	42.43	81.27	83.05	236.85	0.00	21.10
53	13-11-2017	SW 49	1246.78	57.10	248.72	105.38	301.38	0.00	22.39
54	13-11-2017	SW-50	[illegible]	31.69	189.94	65.71	238.77	0.00	112.24
55	13-11-2017	SW-51	1169.97	41.61	[illegible]	67.46	[illegible]	0.00	[illegible]
56	14-11-2017	SW-52	[illegible]	61.63	184.93	84.08	320.29	0.00	106.41
57	15-11-2017	SW 53	1178.79	48.02	174.17	87.12	326.82	0.00	71.59
58	15-11-2017	SW-54	870.98	46.32	143.54	63.87	186.70	0.00	60.59
59	16-11-2017	SW-55	1168.87	88.14	243.71	67.01	175.55	0.00	202.51
60	16-11-2017	SW-56	1285.19	69.46	190.32	17.84	165.55	0.00	199.49
61	16-11-2017	SW-57	[illegible]	61.94	141.78	22.00	124.57	0.00	121.95
62	17-11-2017	SW-58	1199.12	53.67	176.38	132.38	210.89	0.00	317.79
63	17-11-2017	SW-59	969.84	49.52	128.29	80.99	175.68	0.00	172.06
64	17-11-2017	SW-60	1216.86	93.31	208.54	98.44	223.05	0.00	222.09
65	18-11-2017	SW-61	1167.74	65.02	204.03	77.51	100.43	0.00	208.34
66	18-11-2017	SW-62	1505.78	261.16	314.32	72.24	203.35	0.00	246.93
67	18-11-2017	SW-63	1560.83	227.38	339.61	100.94	256.88	0.00	366.76
68	18-11-2017	SW-07RW	1062.95	149.35	276.30	73.46	255.65	0.00	173.87
69	18-11-2017	SW-40RW	770.00	38.87	0.00	42.41	35.96	0.00	26.60
70	02-11-2017	SW-61 (SW-9 rewash)	1027.69	12.50	157.58	18.55	319.81	26.84	334.59
		Total	86276.42	7%	19%	7%	18%	0%	15%

Note
All weights are in Kg
All weights are normalized to 25% mositure content
Soil washing screen mesh configration from 04/10/17 to 03/11/17 was 25, 10, 6, 3, 2, and 1 mm
Soil washing screen mesh configration from 04/11/17 to 18/11/17 was 25, 10, 5, 3, and 1 mm
VS-3 data is unavialable for soil washing trials post 04/11/17 as the screen was kept blank

Annexure – C 3

HUL Kodaikanal
Contaminated Soil Trials
Soil Washing - Mercury Concentration Distribution
04 October 2017 - 18 November 2017

Sl. No.	Date	SW Ref. No	Input Soil - Hg Conc.	Total Oversize Output 1	HVS Oversize Output 2	VS-1 Oversize Output 3	VS-2 Oversize Output 4	VS-3 Oversize Output 5	VS-4 Oversize Output 6
1	04-10-2017	SW-01	49.09	11.92	10.39	10.85	16.98	3.74	8.40
2	05-10-2017	SW-02	8.05	0.47	1.38	3.32	3.73	0.00	2.74
3	06-10-2017	SW-03	659.56	219.41	576.05	22.45	237.26	0.00	207.59
	07-10-2017	SW-04	138.94	84.17	20.99	11.11	62.99	14.69	58.97
5	10-10-2017	SW-05	44.92	47.12	6.86	9.98	16.66	37.27	32.72
6	12-10-2017	SW-06	427.15	110.19	46.77	20.51	84.76	65.67	108.20
7	14-10-2017	SW-07	1009.79	352.67	142.06	125.12	183.58	206.13	206.01
8	14-10-2017	SW-08	227.38	36.51	62.32	22.97	28.93	61.29	41.69
9	21-10-2017	SW-09	228.78	57.98	28.87	16.15	47.40	44.15	65.65
10	21-10-2017	SW-10	69.35	21.23	13.82	5.99	11.56	15.23	21.96
11	22-10-2017	SW-11	17.21	2.47	4.28	3.15	7.36	0.54	8.28
12	23-10-2017	SW-12	44.07	2.82	3.69	0.84	3.62	3.80	4.99
13	24-10-2017	SW-13	36.99	13.85	5.60	0.60	1.10	14.64	4.53
14	24-10-2017	SW-14	29.27	29.59	4.04	0.83	1.27	1.63	4.90
15	24-10-2017	SW-15	19.61	22.93	2.74	0.61	0.65	1.85	2.88
16	14-10-2017	SW-16	245.47	25.16	32.63	11.31	45.28	56.49	46.79
17	26-10-2017	SW-17	84.01	3.93	11.20	17.72	13.52	17.49	23.78
18	27-10-2017	SW-18	47.44	9.68	5.43	15.8	7.65	12.9	14.55
19	27-10-2017	SW-19	43.24	57.33	9.16	7.58	8.86	7.52	15.18
20	27-10-2017	SW-20	111.03	115.17	17.78	14.87	15.97	19.2	25.33
21	28-10-2017	SW-21	173.68	5.34	47.40	53.85	24.97	30.07	47.36
22	28-10-2017	SW-22	137.53	9.24	32.46	68.55	25.46	20.86	34.70
23	30-10-2017	SW-23	151.54	4.44	40.38	42.91	19.64	23.00	32.16
24	30-10-2017	SW-24	171.94	6.31	37.56	63.82	36.92	30.11	37.73
25	31-10-2017	SW-25	165.12	7.06	23.65	16.87	22.63	21.18	24.53
26	01-11-2017	SW-26	162.57	1.52	17.79	29.75	27.99	23.82	35.67
27	02-11-2017	SW-27	218.12	91.95	20.48	26.74	21.63	25.69	38.31
28	03-11-2017	SW-28	61.02	3.58	12.11	6.27	11.04	15.10	23.44
29	03-11-2017	SW-29	53.22	6.30	15.77	4.79	4.18	6.21	15.86
30	03-11-2017	SW-30	46.77	6.72	10.50	2.15	3.34	4.65	11.05
31	04-11-2017	SW-31	31.56	2.78	8.46	2.23	1.70	3.26	6.61
32	07-11-2017	SW-31R	351.70	21.02	21.33	8.37	16.06	-	34.15
33	04-11-2017	SW-32	37.59	2.22	13.52	3.69	4.26	2.99	23.21
34	07-11-2017	SW-32R	319.80	2.18	20.02	15.86	42.73	-	61.70
35	06-11-2017	SW-33	23.43	4.04	4.97	7.65	4.06	-	5.82
36	07-11-2017	SW-33R	302.10	32.75	16.69	11.38	26.84	-	47.40
37	06-11-2017	SW-34	37.38	0.64	5.54	4.18	3.12	-	5.65
38	08-11-2017	SW-34R	283.20	79.80	40.45	34.08	64.54	-	70.35
39	06-11-2017	SW-35	47.12	12.88	14.80	16.73	5.12	-	6.86
40	06-11-2017	SW-36	89.76	10.03	14.40	5.03	5.79	-	13.64
41	06-11-2017	SW-37	50.86	6.89	8.70	2.21	6.77	-	9.28
42	09-11-2017	SW-38	211.71	20.36	43.21	19.47	46.58	-	75.78
43	09-11-2017	SW-39	267.20	3.66	67.49	46.71	43.09	-	71.88
44	09-11-2017	SW-40	592.30	252.20	67.97	44.62	201.00	-	115.60
45	07-11-2017	SW-41	416.33	11.10	61.25	28.55	51.49	-	73.80
46	08-11-2017	SW-42	833.80	41.96	132.50	51.50	74.60	-	137.70
47	10-11-2017	SW-43	444.95	2.24	105.94	43.02	23.78	-	61.78
48	11-11-2017	SW-44	141.06	59.95	49.68	15.33	49.01	-	59.80
49	11-11-2017	SW-45	145.70	11.44	82.09	31.54	28.08	-	40.84
50	11-11-2017	SW-46	217.84	14.59	56.79	28.73	22.13	-	47.21
51	11-11-2017	SW-47	227.68	7.47	61.21	41.30	32.64	-	106.06
52	13-11-2017	SW-48	160.11	68.82	58.55	10.81	13.21	-	72.81
53	13-11-2017	SW-49	189.22	2.73	60.34	20.83	28.18	-	35.84
54	13-11-2017	SW-50	38.37	3.93	7.50	3.28	11.19	-	18.56
55	13-11-2017	SW-51	152.25	8.64	36.19	36.31	23.09	-	39.09
56	14-11-2017	SW-52	63.97	36.51	23.44	5.03	23.73	-	17.19
57	15-11-2017	SW-53	80.52	4.26	13.55	4.18	20.99	-	66.18
58	15-11-2017	SW-54	93.93	15.15	17.31	5.59	16.80	-	48.64
59	16-11-2017	SW-55	300.50	66.66	52.79	17.64	35.69	-	38.56
60	16-11-2017	SW-56	313.20	1.49	25.01	27.75	23.22	-	45.05
61	16-11-2017	SW-57	114.98	5.23	3.21	8.53	4.30	-	11.96
62	17-11-2017	SW-58	84.84	2.93	16.80	2.30	18.44	-	19.94
63	17-11-2017	SW-59	79.51	3.45	9.16	3.50	14.64	-	16.35
64	17-11-2017	SW-60	102.47	2.09	3.07	7.67	13.16	-	14.99
65	18-11-2017	SW-61	96.32	1.04	9.39	9.61	23.20	-	11.70
66	18-11-2017	SW-62	122.39	0.81	6.05	11.58	9.17	-	10.94
67	18-11-2017	SW-63	97.48	3.36	10.79	7.44	23.48	-	18.22
68	18-11-2017	SW-07RW	1009.79	26.66	23.41	36.41	45.25	-	31.45
69	18-11-2017	SW-40RW	592.58	9.78	-	41.24	35.56	-	30.25
70	02-11-2017	W-61 (SW-9 rewash	228.78	10.55	20.88	16.50	10.43	15.98	39.36

Note:
All mercury concentrations are in mg/Kg
Soil washing screen mesh configrat.on from 04/10/17 to 03/11/17 was 25, 10, 6, 3, 2, and 1 mm
Soil washing screen mesh configration from 04/11/17 to 18/11/17 was 25, 10, 5, 3, and 1 mm
VS-3 data is unavialable for soil washing trials post 04/11/17 as the screen was kept blank

Annexure – C 4

Soil Air Washing - Mercury Concentration Distribution (Screened)
04 October 2017 - 18 November 2017

Sr. No	Date	SW Ref. No.	Input Soil - Hg Conc.	Feed Oversize - Output 1	HVS Oversize - Output 2	VS-1 Oversize - Output 3	VS-2 Oversize - Output 4	VS-3 Oversize - Output 5	VS-4 Oversize - Output 6
1	14-10-2017	SW-07	1009.79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	18-11-2017	SW-07RW		[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
2	09-11-2017	SW-40	592.30	[illegible]	67.97	[illegible]	[illegible]	-	[illegible]
	18-11-2017	SW-40RW		[illegible]	-	[illegible]	[illegible]	-	[illegible]
3	21-10-2017	SW-09	228.78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	02-11-2017	SW-61 (SW-9 rewash)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note:
All mercury concentrations are in mg/Kg
Soil washing screen mesh configration from 04/10/17 to 03/11/17 was 25, 10, 6, 3, 2, and 1 mm
Soil washing screen mesh configration from 04/11/17 to 18/11/17 was 25, 10, 5, 3, and 1 mm
VS-3 data is unavialable for soil washling trials post 04/11/17 as the screen was kept blank

Annexure – C 5

Contaminated Soil Trials

Retort - Filter Press Results Summary

04 October 2017 - 18 November 2017

Date	Batch	Hg Concentration (mg/Kg)	Moisture (%)	Weight (Kg)	Remarks
11/10/2017	FP-01	278.5	60.33%	3322	FP-01 is consolidated for soil washing batches SW-01 through SW-05
16/101/7	FP-02	393.04	51.86%	2765	FP-02 is consolidated for soil washing batches SW-06 through SW-07
23/101/7	FP-03	325.16	59.45%	2276	FP-03 is consolidated for soil washing batches SW-09 through SW-11
26/10/17	FP-04	99.63	44.38%	2281	FP-04 is consolidated for soil washing batches SW-12 through SW-15
28/10/17	FP-05	155.98	47.20%	2385	FP-05 is consolidated for soil washing batches SW-08, SW-16 through SW-17
1/11/2017	FP-06	191.35	47.64%	2385	FP-06 is consolidated for soil washing batches SW-18 through SW-25
6/11/2017	FP-07	146.28	40.12%	3101	FP-07 is consolidated for soil washing batches SW-26 through SW-32 & SW-61R
8/11/2017	FP-08	92.65	40.54%	2635	FP-06 is consolidated for soil washing batches SW-33 through SW-41
10/11/2017	FP-09	488.66	47.04%	2606	FP-09 is consolidated for soil washing batches SW-34R, 38, 39, 40 and 42
14/11/17	FP-10	379.24	44.58%	3076	FP-10 is consolidated for soil washing batches SW-43 to 51
16/11/17	FP-11	179.59	45.24%	2968	FP-11 is consolidated for soil washing batches SW-51 to 55
18/11/17	FP-12	283.65	46.77%	2526	FP-12 is consolidated for soil washing batches SW-56 to 63, 07RW&40RW

Annexure – C 6

Date	Batch	Input Hg (mg/Kg)	Input Moisture (%)	Output Hg (mg/Kg)	Output Moisture (%)	Input Weight (Kg)	Remarks
1/11/2017	RT-01						RT-01 is Uncontaminated Soil Trial. batches RT-02 through RT-11 are contaminated soil trials
2/11/2017	RT-02	146	29.30%	28.5	2.79%	100	Max Set Point = 300°C, Operation Time = 30 min. Operating Vacuum at 90mm Hg at the Condenser
6/11/2017	RT-03	133.5	29.50%	26.1	6.60%	73	Max Set Point = 300°C, Operation Time = 30 min. Operating Vacuum at 80mm Hg at the Condenser
7/11/2017	RT-04	184.5	41.30%	38	3.60%	87	Max Set Point = 300°C, Operation Time = 30min. Operating Vacuum at 100mm Hg at the Condenser
8/11/2017	RT-05	108	23.00%	27.9	0.60%	75	Max Set Point = 300°C, Operation Time = 30min. Operating Vacuum at 90mm Hg at the Condenser
9/11/2017	RT-06	139	31.70%	25.5	1.20%	75	Max Set Point = 300°C, Operation Time = 30min. Operating Vacuum at 90mm Hg at the Condenser
10/11/2017	RT-07	269	24.40%	79.1	2.20%	75	Max Set Point = 300°C, Operation Time = 30min. Operating Vacuum at 80mm Hg at the Condenser
11/11/2017	RT-08	252.5	33.10%	12.9	6.00%	80	Max Set Point = 350°C, Operation Time = 30min. Operating Vacuum at 80mm Hg at the Condenser
13/11/2017	RT-09	163.5	29.00%	7.3	30.00%	75	Max Set Point = 350°C, Heaters Off after 1 hr. after reaching set point temperature. Operating Vacuum at 80mm Hg at the Condenser
14/11/2017	RT-10	269	24.40%	34	2.50%	75	Max Set Point = 325°C, Heaters Off after 1.25 hr. after reaching set point temperature. Operating Vacuum at 100mm Hg at the Condenser
15/11/2017	RT-11	262.1	29.90%	53.3	5.50%	100	Max Set Point = 350°C, Heaters Off after 1.5 hr. after reaching set point temperature. Operating Vacuum at 100mm Hg at the Condenser

Note:
Filter press cake was dehumidified and then used as feed for retort bacthes

Annexure – D 1

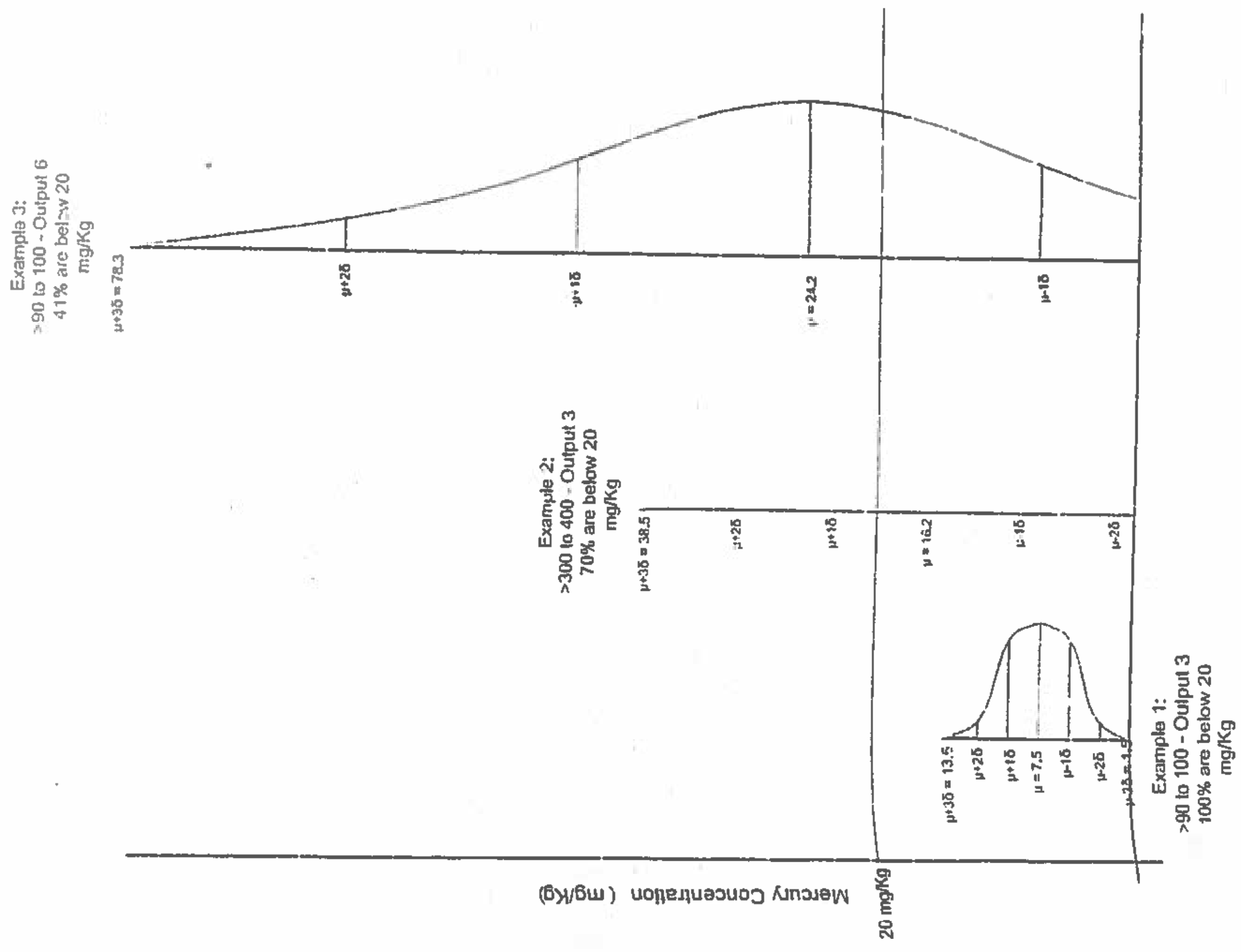
HUL Kodaikanal
Contaminated Soil Trials
Soil Washing - Mercury Concentration Distribution Statistical Summary
04 October 2017 - 18 November 2017

ANALYSIS OF SOIL WASHING TRIAL RESULTS

Mercury concentration mg/kg	Number of batches of trials	Description	Input	Output1	Output2	Output3	Output4	Output5	Output6
20 to 30	2	Mean, SD 3 sigma limits	26.4, 4.0 14.3, 38.4	16.8, 18.1 0, 71.0	[illegible]	4.2, 4.8 0, 18.7	2.5, 1.7 0, 7.6	1.6, NA NA, NA	[illegible]
>30 to 40	5	Mean, SD 3 sigma limits	36.5, 4.7 22.6, 50.5	4.7, 5.3 0, 20.5	7.4, 4.7 0, 21.4	[illegible] 0, 9.3	[illegible]	7.0, 6.6 0, 26.9	8.8, 7.0 0, 29.9
>40 to 50	7	Mean, SD 3 sigma limits	47.2, 10 17.2, 77.2	15.5, 15.7 0, 62.6	9.1, 5.2 0, 24.8	10.2, 5.5 0, 26.9	11.6, 8.1 0, 35.9	11.7, 13.0 0, 50.7	16.8, 10.5 0, 49.5
>50 to 60	2	Mean, SD 3 sigma limits	51.9, 8.5 26.3, 77.5	11.6, 7.5 0, 34.1	11.5, 9.0 0, 38.7	[illegible]	[illegible]	6.2, NA NA, NA	13.7, 3.8 2.2, 25.1
>60 to 70	3	Mean, SD 3 sigma limits	64.9, 17.5 12.4, 117.5	16.2, 15.9 0, 63.9	14.6, 5.1 0, 29.9	[illegible]	13.0, 4.5 0, 27.4	[illegible]	[illegible]
>70 to 80	1	Mean, SD 3 sigma limits	79.5, 9.3 51.6, 107.4	3.5, NA NA, NA	8.2, NA NA, NA	3.5, NA NA, NA	14.6, NA NA, NA	NA, NA NA, NA	16.3, NA NA, NA
>80 to 90		Mean, SD 3 sigma limits	84.7, 24.7 10.7, 158.7	[illegible]	13.8, 5.6 0, 30.5	6.9, 6.5 0, 26.3	12.0, 6.6 0, 31.7	17.5, NA NA, NA	[illegible]
>90 to 100	3	Mean, SD 3 sigma limits	95.9, 11.1 62.5, 129.3	6.5, 7.6 0, 29.2	12.1, 4.6 0, 25.8	[illegible]	[illegible]	NA, NA NA, NA	[illegible]
>100 to 200	16	Mean, SD 3 sigma limits	153.7, 25.3 77.9, 229.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
>200 to 300	10	Mean, SD 3 sigma limits	223.1, 92.2 0, 499.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
>300 to 400	5	Mean, SD 3 sigma limits	320.5, 92.1 44.3, 596.8	[illegible]	[illegible]	16.2, 7.4 0, 38.5	[illegible]	NA, NA NA, NA	[illegible]
>400 to 500	3	Mean, SD 3 sigma limits	428.4, 38.5 312.9, 543.9	[illegible]	[illegible]	[illegible]	[illegible]	NA, NA NA, NA	[illegible]
>500 to 1100	6	Mean, SD 3 sigma limits	786.7, 260.1 6.3, 1567.1	[illegible]	[illegible]	[illegible]	[illegible]	206.1, NA NA, NA	[illegible]
Total Batches	67								

Annexure -- D 2

Analysis of Soil Washing Results- Treated Soil variation in Hg concentration



Annexure 3: Equipment decontamination protocol

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^{0}C. 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 overal's
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.

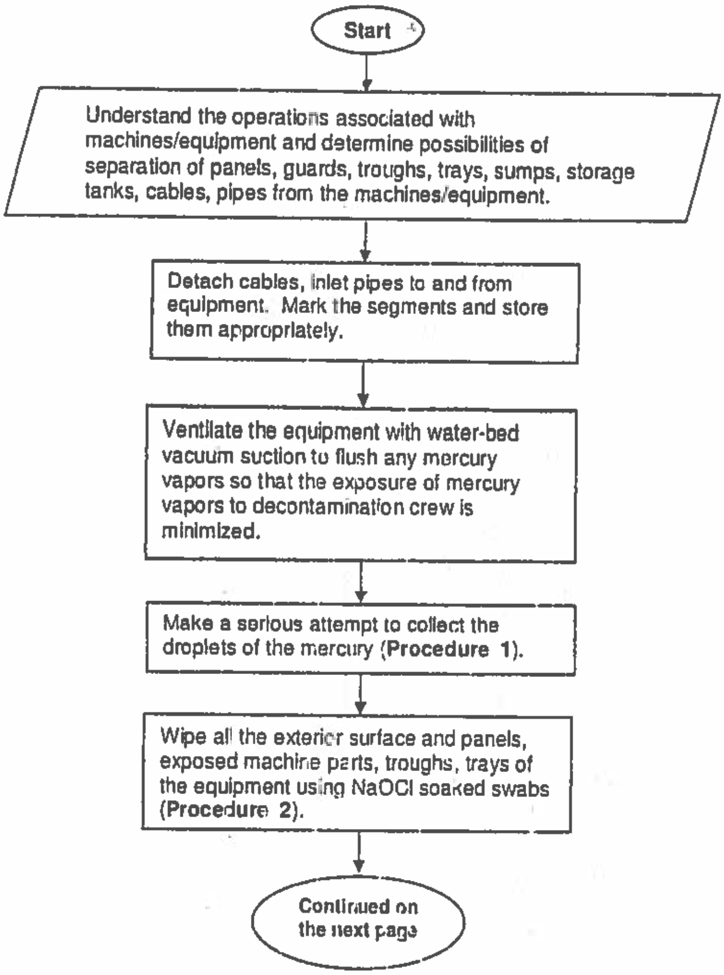


Figure 1 continued

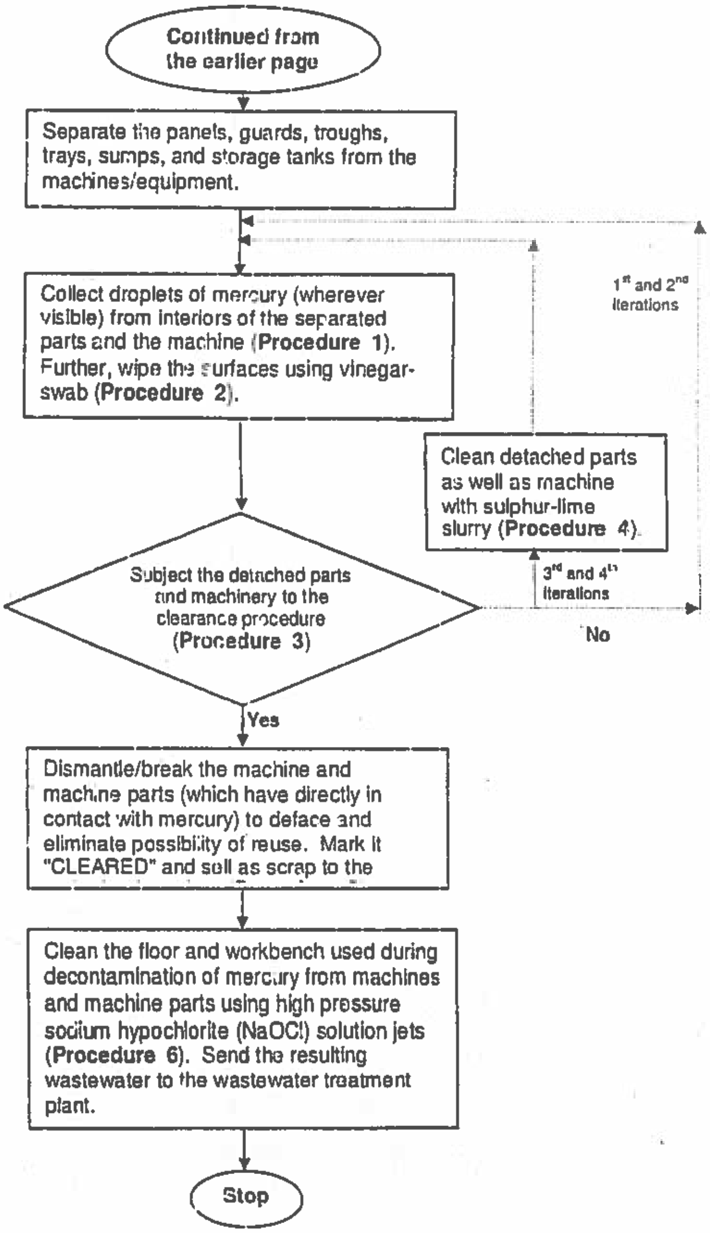


Figure 1 The logic diagram for the proposed mercury decontamination protocol

Rate of Soil and Mercury Loss into Pambar Shola from M/s Hindustan Unilever's Mercury-contaminated Site

By Nityanand Jayaraman, Chennai Solidarity Group. August 2021

In January 2020, Hindustan Unilever clearfelled more than 4 acres (1.62 ha) of its 8.7 ha mercury-contaminated site and cleared it of all vegetation. The cleared section also coincided with the most contaminated portions of the site. The removal of protective vegetative cover has exposed the contaminated soils to erosion by rainwater and winds. The approved Remediation Plan for the site and soil and tree protection studies that are to guide the remediation expressly forbid the felling of trees and insist on extreme caution in excavating soil near large trees.

M/s HUL has claimed that mercury is limited to the factory premises, and is not mobilised offsite by air or water route. However, sediment samples taken from Pambar Shola along the streams draining the factory site have regularly returned with high mercury levels. Despite repeated requests to TNPCB to carry out independent verification of HUL's claims, no studies have been commissioned directly by TNPCB. All decisions have been taken exactly as proposed by HUL and based on studies carried out by HUL's consultants.

According to HUL's consultants, including NEERI, the factory site contains 366 kg of mercury mixed in the soil at concentrations above 10 mg/kg. Of this, the proposed remediation will address only around 200 kg. The remainder will be allowed to remain in soil. Civil society activists have sounded an alarm at the implications of such a substandard clean-up on the Kodaikanal Wildlife Sanctuary.

The clearfelling of forest by HUL changes everything. Even in February 2020, neighbouring residents had written to the DFO, Kodaikanal and other authorities about the dangers of the deforestation. No action has been taken. As a result, mercury contaminated soils have been allowed to run off at a much higher rate than earlier with no monitoring.

The following study attempts to estimate the rainwater run-off, the sediment run-off and quantum of sediment-bound mercury discharged from the site with the rainwater. A more robust study would offer a better idea, but such a study is beyond the means of this organisation.

1. Rainwater Run-off potential of site:

Before Clearfelling: As per Bonnell et al (2010), infiltration rates at top layer for a forested land-cover are between 30 and 150 mm/hr. For a 50 mm/hr rain intensity, the infiltration excess overland flow would be between 0 and 20 mm/hr.

- Runoff generated would be 10 mm/hr*0.001 m*1.62*10000 sq m = **162 m3/hr**

Source: *"The impact of forest use and reforestation on soil hydraulic conductivity in the Western Ghats of India: Implications for surface and sub-surface hydrology." M. Bonell, B.K. Purandara, B. Venkatesh, Jagdish Krishnaswamy, H.A.K. Acharya, U.V. Singh, R. Jayakumar, N. Chappell. Journal of Hydrology 391 (2010) 47–62*

After Clearfelling: Assuming even 20-30 mm/hr infiltration rates in disturbed sites and 50 mm/hr rain intensities (rainfall can exceed 200 mm/day), the infiltration excess overland flow would be approximately 20-30 mm/hr and 1.62 ha total area.

- Runoff generated would be 25 mm/hr *0.001 m * 1.62 *10000 sq m= **405 m3/hr**

2. Soil Erosion and Runoff Potential at Site

The average rate of erosion for the mercury-contaminated Unilever site was calculated using Universal Soil Loss Equation computed by the online Soil Erosion Calculator tool. https://www.ruvival.de/soil-erosion-calculator/

The various fields for the online calculator were filled conservatively based on known information from above-mentioned sources.

The Detailed Project Report prepared by the company's consultant has classified the contaminated grounds within the larger factory site (8.7 ha) into several Sections – C1, C2, A, B etc.

Section	Area (ha)	Slope	Slope length (m)	Crop Factor Before/After	Till Factor Before/After	Support Factor
C1	0.73	8	35	0.1/0.4	0.25/1.0	0.75
C2	0.73	15	45	0.1/0.4	0.25/1.0	0.75
A	0.16	33	40	0.1/0.4	0.25/1.0	0.75

Assumptions:
Erosivity Factor: 3100. Source: Online Erosivity Factor (II) Global map provided in online calculator.

Soil Erodibility: Soil type and organic matter content is required for calculation of erodibility.

Section	Soil Type	Organic Matter Content
C1	Clay Loam	>2%
C2	Clay Loam	>2%
A	Silty Clay	>2%

Support Factor: Cross slope
Crop Type Factor: Fruit Trees (with vegetation); Grain corn (after clearfelling)
Tillage: No Till (with vegetation); Fall plow (after clearfelling)

Results

Erosion rate is reported in tonnes of soil/ha/year

Section	Before Clearfelling (t/ha/yr)	After Clearfelling (t/ha/yr)	Soil Loss by Section Before/After (tonnes)
C1 (0.73 ha)	39	625.6	29/457
C2 (0.73 ha)	116	1856.6	85/1355
A (0.16 ha)	394	6308	63/1009

3. Estimation of Quantum of Mercury Leaking into Pambar Shola as Sediment-bound Mercury with Rainwater Runoff

Area C1

75% area has Hg in range 10-50mg/kg
20% with 50-100 mg/kg. Rest is building

Before Clearfelling
29*(1000)*((0.75*(30)+0.2*(75)) = 1087500 mg/ha/yr = 1.088 kg Hg/ha/yr
0.73 ha*1.088 kg of Hg/ha/year = **0.79 kg Hg/yr**

After Clearfelling
457 *(1000)*((0.75*(30)+0.2*(75))) = 17137500 mg of Hg = 17.1 kg of Hg /ha/yr
0.73 ha*17.1 kg of Hg /ha/yr = **12.5 kg Hg/yr**

Area C2

70% area has Hg in range 10-50 mg/kg
12% area has 50-200 mg/kg
8% area has 100-200 mg/kg

Before Clearfelling
116*(1000)*((0.7*30)+(0.12*125)+(0.08*150)) = 5568000 mg of Hg/ha/yr = 5.57 kg Hg/ha/yr
0.73 ha*5.57 kg/ha/yr = **4.06 kg/yr**

After Clearfelling
1355*(1000)*((0.7*30)+(0.12*125)+(0.08*150)) = 65040000 mg of Hg = 65 kg of Hg/ha/yr
0.73 ha*65 kg of Hg/ha/yr = **47.5 kg Hg/yr**

Area A

80% area has Hg in range 10-50 mg/kg
20% area has Hg in range 50-100 mg/kg

Before Clearfelling
63*1000*((0.8*(30)+(0.2*(75)) = 2457000 mg of Hg/ha/yr = 2.46 kg Hg/ha/yr
0.16 ha*2.46 kg Hg/ha/yr = **0.4 kg Hg/yr**

After Clearfelling
1009*(1000)*((0.8*(30)+0.2*(75))) = 39351000 mg of Hg = 39.35 kg Hg /ha/yr
0.16 ha*39.35 kg Hg /ha/yr = **6.296 kg Hg/yr**

Total across sites from 1.62 ha contaminated site containing more than 10 mg/kg mercury.
Before Felling **=** 0.79+4.06+0.4 = **5.25 kg Hg/yr**
After Felling **=** 12.5+47.5+6.3 = **66 kg Hg/yr**

4. Findings

- In 19 years between 2001 and 2020, 100 kg of mercury has leaked into Pambar Shola.
- In 18 months between January 2020 and present, another 100 kg of mercury has leaked into Pambar Shola.
- Soil erosion and release of soil-bound mercury has increased 12 fold because of clearfelling and clearing of vegetation from 4 acres of most contaminated factory grounds. Company's

claim that mercury was contained within the site is wrong. Mercury was leaking into the Pambar Shola at a rate of 5.25 kg/year with vegetation. After clear-felling, mercury leaving contaminated site is about 66 kg/year.

- Clear-felling is in violation of laws. Factory site fell within 10 km Eco-sensitive Zone of Kodaikanal Wildlife Sanctuary. Tree felling as part of handling of mercury wastes within factory site required permission from State Government and National Board of Wildlife.
- NEERI, TNPCB and Forest Department have allowed the discharge of at least 200 kg of mercury into Pambar Shola by a known offender despite being warned against it.
- As a result of deforestation, rainwater flow into Pambar Shola has been increased from 162 m3/hr to 405 m3/hr – an enhancement of 243 m3/hr.

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Kodaikanal tree felling: 65 academics, ecologists write to CM Stalin against Unilever

Hindustan Unilever Ltd has clear-felled 425 trees as part of the remediation of mercury-contaminated soil in the four acres of its now-defunct factory in Kodaikanal, say activists.

IMAGE CREDIT: CHENNAI SOLIDARITY GROUP

NEWS ENVIRONMENT | WEDNESDAY, SEPTEMBER 15, 2021 - 15:46

Sreedevi Jayarajan Follow @Sreedevi_Jay

Sixty-five artists, educators, ecologists, and environmentalists have written to Tamil Nadu Chief Minister Stalin urging the state to take action against Hindustan Unilever Ltd or HUL for cutting down hundreds of trees in Kodaikanal. In January 2020, Unilever clear-felled 425 trees from its property in Kodaikanal which sees high soil mercury concentration. According to the letter, this has now exposed the toxic soil in the land which can now wash into the adjacent Kodaikanal Wildlife Sanctuary and eco-sensitive Pambar-Shola evergreen forests threatening its ecosystem.

In the letter to CM Stalin, the 65 signatories sounded 'a red alert' against Unilevel for the large-scale deforestation. "It is shocking that the Scientific Experts Committee appointed to oversee remediation of the contaminated site has approved the clear-felling of trees without even a cursory environmental impact assessment. Not only that, they have failed to point out and act against Unilever's failure to monitor the sediment and water entering the Pambar Shola as per the approved environmental monitoring plan," the letter reads. The letter was signed by big names including Romulus Whitaker, Founder of Madras Snake Park and Madras Crocodile Bank, S. Theodore Baskaran, Former Trustee, WWF-India and the likes.

Unilever argues that the deforestation was done as part of the remediation of mercury-contaminated soil in the four acres of its now-defunct factory ... emediation Upscaling Plan did it ask for trees t

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While preparing the Remediation Plan, domain expert Soil and Water Conservation Research & Training Institute, Udhagamandalam, “insisted on steps that need to be taken during remediation to ensure that no trees are felled,” the letter read. It argued that this “cannot be set aside by the Scientific Experts Committee, Tamil Nadu Pollution Control Board and the Forest Department without scientific basis or an assessment of the impacts of deforestation”.

The HUL Soil Remediation Upscaling Plan was made with directions from the Scientific Experts Committee, which was appointed by the Supreme Court Monitoring Committee. HUL is expected to execute soil remediation based on this plan.

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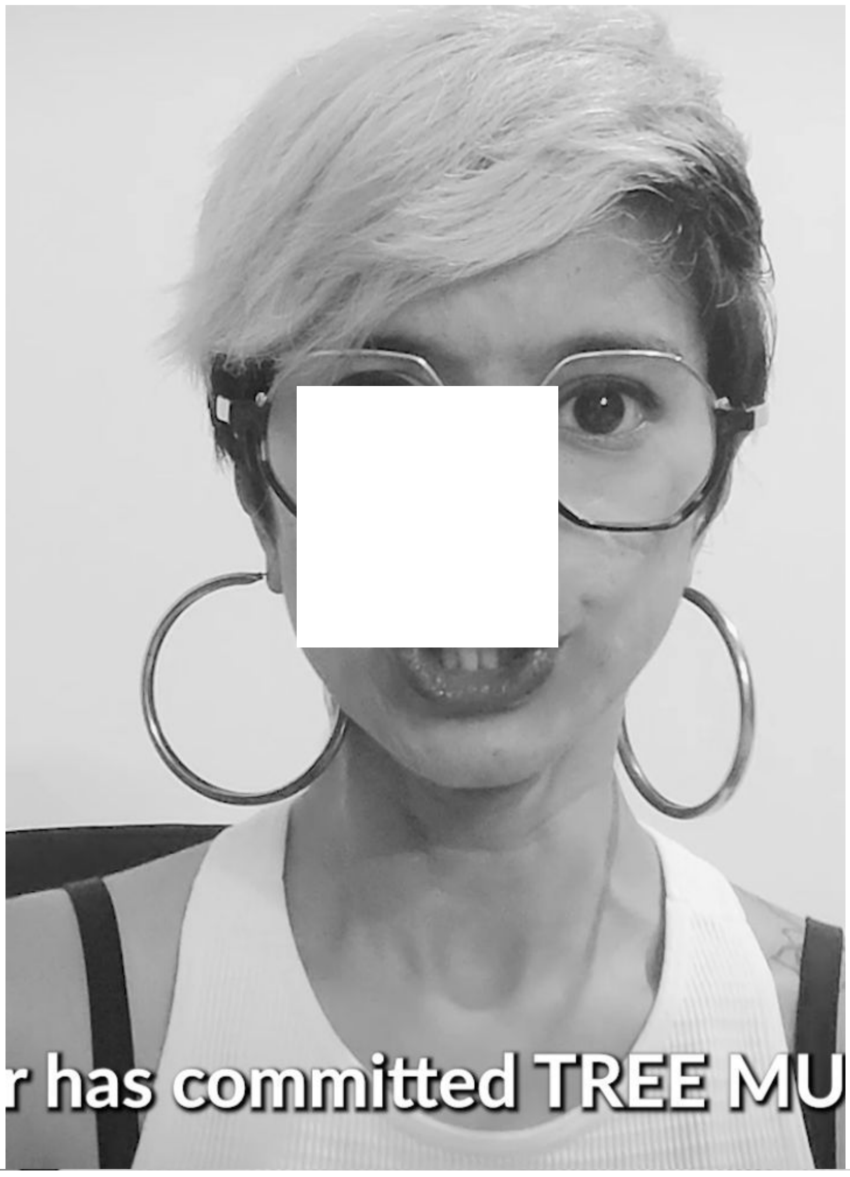

View More on Instagram

1,341 likes

onceuponasofie Illegal Felling of Trees

SOUND ON 🔊 Link in bio:
Because of the reckless actions of @unilever , rains have washed out more than 100kg of toxic mercury into the Kodaikanal Wildlife Sanctuary, poisioning aquatic food chains. Sign the petition and join us in demanding action immediate against @unilever.

#UnileverPollutes

@jhatkaadotorg

view all 27 comments

Add a comment...

The letter adds that the Experts Committee and its decision and the role of TNPCB and Forest Department need to probe and the approval to fell trees "is the basis of a crime against India's wildlife". "Section 29 of the Wildlife Protection Act states that any action that enhances the flow of water into the sanctuary can only be done in accordance with a permit granted by the Chief Wildlife Warden. According to the enclosed study, the removal of trees is likely to have enhanced water flow into the sanctuary during heavy rain events by 243 m3/hr – from 162 m3/hr to 405 m3/hr," the letter explained. The deforested land is sloping and receives plenty of rainfall. The soil- mercury erosion due to winds and rains into the Kodaikanal Wildlife Sanctuary will not only poison the aquatic food chain in the Pambar-Shola stream but also affect the downstream fish consumers, the letter further added.

The letter has made three requests to the State government:

To seek expert advice to identify measures that can be taken to mitigate damage to the sanctuary from water and soil runoff and nearby residents from exposure to contaminated dust.
To reconstitute the Scientific Experts Committee with credible experts.
To initiate an enquir and endanger the Wildlife
Sanctuary, and take

the Kodaikanal Wildlife Sanctuary. For the 17 months since 425 trees were removed, Unilever ought to have taken a total of 952 samples. However, HUL has never analysed the soil and water samples.

The Tamil Nadu Pollution Control Board (TNPCB) which is required to analyse soil and water for mercury concentration has failed to do so. The RTI response revealed that the Dindigul TNPCB office did not have any "records in the office."

"The monitoring information and mercury mass balance are crucial to estimating the quantum of mercury leaking into the Kodaikanal Wildlife Sanctuary. Without such information, TNPCB and the Experts Committee have no basis to claim that all is well with the remediation. It is the hands-off approach of TNPCB and the Experts Committee that has led to the poisoning of the sanctuary," said Meenakshi Subramaniam, a former member of the committee appointed by the Supreme Court Monitoring Committee to oversee mercury remediation in Kodaikanal.

Nityanand Jayaraman of the Chennai Solidarity group says, "The failure to monitor allows Unilever to wash out tonnes of mercury into the shola without any oversight. Most of these offenses have occurred during the tenure of the previous government. We hope that the present government will ensure that Unilever, TNPCB and the errant experts are held to account".

Further, Jhatkaa.org, a campaigning organisation along with the Chennai Solidarity Group has initiated a campaign to demand urgent action against HUL. The online petition has received around 8000 signatures so far.

Here is the link to the petition.

Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health

MERCURY (INORGANIC) 1999

This fact sheet provides Canadian soil quality guidelines for mercury (Hg) for the protection of environmental and human health (Table 1). Supporting scientific documents are also available (Environment Canada 1996; Health Canada 1996).

Background Information

Mercury (CAS 7439-97-6) is a dense silver-white metal that is liquid at room temperature and is characterized by low electrical resistivity, high surface tension, and high thermal conductivity (Andren and Nriagu 1979; Environment Canada 1981).

The two properties that largely determine the environmental behaviour of mercury are the high vapour pressure of liquid mercury, yielding hazardous vapour concentrations, and the relative insolubility of ionic and organic forms. Mercury can exist in three stable oxidation states: elemental mercury (Hg^0, Hg(0)), mercurous ion (Hg_2^{2+}, Hg(I)), and mercuric ion (Hg^{2+}, Hg(II)).

Mercury (II) can be oxidized to both inorganic and organic salts, such as chlorides, sulphates, and organo-mercury compounds. A wide range of organomercury compounds are present in the environment and are characterized by the attachment of mercury to one or two carbon atoms to form compounds of the type R-Hg-X and R-Hg-R', where R and R' represent the organic moiety, and X represents a halogen. The organic moiety may take the form of alkyl, phenyl, or methoxyethyl radicals (WHO 1976). A subclass of short-chained alkylmercurials, which include monomethyl (CH_3Hg^+) and dimethylmercury ($(CH_3)_2Hg$), are the predominant organic mercury compounds found in natural systems. Dimethylmercury is less stable and more volatile than monomethyl compounds (Environment Canada 1981). Other organic forms of

Table 1. Soil quality guidelines for mercury (mg·kg^{1}).

	Land use			
	Agricultural	**Residential/ parkland**	**Commercial**	**Industrial**
Guideline	**6.6**[a]	**6.6**[a]	**24**[a]	**50**[a]
SQG_{HH}	6.6	6.6	24	99
Limiting pathway for SQG_{HH}	Soil ingestion	Soil ingestion	Soil ingestion	Off-site migration
Provisional SQG_{HH}	NC[b]	NC[b]	NC[b]	NC[b]
Limiting pathway for provisional SQG_{HH}	ND	ND	ND	ND
SQG_E	12	12	50	50
Limiting pathway for SQG_E	Soil contact	Soil contact	Soil contact	Soil contact
Provisional SQG_E	NC[c]	NC[c]	NC[c]	NC[c]
Limiting pathway for provisional SQG_E	ND	ND	ND	ND
Interim soil quality criterion (CCME 1991)	0.8	2	10	10

Notes: NC = not calculated; ND = not determined; SQG_E = soil quality guideline for environmental health; SQG_{HH} = soil quality guideline for human health.

[a]Data are sufficient and adequate to calculate an SQG_{HH} and an SQG_E. Therefore the soil quality guideline is the lower of the two and represents a fully integrated de novo guideline for this land use, derived in accordance with the soil protocol (CCME 1996a). The corresponding interim soil quality criterion (CCME 1991) is superseded by the soil quality guideline.

[b]Because data are sufficient and adequate to calculate an SQG_{HH} for this land use, a provisional SQG_{HH} is not calculated.

[c]Because data are sufficient and adequate to calculate an SQG_E for this land use, a provisional SQG_E is not calculated.

The guidelines in this fact sheet are for general guidance only. Site-specific conditions should be considered in the application of these values. The values may be applied differently in various jurisdictions. The reader should consult the appropriate jurisdiction before application of the values.

mercury are phenylmercuric acetate (PMA), phenylmercuric chloride (PMC), methylmercuric dicyandiamide (MMD), methylmercuric acetate (MMA), and methylmercuric chloride (MMC).

The vapour pressure of mercury is highly dependent on temperature, and the tendency of liquid mercury to form small droplets increases its rate of evaporation. Mercury is found in the environment, not as the liquid metal, but mainly in the form of amalgams and inorganic salts, which have lower vapour pressures than elemental mercury (Andren and Nriagu 1979). The solubility of mercury compounds in water increases in the order: elemental mercury < mercurous chloride < methylmercury chloride < mercuric chloride. The toxicity of the inorganic forms is generally less than that of the organic compounds. Within the inorganic forms, toxicity increases as lipid solubility increases (Halbach 1990).

A number of mercury compounds were widely used in agriculture, medicine, and industry in Canada and have contributed to environmental contamination. However, there has been no Canadian production of mercury since 1975. Total Canadian anthropogenic emissions to the atmosphere were estimated at 39 855 kg, with the major source being base metal recovery (40%) (Environment Canada 1981). In 1989, Canada imported 32 442 kg of mercury and consumed 27 364 kg (Energy, Mines and Resources Canada 1990). Worldwide production figures for mercury indicate generally declining use (Fergusson 1990; ATSDR 1994).

The average terrestrial concentration of mercury in the Canadian environment is in the range of 0.01 to 0.4 $mg \cdot kg^{-1}$ (Jonasson and Boyle 1972; Gracey and Stewart 1974; McKeague and Kloosterman 1974; Environment Canada 1979; OMEE 1994), except in areas of ore deposits, spills, landfills, and accidents at metal-processing plants.

Frank et al. 1976 observed mercury concentrations ranging from 0.01 to 1.14 $mg \cdot kg^{-1}$ in Ontario agricultural soils, with a mean of 0.11 mg $Hg \cdot kg^{-1}$. In surface soil samples from areas not impacted by local point sources of pollution throughout Ontario, the 98th percentiles of mercury concentration measurements are 0.13 and 0.18 $mg \cdot kg^{-1}$ for rural parkland and old urban parkland soils, respectively (OMEE 1993).

In Alberta soils, background mercury levels ranging from 0.01 to 0.135 $mg \cdot kg^{-1}$ have been reported (Dudas and Pawluk 1976; Dudas and Cannon 1983; George et al. 1994). Elevated mercury levels are common in British Columbia due to the cinnabar deposits. High soil mercury levels are also reported in Quebec and Ontario near areas of known gold, copper, or zinc mineralization (Environment Canada 1979).

Environmental Fate and Behaviour in Soil

The major soil factors that determine the fate and behaviour of mercury are pH, organic matter and clay content, redox potential, cation exchange capacity (CEC), aeration, and texture. The major processes that determine the mobility and distribution of mercury in the terrestrial environment are adsorption, chemical reactions, leaching, volatilization, photolysis, and biodegradation. These processes are dependant on the soil factors mentioned above.

In soils, mercury occurs mainly in the Hg^0 and Hg^{2+} valence states. Depending on redox conditions, the dimeric ion (Hg_2^{2+}) may also be encountered. The speciation of mercury in soils also depends on the pH and the concentration of chloride ions. Under natural conditions, most of the Hg^{2+} in the soil is either bound in the soil minerals or adsorbed onto organic or inorganic solids, with only a very small portion present in the soil solution (Steinnes 1995).

Adsorption is the dominant process determining mercury's fate in the terrestrial environment (Hogg et al. 1978). It depends on mercury's chemical form, soil pH, colloids, CEC, and redox potential (Hogg et al. 1978; Kabata-Pendias and Pendias 1992). Adsorption is increased by the presence of organic matter due to mercury complexation with humic and fulvic acids, and therefore it is greater in surface horizons due to high humus content (Lodenius et al. 1987). Adsorption is maximized at pH 4–5 (Thanabalasingam and Pickering 1985; Semu et al. 1986) and is decreased by Cl^- ions (Andersson 1979). In neutral and low organic matter soils, it depends on iron and clay minerals as important adsorption sites (OECD 1993). When added in elemental, cationic, or anionic forms, mercury strongly adsorbs to soils (Kabata-Pendias and Pendias 1992).

Mercury undergoes methylation by aerobic and anaerobic bacteria (NRCC 1979; WHO 1991). Methyl mercury species are mobile, bioavailable, and highly toxic (Lexmond et al. 1976; Bigham and Henry 1993). Under reduced conditions, mercury and sulphide ions form HgS, an insoluble salt that is resistant to methylation. Under aerobic conditions, HgS is oxidized to the sulphate form $HgSO_4$, which can undergo methylation. Bacterial action can cause demethylation of methyl mercury compounds. The chloride concentration and pH determine the chemical form of monomethylmercuric ion complexes (NRCC 1979).

Leaching of mercury occurs in soils with little or no organic matter and light texture. Chloride complexes of mercury are soluble and, hence, subject to leaching. In acid soils, mercury is leached out in a bound form with organic matter, whereas in neutral and alkaline soils, mercury is leached out in an inorganic active form (Kabata-Pendias and Pendias 1992). Acid rain increases leaching of mercury (Lodenius et al. 1987). Highest leaching of mercury occurs in spring and autumn (Jonasson and Boyle 1972).

Volatilization is due to chemical and biological transformations of mercury compounds in soils (Frear and Dills 1967; Rogers and McFarlane 1979). The main form of mercury in the air is elemental mercury, but dimethylmercury may also occur (Lindberg et al. 1987; WHO 1989). Volatilization increases with pH and temperature, but also depends on organic matter content, redox potential, moisture content, and pore space of the soil (Frear and Dills 1967). Under favourable conditions, 50% of added mercury has volatilized within a week (Gilmour and Miller 1973).

Monomethylmercury may decompose photolytically to elemental mercury and methyl radicals (NRCC 1979). Dimethylmercury may be transformed to the mono form at low pH by ultraviolet light (Jernelov 1975). Photolysis of mercury chloride compounds may result in the production of methylmercury ions, dimethylmercury, and metallic mercury (Jewett et al. 1975).

Mercury is subject to biotic and abiotic transformations in soils (Andersson 1979; Kabata-Pendias and Pendias 1992). Both aerobic and anaerobic soil microbes can convert elemental mercury to mono and then to dimethylmercury. On the other hand, soil microbes are also capable of converting organic mercury to elemental mercury, but this is a slower process (Kabata-Pendias and Pendias 1992). *Clostridium* species, under anaerobic conditions, transform several mercury species (except HgS) to methylmercury (Yamada and Tonomura 1972). *Pseudomonas* species are mainly responsible for degrading organic and inorganic mercurials to metallic mercury (Furukawa and Tonomura 1972). Methylmercury is stable in soils (Rundgren et al. 1992).

Behaviour and Effects in Biota

Soil Microbial Processes

Von Stadelmann and Santschi-Fuhrimann (1987) reported that the lowest content of total mercury at which effects were detected (25% reduction in microbial respiration) is in the range of 0.06 to 0.08 mg $Hg \cdot kg^{-1}$ soil. Wilke (1988) observed similar effects at 1.3 mg $Hg \cdot kg^{-1}$ in soils. The soluble fractions in both studies were the same, 0.02 mg $Hg \cdot kg^{-1}$ (Lindqvist 1991).

Mercury concentrations that have been shown to reduce microbial CO_2 production in soil range from 0.1 $mg \cdot kg^{-1}$ for a 16% reduction to 400 $mg \cdot kg^{-1}$ for a 69% reduction (Van Faassen 1973; Cornfield 1977; Landa and Fang 1978; Zelles et al. 1985, 1986; Tu 1988).

Reductions in soil nitrogen mineralization have been reported at concentrations ranging from 6 to 1003 mg $Hg \cdot kg^{-1}$ (Van Faassen 1973; Liang and Tabatabai 1977; Wilke 1989).

Studies have also shown that nitrification has been reduced by 8% at 50 mg $Hg \cdot kg^{-1}$ soil, by 21% at 200 mg $Hg \cdot kg^{-1}$ soil, and by 94–98% at 1003 mg $Hg \cdot kg^{-1}$ soil (Liang and Tabatabai 1978; Wilke 1989).

Terrestrial Plants

Common symptoms of mercury toxicity to plants are inhibition of photosynthesis, stunted roots, and stunted seedlings, all with consequent reductions in yield. Some studies reported that the accumulation of mercury in roots inhibits uptake of other elements, such as potassium (Kabata-Pendias and Pendias 1992).

The lowest soil concentrations at which phytotoxic effects have been observed are 7 and 8 mg $Hg \cdot kg^{-1}$, which resulted in a 50% reduction in the first bloom of turnips and decreased growth (not quantifiable) of Bermuda grass (Weaver et al. 1984; Sheppard et al. 1993).

The literature shows that a variety of growth endpoints are reduced by 50% at concentrations ranging from 7 to 1000 mg $Hg \cdot kg^{-1}$ soil (Sheppard et al. 1993; Environment Canada 1995). Twenty-five percent reductions in seedling emergence of lettuce and radishes occurred at 11 and 73 mg $Hg \cdot kg^{-1}$ soil, respectively (Environment Canada 1995).

Macnicol and Beckett (1985) established the critical level of mercury tissue content leading to depression of yield, between 1 and 8 $mg \cdot kg^{-1}$ dw of tissue for barley, cabbage, maize, and oats.

Terrestrial Invertebrates

Mercury accumulates in soil invertebrates even at low soil concentrations (Rundgren et al. 1992). Mercury concentrations in invertebrates ranging from 0.79 $mg \cdot kg^{-1}$ for harvestman *(Phalangida)* to 15.5 $mg \cdot kg^{-1}$ for earthworms *(Oligochaeta)* have been reported by Talmage and Walton (1993) in a mercury-contaminated site. Mean food chain transfer coefficients, defined as the ratio of mercury concentration in the whole body to mercury concentration in food, were 0.88 for herbivore/omnivore invertebrates and 2.35 for carnivore invertebrates.

Earthworms have suffered 25% mortality in soil at mercury concentrations ranging from 130 to 250 $mg \cdot kg^{-1}$, while concentrations resulting in 50% mortality range from 60 to 700 $mg \cdot kg^{-1}$ in varying soil types (Fisher and Koszorus 1992; Sheppard et al. 1993; Environment Canada 1995).

Livestock and Wildlife

In mammals and birds, mercury is usually absorbed through the gastrointestinal tract and through the lungs (WHO 1976; NRCC 1979). Mercury levels are generally highest in the kidney and liver tissues (NRCC 1979; WHO 1989). Brain tissue also absorbs mercury in vapour and organic forms (Aschner and Aschner, 1990). The principal routes of elimination of mercury from the body are through the urine and feces.

Hill and Soares (1984) provide the only toxicological study using inorganic mercury. The LC_{50} for *Coturnix (Cotornix japonica)* was 1751 $mg \cdot kg^{-1}$ bw per day. All of the other livestock and wildlife studies found reported the toxicological effects of organic mercury compounds.

Human and Experimental Animal Health Effects

The pharmacokinetics and toxicological effects of inorganic mercury compounds have been comprehensively reviewed by WHO (1991), ATSDR (1994), and Health and Welfare Canada (1986) and will not be reiterated here.

The International Agency for Research on Cancer working group on the evaluation of carcinogenic risk to humans classified inorganic mercury compounds as "not classifiable as to their carcinogenicity to humans" (Group 3) on the basis of inadequate evidence in humans for the carcinogenicity of mercury and mercury compounds and limited evidence in experimental animals for the carcinogenicity of mercuric chloride (IARC 1993). Although using the same weight of evidence as WHO (1993), the U.S. Environment Protection Agency (IRIS 1996) recently classified mercuric chloride as a possible human carcinogen (Group C). Inorganic mercury compounds have not been classified by Health Canada with respect to human carcinogenicity.

The kidney is the critical organ following the ingestion of inorganic divalent mercury salts (WHO 1991; NTP 1993). The most sensitive adverse effect on the kidney in animal studies is the formation of mercury-induced auto-immune glomerulonephritis, the first step of which is the production and deposition of IgG (immunoglobulin G) antibodies on the glomerular basement membrane (WHO 1991; IRIS 1996). This effect has been consistently observed in studies using the brown Norway rat, a strain considered to be the most sensitive for this endpoint (WHO 1991; IRIS 1996). Laboratory studies using mice (Hultman and Enestrom 1992) and rabbits (Lindqvist et al. 1974), as well as clinical studies (WHO 1991), have also demonstrated the same critical effect after exposure to relatively low doses of inorganic divalent mercury salts by various routes.

In 1995, after an extensive review and workshop discussions of the entire database of studies on inorganic mercury compounds, the U.S. Environment Protection Agency affirmed the oral reference dose (RfD) for inorganic mercury (mercuric chloride) established in 1985 (IRIS 1996). This oral RfD of 0.0003 $mg \cdot kg^{-1}$ bw per day is based on the back calculations from a drinking water equivalent level (DWEL) of 0.10 $mg \cdot L^{-1}$, assuming a water consumption rate of 2 L per day and a body weight of 70 kg. The DWEL was recommended on the basis of the weight of evidence from three key studies using the brown Norway rat (Druet et al. 1978; Bernaudin et al. 1981; Andres 1984) and limited human tissue studies. In those studies, brown Norway rats were administered mercuric chloride by subcutaneous injection (Druet et al. 1978) or by gavage in water (Bernaudin et al. 1981; Andres 1984). The LOAEL doses were determined to be 0.226 $mg \cdot kg^{-1}$ bw per day (after conversion from subcutaneous route (100% absorption) to oral route (7%) (Health Canada 1996), 0.317 $mg \cdot kg^{-1}$ bw per day (Bernaudin et al. 1981), and 0.633 $mg \cdot kg^{-1}$ bw per day (Andres 1984). An uncertainty factor of 1000 was applied (10 for the use of subchronic studies, a combined 10 for both animal to human and sensitive human populations and 10 for the use of LOAELs instead of NOAELs); no modifying factor was used.

Other agencies such as the World Health Organization (WHO 1993) and (Health and Welfare Canada 1986) have conservatively based their drinking water guidelines for mercury (as total) on the neurological effects of methyl mercury in human populations; hence, no TDIs were derived for inorganic mercury. The oral RfD of 0.0003 $mg \cdot kg^{-1}$ bw per day as inorganic divalent mercury, recently reaffirmed by the U.S. Environment Protection Agency (IRIS 1996), is therefore adopted as an oral TDI for the derivation of human health soil quality guidelines.

Guideline Derivation

Canadian soil quality guidelines are derived for different land uses following the process outlined in CCME (1996a) using different receptors and exposure scenarios for each land use (Table 1). Detailed derivations of the soil quality guidelines for mercury are provided in Environment Canada (1996) and Health Canada (1996).

Soil Quality Guidelines for Environmental Health

Environmental soil quality guidelines (SQG_Es) are based on soil contact using data from toxicity studies on plants and invertebrates. In the case of agricultural land use, soil and food ingestion toxicity data for mammalian and avian species are included. To provide a broader scope of protection, a nutrient and energy cycling check is calculated. For industrial land use, an off-site migration check is also calculated.

For all land uses, the preliminary soil contact value (also called threshold effects concentration [TEC] or effects concentration low [ECL], depending on the land use) is compared to the nutrient and energy cycling check. If the nutrient and energy cycling check is lower, the geometric mean of the preliminary soil contact value and the nutrient and energy cycling check is calculated as the soil quality guideline for soil contact. If the nutrient and energy cycling check is greater than the preliminary soil contact value, the preliminary soil contact value becomes the soil quality guideline for soil contact.

For agricultural land use, the lower of the soil quality guideline for soil contact and the soil and food ingestion guideline is recommended as the SQG_E.

For residential/parkland and commercial land uses, the soil quality guideline for soil contact is recommended as the SQG_E.

For industrial land use, the lower of the soil quality guideline for soil contact and the off-site migration check is recommended as the SQG_E.

In the case of mercury, the recommended SQG_E is based on the soil contact guideline for all land use categories (Table 2).

Soil Quality Guidelines for Human Health

Human health soil quality guidelines for threshold contaminants are derived using a TDI for the most sensitive receptor designated for a land use.

The CCME recommends the application of various check mechanisms, when relevant, in order to provide a broader scope of protection. The lowest of the soil ingestion guidelines and any of the calculated checks is recommended as the SQG_{HH}.

Soil Quality Guidelines for Mercury

For each land use category, the soil quality guideline for mercury is the lower of the SQG_{HH} and SQG_E (Table 1).

CCME (1996b) provides guidance on potential modifications to the final recommended soil quality guideline when setting site-specific objectives.

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Table 2. Soil quality guidelines and check values for mercury (mg·kg^{-1}).

	Land use			
	Agricultural	**Residential/ parkland**	**Commercial**	**Industrial**
Guideline	**6.6[a]**	**6.6[a]**	**24[a]**	**50[a]**
Human health guidelines/check values				
SQG_{HH}	6.6[b]	6.6[b]	24[b]	99[b]
Soil ingestion guideline	6.6	6.6	24	690
Inhalation of indoor air check	NC[c]	NC[c]	NC[c]	NC[c]
Off-site migration check	—	—	—	99
Goundwater check (drinking water)	NC[d]	NC[d]	NC[d]	NC[d]
Produce, meat, and milk check	NC[e]	NC[e]	—	—
Provisional SQG_{HH}	NC[f]	NC[f]	NC[f]	NC[f]
Limiting pathway for provisional SQG_{HH}	ND	ND	ND	ND
Environmental health guidelines/check values				
SQG_E	12[g]	12[g]	50[g]	50[g]
Soil contact guideline	12	12	50	50
Soil and food ingestion guideline	NC[h]	—	—	—
Nutrient and energy cycling check	20	20	52	52
Off-site migration check	—	—	—	142
Groundwater check (aquatic life)	NC[d]	NC[d]	NC[d]	NC[d]
Provisional SQG_E	NC[i]	NC[i]	NC[i]	NC[i]
Limiting pathway for provisional SQG_E	ND	ND	ND	ND
Interim soil quality criterion (CCME 1991)	0.8	2	10	10

Notes: NC = not calculated; ND = not determined; SQG_E = soil quality guideline for environmental health; SQG_{HH} = soil quality guideline for human health. The dash indicates a guideline/check value that is not part of the exposure scenario for this land use and therefore is not calculated.

[a]Data are sufficient and adequate to calculate an SQG_{HH} and an SQG_E. Therefore the soil quality guideline is the lower of the two and represents a fully integrated de novo guideline for this land use, derived in accordance with the soil protocol (CCME 1996a). The corresponding interim soil quality criterion (CCME 1991) is superseded by the soil quality guideline.

[b]The SQG_{HH} is the lowest of the human health guidelines and check values.

[c]Applies only to volatile organic compounds and is not calculated for metal contaminants.

[d]Applies to organic compounds and is not calculated for metal contaminants. Concerns about metal contaminants should be addressed on a site-specific basis.

[e]Applies to nonpolar organic compounds and is not calculated for metal contaminants. Concerns about metal contaminants should be addressed on a site-specific basis.

[f]Because data are sufficient and adequate to calculate an SQG_{HH} for this land use, a provisional SQG_{HH} is not calculated.

[g]The SQG_E is the lowest of the environmental health guidelines and check values.

[h]There are insufficient data to calculate a soil and food ingestion guideline for inorganic mercury. Using data available for organic mercury, a soil and food ingestion guideline of 19 mg·kg^{-1} soil has been calculated.

[i]Because data are sufficient and adequate to calculate an SQG_E for this land use, a provisional SQG_E is not calculated.

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This fact sheet was originally published in the working document entitled “Recommended Canadian Soil Quality Guidelines” (Canadian Council of Ministers of the Environment, March 1997, Winnipeg). A revised and edited version is presented here.

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Canadian soil quality guidelines for the protection of environmental and human health: Mercury (inorganic) (1999). In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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Le Conseil canadien des ministres de l'environnement

A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines

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The human health soil quality guidelines are established after accounting for this background exposure to ensure that the tolerable daily intake (TDI) of the contaminant is not exceeded.

2.3 Land Use

Generic soil quality guidelines are derived to protect human and key ecological receptors that sustain normal activities for four land use categories: agricultural, residential/parkland, commercial, and industrial. Generic land use scenarios are envisioned for each category based on how the land is used and on how sensitive and dependent the activity is on the land. Sensitivity to contamination increases among ecological or human health components most dependent on land use activities (i.e., agricultural and residential/parkland) (see Figure 3).

The definition of each land use accommodates generic conditions and puts boundaries on the receptors and exposure pathways considered in the guideline derivation for that land use. The four defined land uses are as follows:

Agricultural: where the primary land use is growing crops or tending livestock. This also includes agricultural lands that provide habitat for resident and transitory wildlife and native flora.

Residential/Parkland: where the primary activity is residential or recreational activity; parkland is defined as a buffer between areas of residency, and also includes campground areas, but excludes wildlands such as national or provincial parks.

Commercial: where the primary activity is commercial (e.g., shopping mall) and not residential or manufacturing. This does not include zones where food is grown.

Industrial: where the primary activity involves the production, manufacture, or construction of goods.

Key biological receptors and exposure pathways were identified for each land use to protect soil quality and maintain activities performed on these lands. Recognizing differences in analyzing human health and ecological issues, soil quality guidelines for each chemical are developed for both ecological and human receptors. For each of the four land uses, to protect both human health and the environment, the most protective guideline is chosen as the recommended soil quality guideline.

The defined exposure scenarios used to develop the soil quality guidelines do not cover the full spectrum of the types of sites, environments, and organism-site interactions that can exist (see Figure 3). For example, a natural areas land use has not been defined. The applicable exposure pathways for natural areas could vary considerably among different sites due to differences, for example, in: resident wildlife species; presence of campers, hikers, trappers, etc.; consumption of country foods by local residents. As a conservative approach, the soil quality guidelines for agricultural land use could be applied to natural areas; alternatively, site-specific exposure scenarios could be considered. Additional land uses and exposure scenarios may be developed

Tamilnadu Pollution Control Board

From	To
Thiru. N. Rajagopal, M.E., Public Information Officer/ District Environmental Engineer Tamilnadu Pollution Control Board, Collector Office Campus, Dindigul - 624 004.	Tmt. Shweta Narayan, No. 92, 3rd Street, Thiruvallur Nagar, Besant Nagar, Chennai – 90.

Letter No: 000385/DEE/TNPCB/DGL/F.RTI/2014 dated: 18.05.2016.

Sir,

Sub: TNPC Board – O/o DEE, Dindigul – Information under RTI Act – Sent – Reg.

Ref: Public Information Officer, Tamilnadu Pollution Control Board, Chennai Letter No: TNPCB/RTIA/010889/F. 128/2016 dt. 28.04.2016 alongwith a copy of your petition dated: 25.04.2016.

With reference to your petition under RTI Act cited above, the following information is furnished pertaining to M/s. Hindustan Unilever Ltd., Kodaikanal.

Information No. 1 :

Yes. The unit M/s. M/s. Hindustan Unilever Ltd. has set up silt traps to prevent mercury contamination from leaching out of the factory site.

Information No. 2 :

Number of silt traps provided are Five. Silt traps are provided along the storm water main stream located within the premises.

Information No. 3 :

Five numbers of silt traps provided during the year 2001.

Information No. 4 :

Quantity of silt collected as on 31.12.2004 is 7505 Kg. Data not available in this office file after 31.12.2004.

Information No. 5 :

Letters / Authorization / Permission given to the unit regarding to set up silt trap is not available in this office file.

Information No. 6 :

During office hours between 10.00 AM to 5.45 PM with prior intimation petitioner is allowed to inspect the file as per the RTI Act 2005.

18/5/16

Public Information Officer/

BEFORE THE NATIONAL GREEN TRIBUNAL (SZ) CHENNAI
IA No. 151 of 2021

In
ORIGINAL APPLICATION No. 161 OF 2021 (Suo Motu)

Between:
Navroz Mody ... Applicant/ proposed respondent
Vs

The Chief Secretary
Government of Tamilnadu
Fort St George
Chennai & Ors .. Respondents/ Respondents

NOTE ON SUBMISSIONS FILED BY THE APPLICANT ALONG WITH DOCUMENTS

Through
A. Yogeshwaran
Poongkhulali B.
Counsels for Applicant