BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
SOUTHERN ZONE, CHENNAI

O.A. NO. 199 of 2021 (SZ)

IN THE MATTER OF:

Sri. Shankar Narayanan Bala Krishnan,
Telangana and Ors ...Applicant(s)

Versus

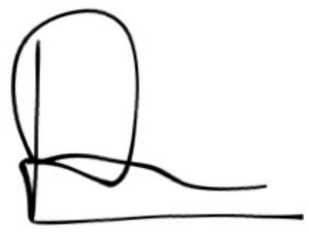
State of Telangana and Ors ...Respondents(s)

I N D E X

S.No.	Particulars	Page No.
1	Report filed on behalf of Respondent No.6	1-7
2	Annexure I – Interim Report 3 submitted by IIT Bombay	8-65
3	Annexure II – Memo of the Government of Telangana Dated 08.12.2022	66
4	Annexure III – Memo of the Government of Telangana Dated 28.01.2023	67
5	Annexure IV – Photographs showing progress of work of erection of Power Evacuation lines for the 14.5 MW capacity WTE plant at Dundigal	68-69
6	Annexure V – Copy of Working Approval accorded by the Principal Chief Conservator of Forests, Telangana for laying of Approach Road for the Pyaranagar Alternate MSW facility	70-73
7	Annexure VI – Copy of the Consent for Establishment granted by Telangana State Pollution Control Board for establishing MSW Processing facility at Pyaranagar	74- 81

Place: Hyderabad

Date: 08.03.2023



Counsel for Respondent No.6

(1)

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
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Sri. Shankar Narayanan Bala Krishnan,
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Versus

State of Telangana
And Ors ...Respondents(s)

REPORT FILED ON BEHALF OF RESPONDENT NO.6

I, D.S. Lokesh Kumar S/o. Sri. Somaraju, aged about 44 years, Occ: Commissioner, Greater Hyderabad Municipal Corporation, Greater Hyderabad Municipal Corporation, R/o. Hyderabad, do hereby solemnly swear and state on oath as follows:

1. It is respectfully submitted that, I am working as Commissioner of Greater Hyderabad Municipal Corporation (GHMC), Hyderabad. As such, I am well acquainted with the facts of the case. Further, I am deposing this report in view of the order dated:19.12.2022 of the Hon'ble National Green Tribunal, South Zone in OA No. 199 of 2021 based on the records available with the Respondent Corporation.

2. Placing on record the details of all the earlier status reports filed by the 6th Respondent before the Hon'ble National Green Tribunal, Southern Zone, Chennai.

- Report filed by the 6th Respondent, dated 07.10.2021
- Report filed by the 6th Respondent, dated 07.12.2021
- Report filed by the 6th Respondent, dated 05.03.2022
- Report filed by the 6th Respondent, dated 29.03.2022
- Additional Report filed by the 6th Respondent, dated 25.08.2022

Commissioner,
Greater Hyderabad Municipal Corporation

Commissioner,
Greater Hyderabad Municipal Corporation

(2)

- Reply memo filed by the 6th Respondent, dated 25.08.2022
- Status report filed by the 6th Respondent, dated 23.11.2022
- Report filed by the 6th respondent, dated 17.12.2022

3. It is respectfully submitted that following is the status update on the assessment studies being conducted by IIT Bombay on suitability of decomposed MSW for bio-mining at Jawaharnagar:

i. Geophysical investigations of Multi Channel Analysis of Surface Waves (MASW) and 2D-Electrical Resistivity Tomography (ERT) were conducted at the site by Fugro Geotech India Pvt Ltd who is engaged by IIT Bombay and report on the same was submitted dated 03.02.2023.

ii. Subsequently, sampling of Decomposed Municipal Solid Waste (DMSW) from the dump was conducted by M/s. Geostruct Engineering Solutions Pvt. Ltd., Mumbai. Though initial sampling was conducted in January 2023, owing to operational issues, fresh sampling started on 2nd February, 2023. Following is the summary of the report submitted by IIT Bombay after sampling of DMSW and extensive characterization of the DMSW at laboratories in IIT Bombay **(Annexure I):**

- MASW results indicate the presence of loosely compacted MSW up to greater depths, indicating the presence of the MSW which is yet to get stabilized.
- ERT results showed the presence of low-resistivity pockets throughout the dump area, which could be due presence of saturated MSW which is prone to decompose in due course or conductive materials.
- Total of 16 boreholes were dug to retrieve 150 samples. The samples after segregation into course and fine fractions were transported to IIT Bombay for characterization.

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(3)

- During sampling, a few of the boreholes released liquid foam and bubbling of gas through the foam was observed hence indicating the presence of active leachate, which is generated by the decomposition of MSW and the release of landfill gas.
- The segregation of DMSW samples indicates the presence of a dominant fraction of plastics and fine fractions (i.e., ≈40 % each).
- The moisture content of the fine fraction is high (>100 %), which is most probably due to the presence of high organic matter that would decompose in the long run.
- The specific gravity of the fine fractions is around 2.30, which makes it an unsuitable material for structural filling.
- Further, the leachate and foam generation and the emission of landfill gas indicate the ongoing active decomposition of MSW in JLH. Hence, going for biomining at its present status is not recommended.
- However, the environmental suitability of the fine fractions is yet to be established, which would also indicate suitability of this material for agricultural applications. Also, the suitability of coarse fractions as refuse-derived fuel is also being investigated.

4. It is respectfully submitted that following is the compliance to the directions of the Hon'ble NGT, New Delhi orders dated 29.09.2022 in OA 606 of 2018:

i. As per the directions of the Hon'ble NGT, New Delhi, the CPCB has constituted a Committee of Experts with the following members to finalize its viewpoint on whether capping can be retained:

1. Dr. Binisha Payattati, Executive Director, International Institute of Waste Management, Board Member of Technology

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Greater Hyderabad Municipal Corporation

Commissioner,
Greater Hyderabad Municipal Corporation

(4)

Development Board, Ministry of Science and Technology, Govt. of India.

2. Sh. P K Khandelwal, Erstwhile Director, Director NTPC-EDMC Waste Solution Ltd.

3. Dr. B Sengupta, Erstwhile Member Secretary, Central Pollution Control Board.

4. Prof S K Singh, Erstwhile Head of Civil Engineering, Delhi Technological University, Currently VC Rajasthan University

5. Dr. Rakesh Kumar, Erstwhile Director NEERI, CSIR

6. Dr. P U Asnani, Chairman, UMC Global

7. Dr. Asad Warsi, Project Consultant, Indore Municipal Corporation and Director of Eco Pro Environmental Services

8. Dr. Anil Kumar, Erstwhile Director, Department of Environment, Government of Delhi

9. Dr. Levinson J Martins, Managing Director, Goa Waste Management Corporation

10 Sh. J B Ravinder, Joint Adviser (PHEE), Ministry of Housing and Urban Affairs

ii. The Committee of Experts interacted with GHMC, CPCB and TSPCB through video conference on 30.12.2022 in which the capping works were critically examined vis a vis the measures being taken by GHMC to protect the environment while keeping in view the fact that the daily generated MSW of GHMC is also being treated and disposed scientifically in the same site. The report of the Expert Committee is awaited.

5. It is respectfully submitted that following is the progress of 3 proposed alternate sites for diversion of MSW received at Jawahar Nagar facility:

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(5)

A. **Dundigal:**

Construction works of the 14.5 MW Waste to Energy project works have reached final stage. In respect of power evacuation lines, the Govt vide memo dated 08.12.2022 **(Annexure II)** permitted for laying of underground lines. However, citing the difficulties and time delay in laying of underground lines the Concessionaire has requested the Government for according permission for laying of overhead lines. Accordingly, vide Memo dated 28.01.2023 the Government has considered the request **(Annexure III).** The work of erection of power evacuation lines is under progress (**Photographs enclosed as Annexure IV)** and is expected to be completed by the end of March'2023. The plant is expected to be commissioned by end of April' 2023.

B. **Pyaranagar**:

The work of laying of approach road has got delayed due to delay in felling/ translocation of trees as per the conditions in the working approval **(Annexure V)** accorded by the Principal Chief Conservator of Forests. The District Forest Officer, Sangareddy has initiated the process of calling tenders for felling/ translocation of trees as per the conditions in the working approval. After completion of above procedure by the DFO, the approach road work shall commence and the construction works of the Processing Facility shall commence immediately. Consent for Establishment (CFE) has been granted by the TSPCB on 06.02.2023 **(Annexure VI).** Development of MSW processing facility for diversion of 2000 TPD MSW from Jawahar Nagar with 130 tons per day capacity Raw Biogas facility, 45 tons per day capacity Plastic Recycling facility, 100 tons per day capacity Compost facility and 1000 tons per day capacity RDF facility will be taken up immediately after completion of approach road and will be completed in (06) months. The capacity of the above plant will be doubled in second phase including construction of 15 MW Waste to

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Greater Hyderabad Municipal Corporation

(6)

Energy plant for disposal of RDF which will take (01) year for completion from the date of commissioning of 1st phase.

GHMC is putting all efforts and pursuing with the Concessionaire to achieve the project development as per above timelines.

C. **Yacharam:**

The request of the project proponent M/s. Sri Venkateshwara Green Power Projects Ltd for granting permission for enhancement of the project capacity from 12 MW to 14 MW for the reason of financial viability is under the consideration of the Government of Telangana. The project is expected to be completed in (01) year's time.

Submission:

For the aforementioned facts and circumstances, it is therefore prayed that this Hon'ble Tribunal may be pleased to Close the OA No. 199 of 2021 and pass such other order or orders as this Hon'ble Tribunal deems fit and proper in the circumstances of the case and thereby render Justice.

Sworn and signed on this the
8th day of March, 2023 at Hyderabad

Before me
Commissioner,
Greater Hyderabad Municipal Corporation
Advocate

Commissioner,
Greater Hyderabad Municipal Corporation

(7)

VERIFICATION

I, D.S. Lokesh Kumar, S/o. Sri. Soma Raju, aged about 44 years, Occ: Commissioner, Greater Hyderabad Municipal Corporation, R/o Hyderabad, do hereby declare that the contents made in the above paragraphs are true and correct to the best of my knowledge and based on records available with Respondent Corporation and I believe the same to be true and correct. Hence verified on this the 8th day of March, 2023.

Respondent-6

Commissioner,
Greater Hyderabad Municipal Corporation

Interim Report-3

Assessment studies on Suitability of Decomposed Municipal Solid Waste for Bio-mining at Jawaharnagar Capped Dumpsite, Hyderabad

Submitted to

Greater Hyderabad Municipal Corporation (GHMC)

By

Goli Venkata Siva Naga Sai
Mrunal Sunil Bokade
Yogendra Narayanan
Sinny Manohar
Kamran Ilahi
Prithvendra Singh
(Research Scholars)

Pintu Kumar Saw
(Undergraduate student)

and

Prof. D. N. Singh
Principal Investigator
&
D.L. Shah Chair Professor for Innovation

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
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5th March 2023

Table of Contents

List of Figures ii
List of Tables iv
1. Background 1
2. Scope of work 2
3. Reconnaissance survey 2
4. Proposed Investigations 4
4.1. Geophysical investigations 4
4.2. Retrieval of Decomposed MSW from JLH and characterization 4
4.3. Characterization of the DMSW samples 5
4.3.1 Physical characteristics 5
4.3.2 Chemical characteristics 5
5. Investigations carried out and results 5
5.1. Geophysical investigations 5
6. Details of the decomposed MSW sampling and on-site segregation 18
7. Laboratory segregation and characterization 26
7.1. Characterization of the fine fractions 29
7.1.1 Moisture content determination 29
7.1.2 Specific gravity 30
8. Conclusions and way forward 32
Appendix A 33
Appendix B 47
References 53

List of Figures

Figure 1. Photographs of the site taken during the visit.....3
Figure 2. Google map of the JLH with locations selected for Geophysical investigations 4
Figure 3 Google Earth map locating the locations and stretches of the MASW and ERT investigations 6
Figure 4 MASW analysis results of Line-1 7
Figure 5 MASW analysis results of Line-2 7
Figure 6 MASW analysis results of Line-3 8
Figure 7 MASW analysis results of Line-4 8
Figure 8 MASW analysis results of Lines 6 and 7 9
Figure 9 MASW analysis results of Line 8.....9
Figure 10 MASW analysis results of Line 9.....10
Figure 11 MASW analysis results of Line 10.....10
Figure 12 MASW analysis results of Line 11.....11
Figure 13 MASW analysis results of Line 12.....11
Figure 14 MASW analysis results of Line 13.....12
Figure 15 MASW analysis results of Line 14.....12
Figure 16 2D- electrical resistivity imaging map for Line 1.....13
Figure 17 2D- electrical resistivity imaging map for Line 2.....14
Figure 18 2D- electrical resistivity imaging map for Line 3.....14
Figure 19 2D- electrical resistivity imaging map for Line 4.....14
Figure 20 2D- electrical resistivity imaging map for Line 6.....15
Figure 21 2D- electrical resistivity imaging map for Line 7.....15
Figure 22 2D- electrical resistivity imaging map for Line 8.....15
Figure 23 2D- electrical resistivity imaging map for Line 9.....16
Figure 24 2D- electrical resistivity imaging map for Line 10.....16
Figure 25 2D- electrical resistivity imaging map for Line 11.....16
Figure 26 2D- electrical resistivity imaging map for Line 12.....17
Figure 27 2D- electrical resistivity imaging map for Line 13.....17
Figure 28 2D- electrical resistivity imaging map for Line 14.....17
Figure 29 Photographs depicting the flight auger used and sample collection procedure.....20
Figure 30 Photographs depicting sample on-site segregation, weighing and packing and GHMC team at the site 21

Figure 31 Photographs depicting the borehole before and after closure.....25
Figure 32 Photographs depicting leachate and bubble formation and bursting by landfill gas emission 26
Figure 33 Photographs depicting the laboratory segregation process of coarse fractions 27

List of Tables

Table 1 Coordinates for start and end points of MASW & ERT investigations 6

Table 2 Expected lithology for corresponding shear wave velocities in JLH.....13

Table 3 Details of the borehole location, termination depth and number of samples collected 19

Table 4 Weight percentage of coarse and fine samples obtained from in-situ segregation 21

Table 5 Results laboratory segregation of coarse fraction from different boreholes 28

Table 6 Borehole-wise variation in the moisture content of fine fractions 30

Table 7 Borehole-wise variation in the specific gravity of fine fractions 31

1. Background

Landfill biomining (LFM) of existing dumpsites and landfills has been encouraged to avoid the contamination of the geoenvironment (soil, groundwater, and air), recover the precious land occupied by these facilities, and utilization of landfill-mined residues (LMRs) such as plastics, glass, metals and combustibles and soil-like materials for different applications. Nevertheless, to decide on the feasibility of LFM, it is crucial to ascertain the state of the MSW in the landfill/dumpsite. This would not only help in understanding the utilization potential of LMRs but also help in finding the answers to questions such as whether the MSW in the landfill is suitable to be mined, what are the possible issues that can arise during mining operations, and the methodology to be adopted for landfill mining, etc. In this context, the state of MSW in landfill/dumpsite can be determined easily by characterizing the samples of DMSW collected from a landfill for their physical and chemical characteristics. Based on these investigations, a further decision on LFM should be taken. Further, geophysical investigations such as Multi-channel Analysis of Surface Waves (MASW) and Electrical resistivity tomography (ERT) would help in understanding the subsurface properties of the landfill. This would also help to identify leachate and gas pockets that could become an issue during mining activity if not known in advance.

As per the directions of the National Green Tribunal (NGT) Principal Bench, Greater Hyderabad Municipal Corporation (GHMC) is prepared to take up the biomining of capped Jawaharnagar Dumpsite, Hyderabad and called for tenders. However, as the dumpsite is capped recently (i.e., 2018), the GHMC approached Prof. D. N. Singh, Department of Civil Engineering, Indian Institute of Technology Bombay, for help in several technical aspects such as evaluating the readiness of the capped dumpsite for biomining, evaluating the technical proposal received for biomining operation, establishing the methodology for biomining, etc. Keeping these in view, a scientific study on capped dumpsite at Jawaharnagar, Hyderabad, is planned by the Indian Institute of Technology Bombay under the supervision of Prof. D. N. Singh, IIT Bombay. In this regard, to evaluate the readiness of the capped dumpsite at Jawaharnagar, Hyderabad, for biomining, a study has been proposed by IIT Bombay. The technical and financial aspects of the study proposed are mentioned below.

2. Scope of work

The broad scope of this proposal is to help GHMC in the bid process and carry out geophysical investigations, retrieval, and characterization of the decomposed MSW (DMSW) samples at Jawaharnagar landfill Hyderabad (referred to as JLH).

The detailed scope of the work is mentioned below:

- Guiding GHMC in the bidding process for the work of biomining of the capped legacy dumpsite.
- Conducting geophysical investigations, namely Multichannel Analysis of Surface Waves (MASW) and 2-dimensional Electrical Resistivity Tomography (2D-ERT) on the dumpsite at different locations to understand the subsurface features.
- Extensive sampling of DMSW samples from different locations.
- Segregation and characterization of the DMSW samples for their Physico-chemical parameters.
- Establishing the present state of the decomposition of the MSW.
- Characterization of leachate samples (if any) during the sampling of the DMSW from different boreholes.
- A critical analysis of the way forward.

3. Reconnaissance survey

Based on the data shared by GHMC on 22.04.2022, a proposal was prepared by IIT Bombay and shared to conduct the investigations within the scope mentioned above. The study broadly involves conducting geophysical (MASW and ERT) investigations and retrieval and characterization of the DMSW samples.

In this context, the IIT Bombay team, along with the representatives of M/s. Ramky Enviro Engineers Ltd. (REEL), Environmental Protection Training and Research Institute, Hyderabad (EPRTI), and GHMC visited the site to select the locations for conducting Geophysical investigations at the JLH site (refer to Figure 1). This exercise would help in selecting the subsequent locations for retrieval of the samples from the landfill without causing much harm to the existing cover, gas and leachate collection systems.



(a)



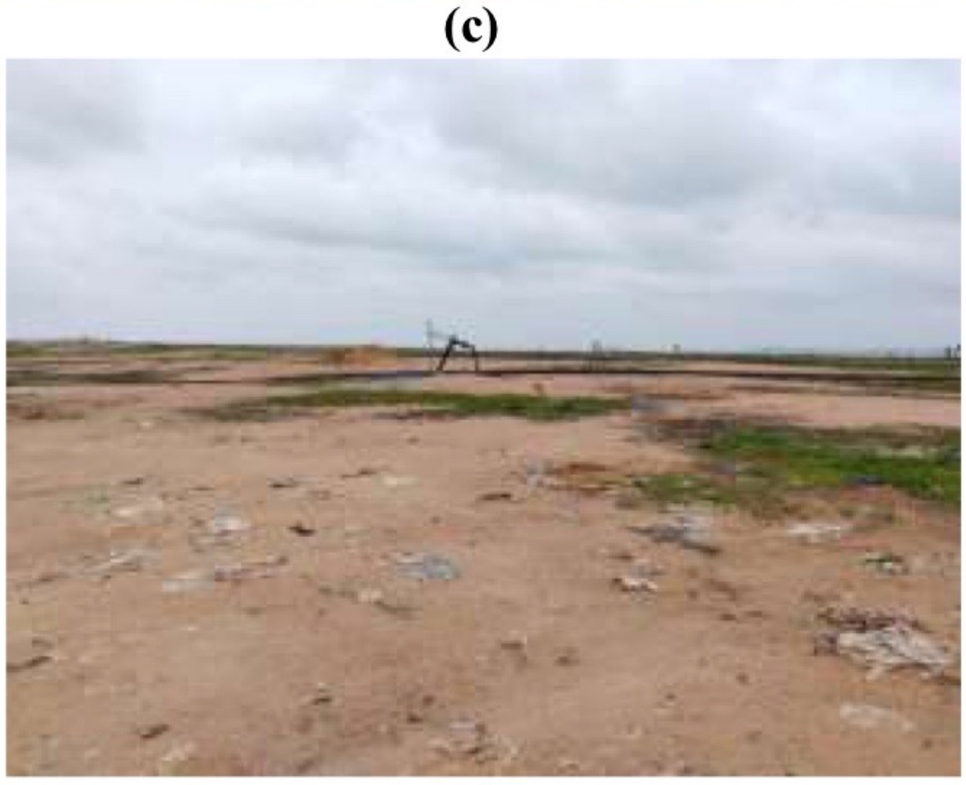
(b)



(c)



(d)



(e)



(f)

Figure 1. Photographs of the site taken during the visit

4. Proposed Investigations

4.1. Geophysical investigations

Based on the site visit and the information given by the representatives of REEL, EPTRI and GHMC, locations for the Geophysical investigations have been selected, as represented in Figure 2. Please refer to Lines 1 to 5 (designated as L1 to L5). Lines L1 to L4 have been selected based on the maximum height of the landfill at these locations, whereas L5 has been selected to identify the presence/absence of leachate pockets as it is a low-lying area previously and close to leachate ponds. The preliminary site survey helped us estimate that each MASW and ERT investigation should be conducted for a total of 3000 meters.



Figure 2. Google map of the JLH with locations selected for Geophysical investigations

4.2. Retrieval of Decomposed MSW from JLH and characterization

The top cover (including green and clay) and other geotextile layers will be removed manually. Followed by a flight auger (diameter ranging between 100 and 300 mm), attached to a pile-driving unit, will be inserted in the capped landfill to drill a borehole using hydraulic equipment (Mohammad et al., 2021). The DMSW and leachates obtained at different borehole depths will be collected. Borehole drilling from the top of the landfill will be initiated by inserting a mild steel casing. The casing helps in stabilizing the borehole during the drilling operation. The drilling would be continued as deep as possible based on the site conditions, keeping in view the safety of buried utilities. A sampling of MSW will be done every 2-3 m or wherever changes in the strata. The boreholes should be sealed again by the landfill operator

after the sampling is completed. The retrieved samples will be spread on a clean geomembrane (near the borehole on the two loops) and divided into four quarters with the help of a shovel. Furthermore, the MSW samples (≈5-10 kg) would be randomly collected for *three quarters* for laboratory testing. The leftover samples of MSW should be backfilled into the boreholes. Depending upon the state of the exhumed MSW samples, their storage at 4 °C, in a refrigerator at the site will be done. Subsequently, the samples will be transported to the IIT Bombay laboratory for their characterization, as mentioned in the following.

4.3. Characterization of the DMSW samples

4.3.1 Physical characteristics

The DMSW will be sieved through 20 mm size sieve and the retained portion will be manually segregated into various fractions such as plastics, textiles, metals, glass, paper, etc. Further, the <20 mm fraction considered as soil-like materials will be tested for moisture content and specific gravity.

4.3.2 Chemical characteristics

The biochemical processes involved in the decomposition of MSW in a landfill transform the organic matter (OM) present in it. With this in view, the chemical parameters of MSW, namely, volatile solids, elemental content, total organic carbon, ammonium and nitrate nitrogen, and heavy metals, will be performed on the MSW samples retrieved from the landfill. In addition to the characterization of MSW, a few leachate samples will be tested for their chemical parameters (viz., pH, EC, TOC, COD, sulfates, phosphates, nitrate-nitrogen, ammonium-nitrogen, and heavy metals).

Based on the above-mentioned comprehensive testing protocol, the readiness of the JLH for booming will be established. If the dumpsite can be mined, the recommendations for initiating mining will be submitted to GHMC.

5. Investigations carried out and results

5.1. Geophysical investigations

IIT Bombay engaged Fugro Geotech India Pvt. Ltd. (FGTL) to conduct MASW and 2-dimensional ERT as a part of geophysical investigations and the results are presented in the following:

Different representative locations and stretches (read lines) on the JLH were selected, refer to Figure 3, and a total of 3000 m length was covered. The coordinates of the start and end points for each of these stretches are mentioned in Table 1.

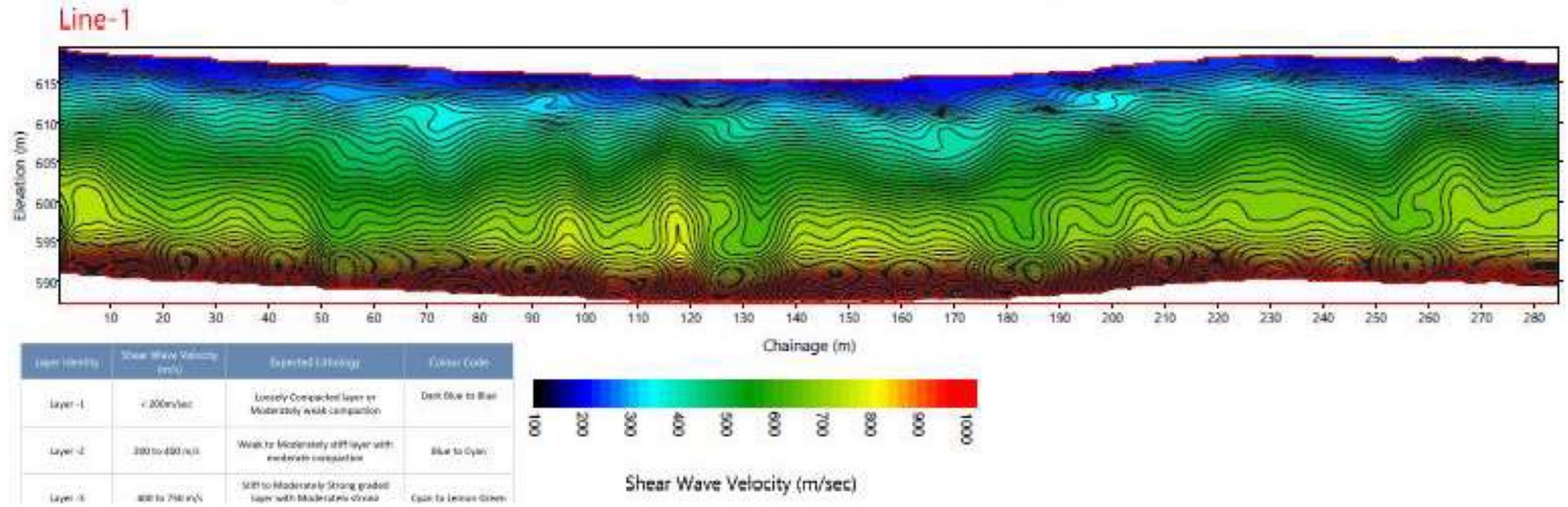


Figure 3 Google Earth map locating the locations and stretches of the MASW and ERT investigations

Table 1 Coordinates for start and end points of MASW & ERT investigations

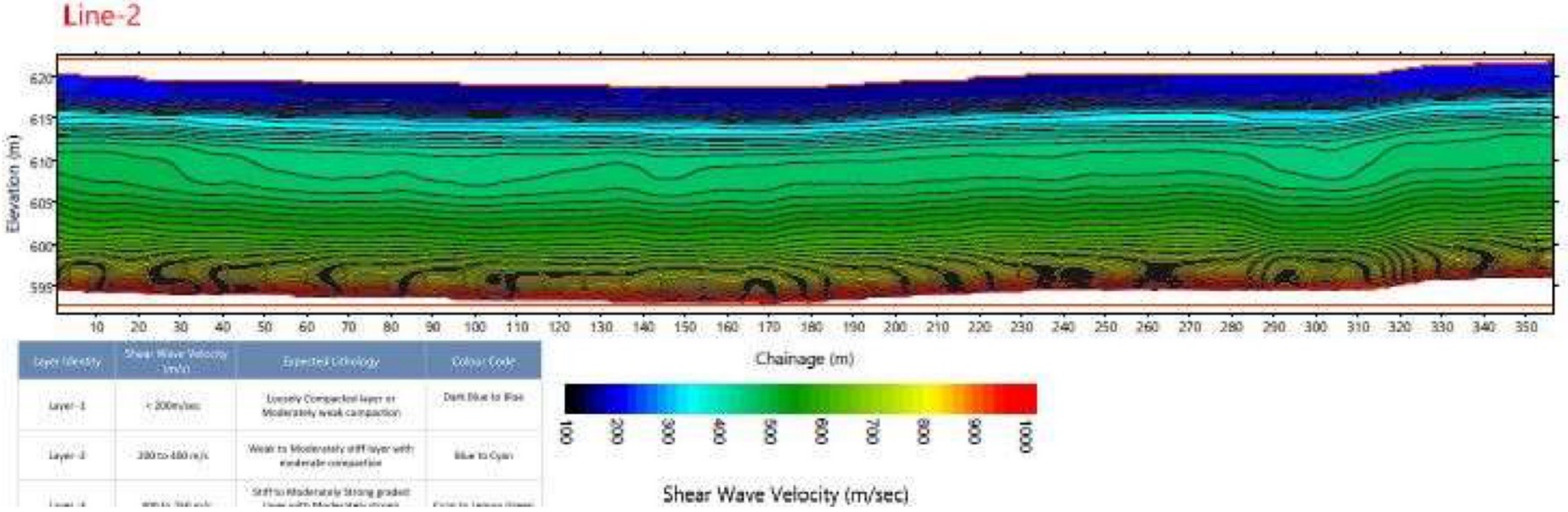
Line Name	Start Coordinates		End Coordinates		Line Length (m)
	Easting	Northing	Easting	Northing	
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Line No 02	244463.67	1939005.7	244538.64	1938657.9	356
Line No 03	244509.12	1938654.7	244453.77	1939005.8	356
Line No 04	244627.65	1939043.2	244724.49	1938854.1	216
Line No 06	244747.97	1938687.1	244769.86	1938790.4	108
Line No 07	244768.09	1938692.5	244799.6	1938793.8	108
Line No 08	244303.79	1939060.6	244330.64	1938704.7	356
Line No 09	244041.55	1939193.8	244004.74	1939094.2	108
Line No 10	244498.79	1938955.8	244357.72	1938962.6	144
Line No 11	244518.41	1938875	244375.79	1938876.6	144
Line No 12	244557.57	1938838.2	244355.08	1938772.7	216
Line No 13	244580.39	1938707.8	244368.13	1938706.5	216
Line No 14	244395.78	1939035.7	244481.63	1938619.3	428

The results obtained from the analysis is depicted in Figure 4 to 15.



Layer Identity	Shear Wave Velocity (m/s)	Expected Lithology	Colour Code
Layer -1	< 200m/sec	Loosely Compacted layer or Moderately weak compaction	Dark Blue to Blue
Layer -2	200 to 400 m/s	Weak to Moderately stiff layer with moderate compaction	Blue to Cyan
Layer -3	400 to 750 m/s	Stiff to Moderately Strong graded layer with Moderately dense	Cyan to Lemon Green

Figure 4 MASW analysis results of Line-1



Layer Identity	Shear Wave Velocity (m/s)	Expected Lithology	Colour Code
Layer -1	< 200m/sec	Loosely Compacted layer or Moderately weak compaction	Dark Blue to Blue
Layer -2	200 to 400 m/s	Weak to Moderately stiff layer with moderate compaction	Blue to Cyan
Layer -3	400 to 750 m/s	Stiff to Moderately Strong graded layer with Moderately dense	Cyan to Lemon Green

Figure 5 MASW analysis results of Line-2

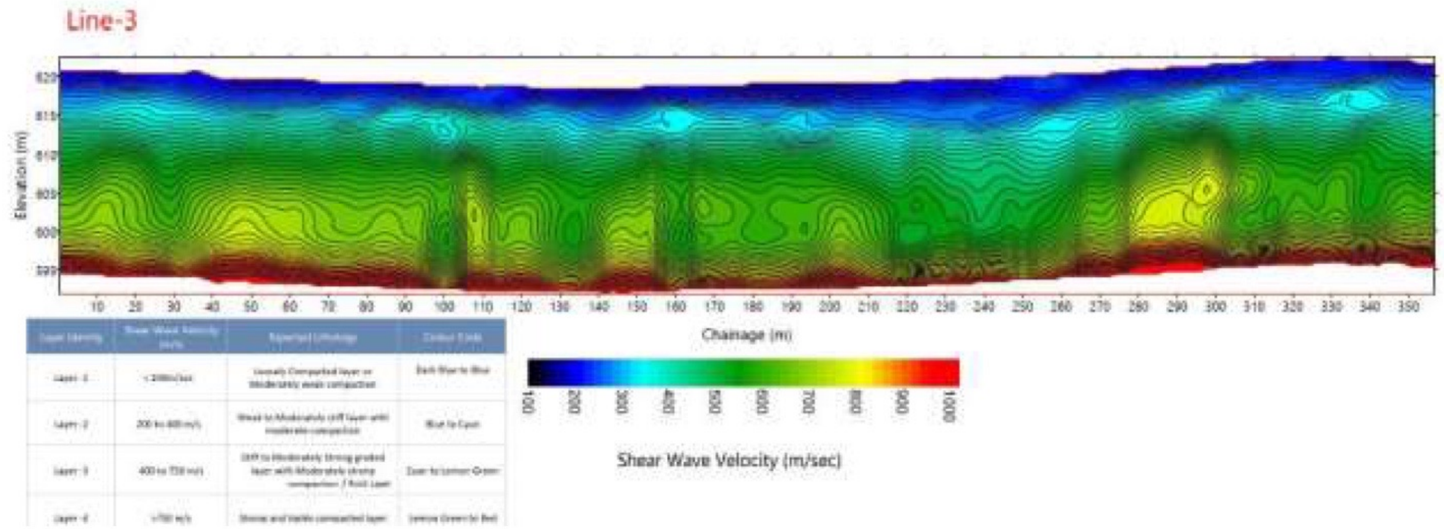


Figure 6 MASW analysis results of Line-3

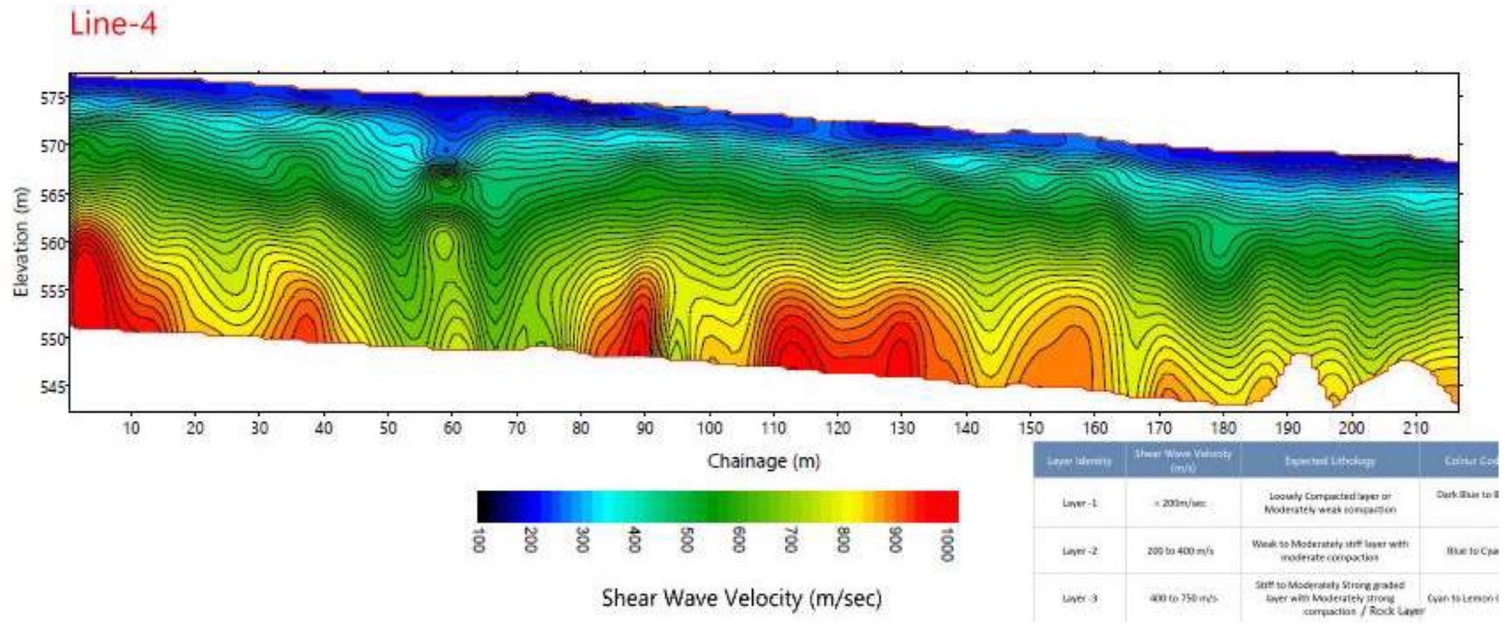


Figure 7 MASW analysis results of Line-4

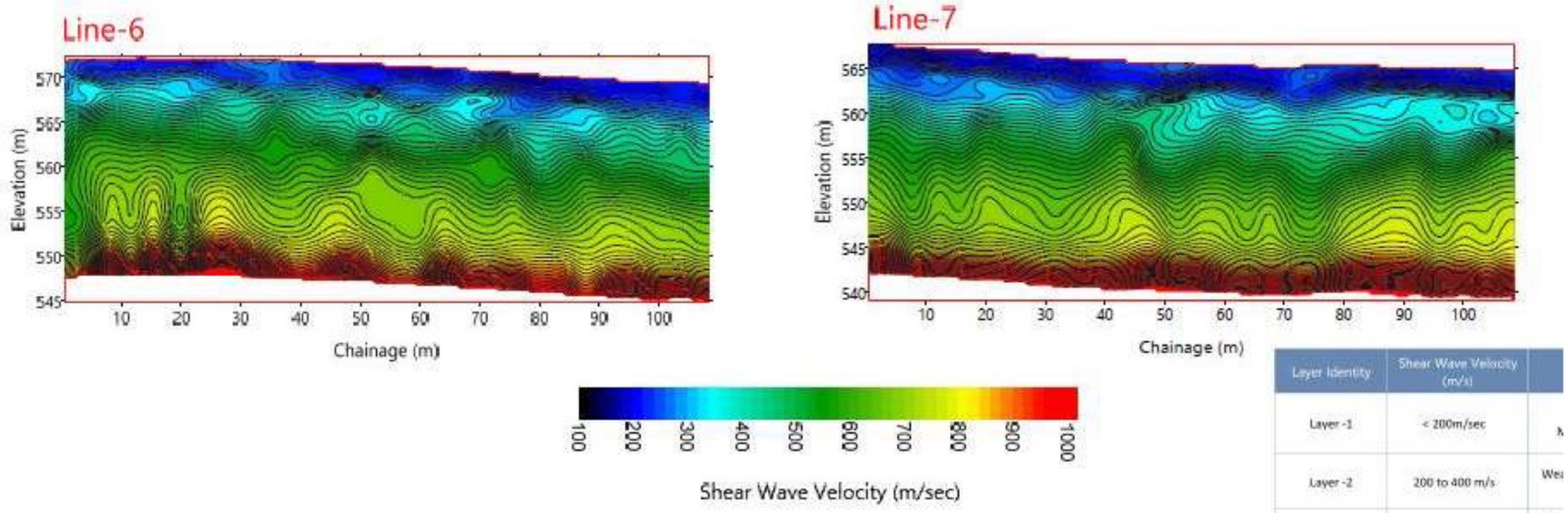


Figure 8 MASW analysis results of Lines 6 and 7

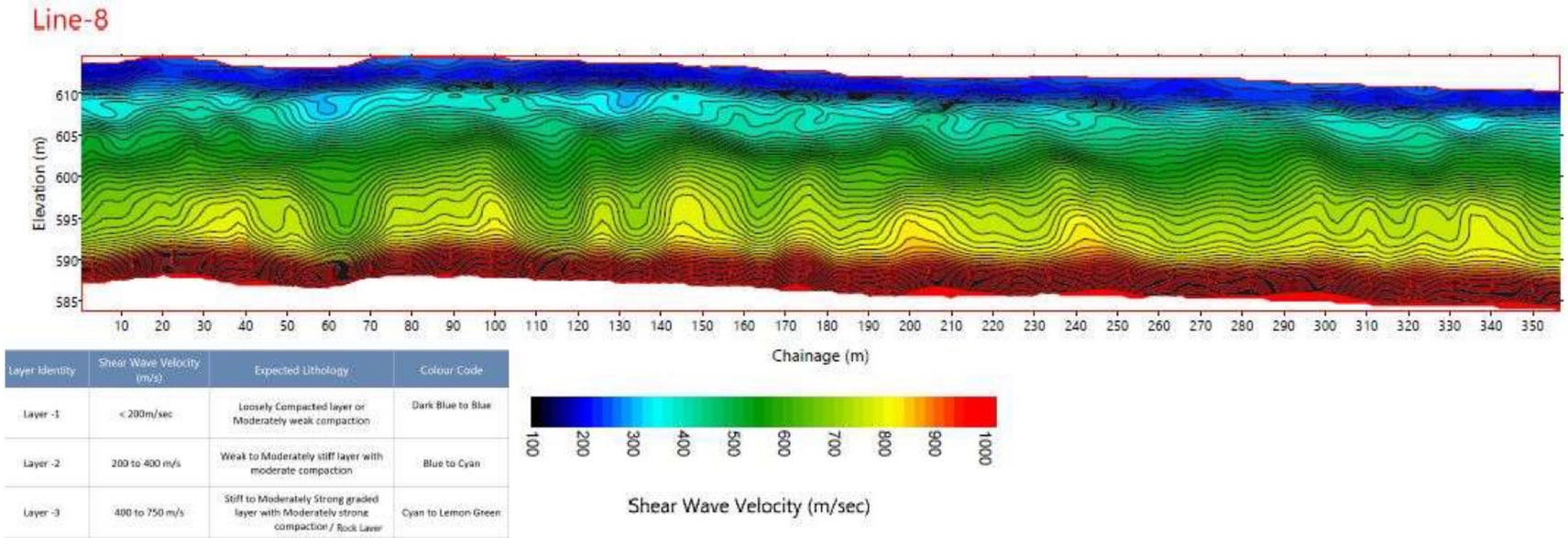


Figure 9 MASW analysis results of Line 8

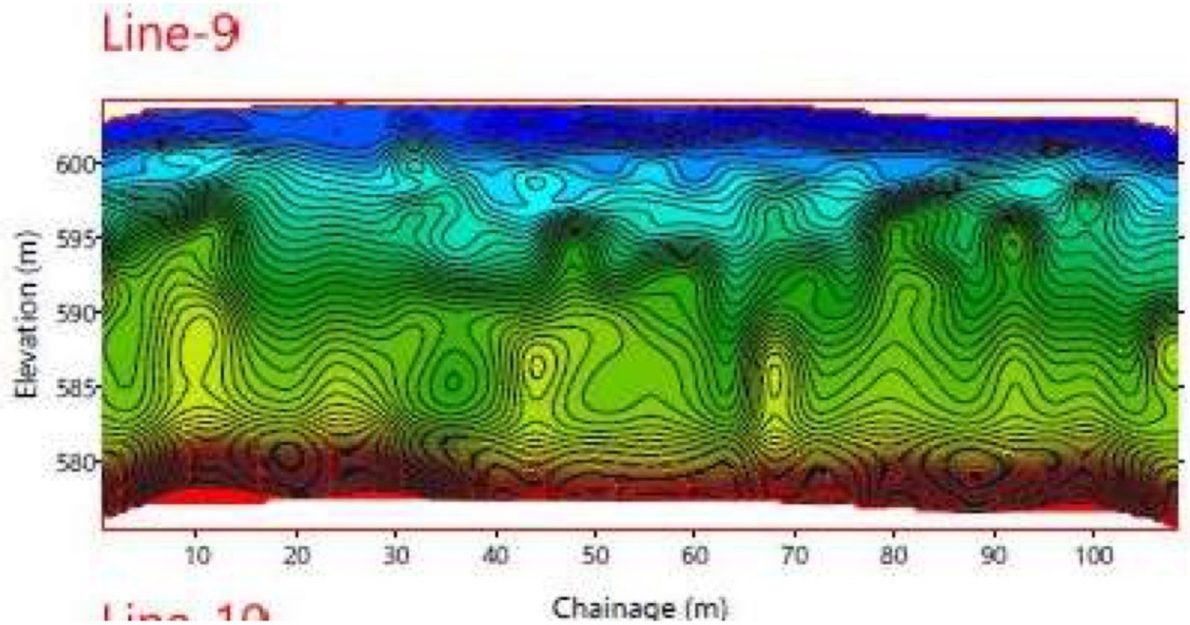


Figure 10 MASW analysis results of Line 9

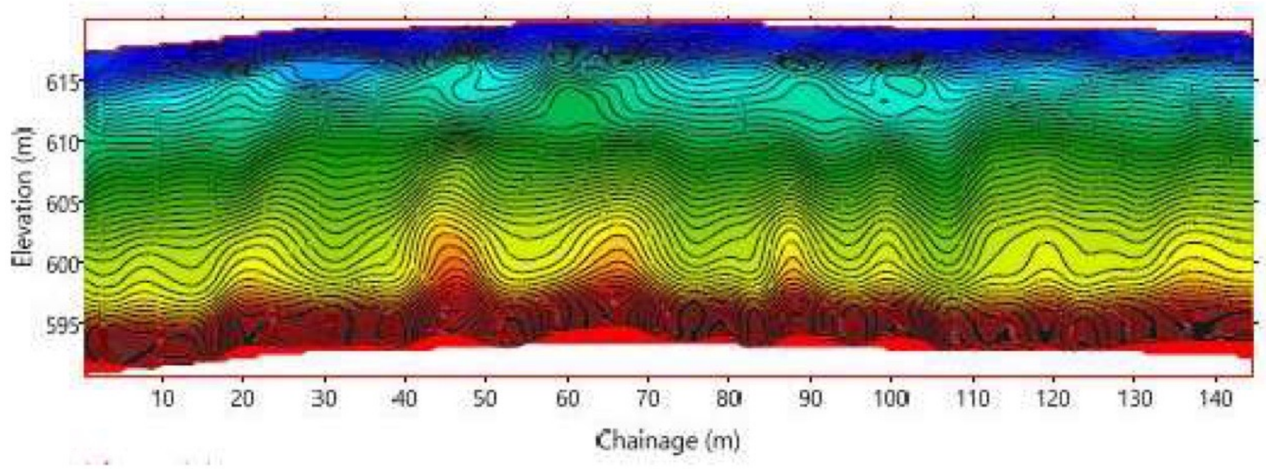


Figure 11 MASW analysis results of Line 10

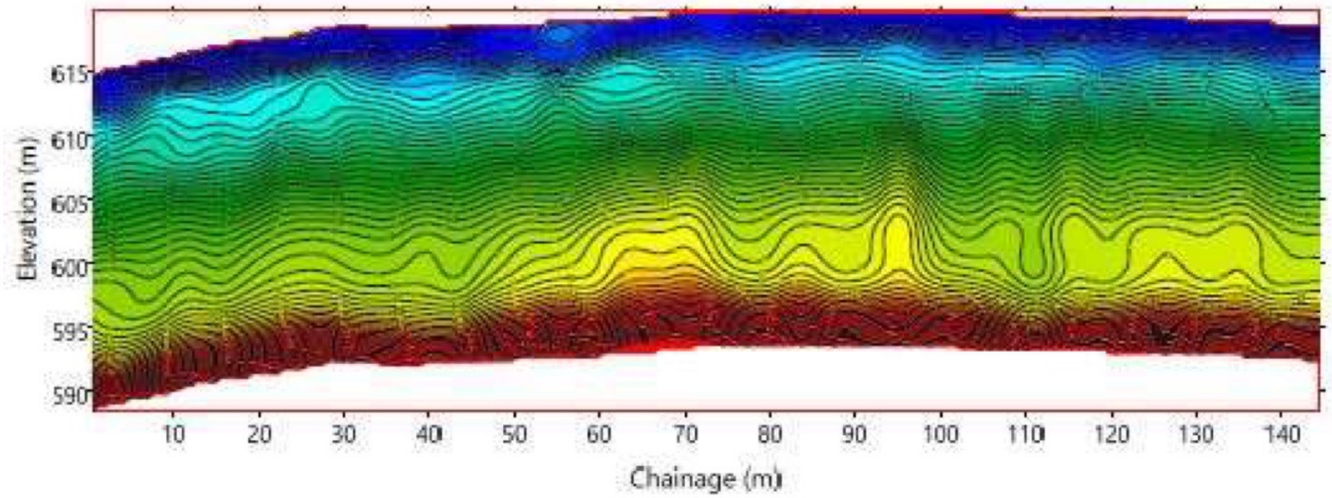


Figure 12 MASW analysis results of Line 11

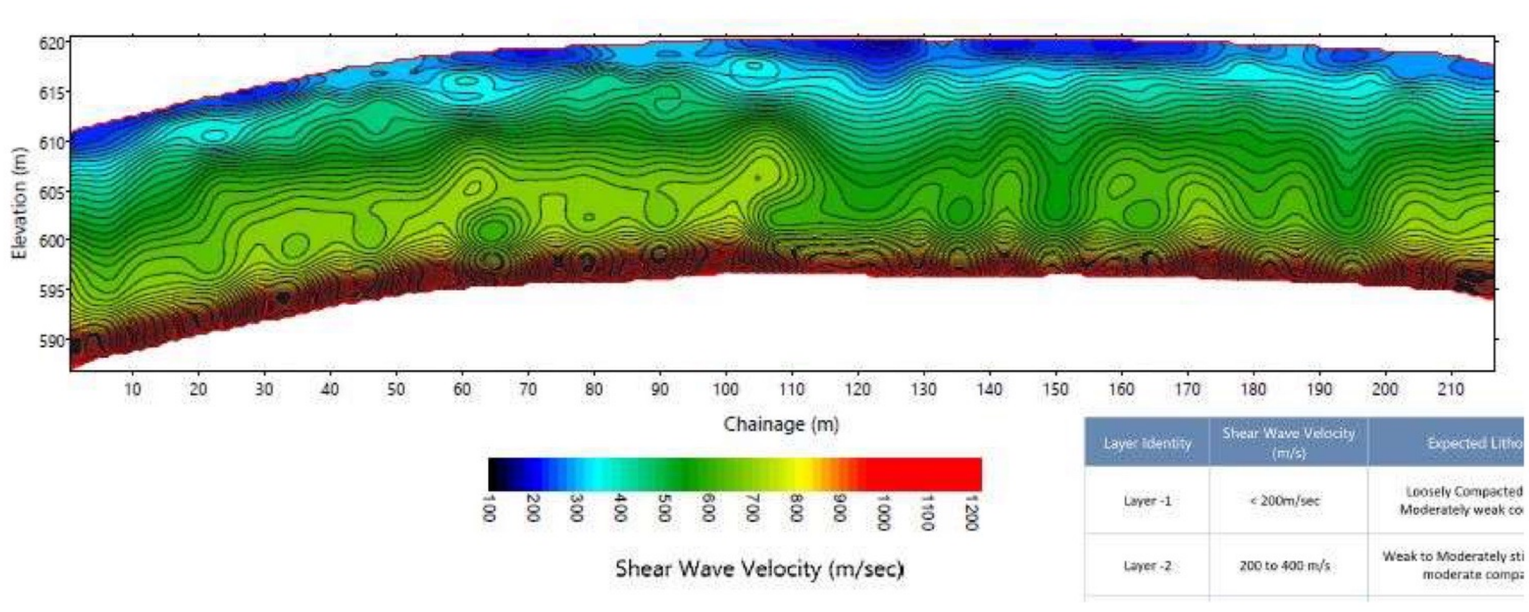


Figure 13 MASW analysis results of Line 12

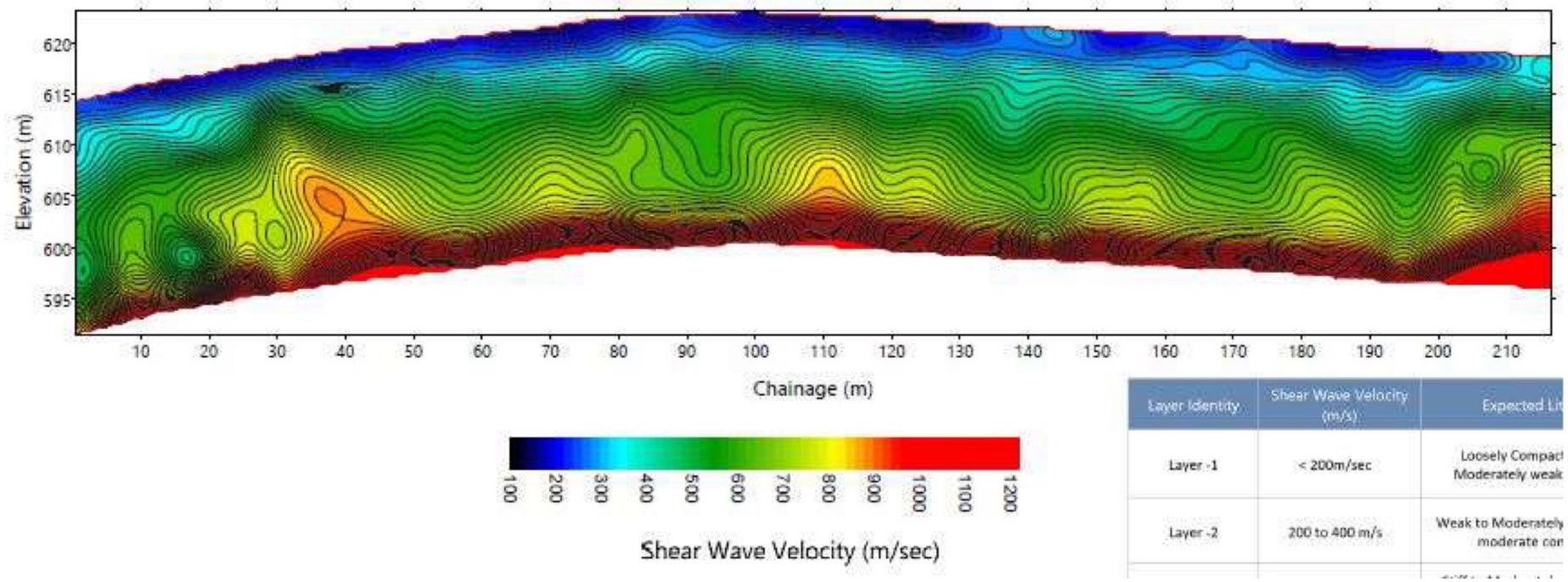


Figure 14 MASW analysis results of Line 13

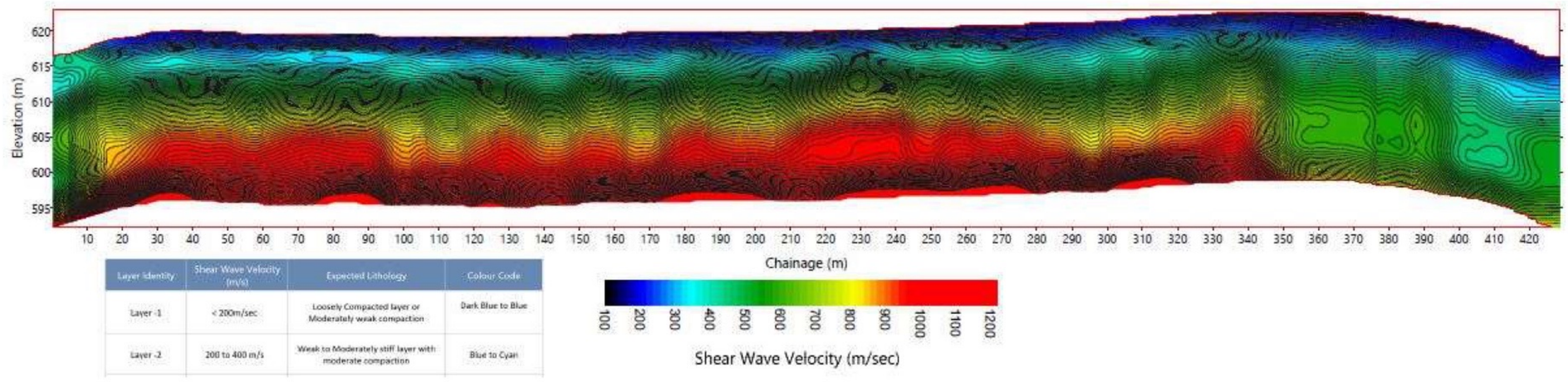


Figure 15 MASW analysis results of Line 14

Details of the subsurface properties (read lithology) obtained from the MASW are listed in Table 2. It can be observed from Table 2 and Figures 4 to 15 that the majority portion of the JLH contains loosely compacted material, which can be due to the (i) presence of a high percentage of leachates and (ii) undecomposed MSW.

Table 2 Expected lithology for corresponding shear wave velocities in JLH

Layer Identity	Shear Wave Velocity (m/s)	Expected Lithology	Colour Code
Layer -1	< 200m/sec	Loosely Compacted layer or Moderately weak compaction	Dark Blue to Blue
Layer -2	200 to 400 m/s	Weak to Moderately stiff layer with moderate compaction	Blue to Cyan
Layer -3	400 to 750 m/s	Stiff to Moderately Strong graded layer with Moderately strong compaction	Cyan to Lemon Green
Layer -4	>750 m/s	Strong and highly compacted layer	Lemon Green to Red

Further, to identify the presence of leachate and the state of the MSW, 2D-ERT investigations were conducted and the results are presented in the following (Lines 1 to 14 in Figures 16 to 28).

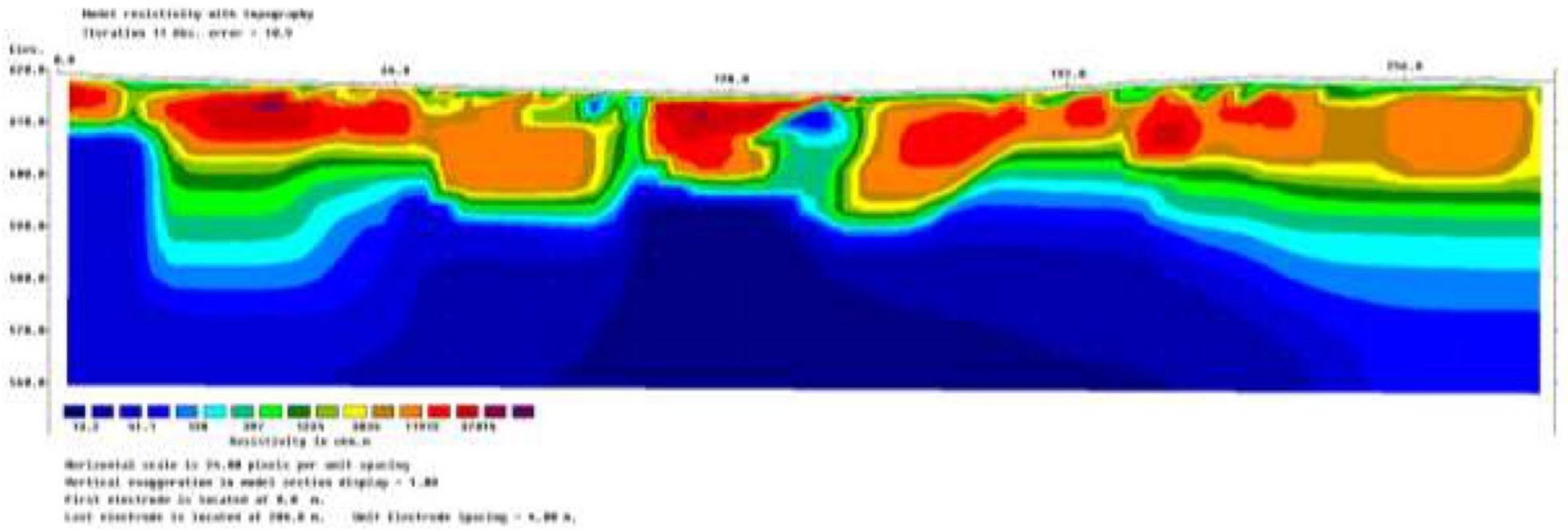


Figure 16 2D- electrical resistivity imaging map for Line 1

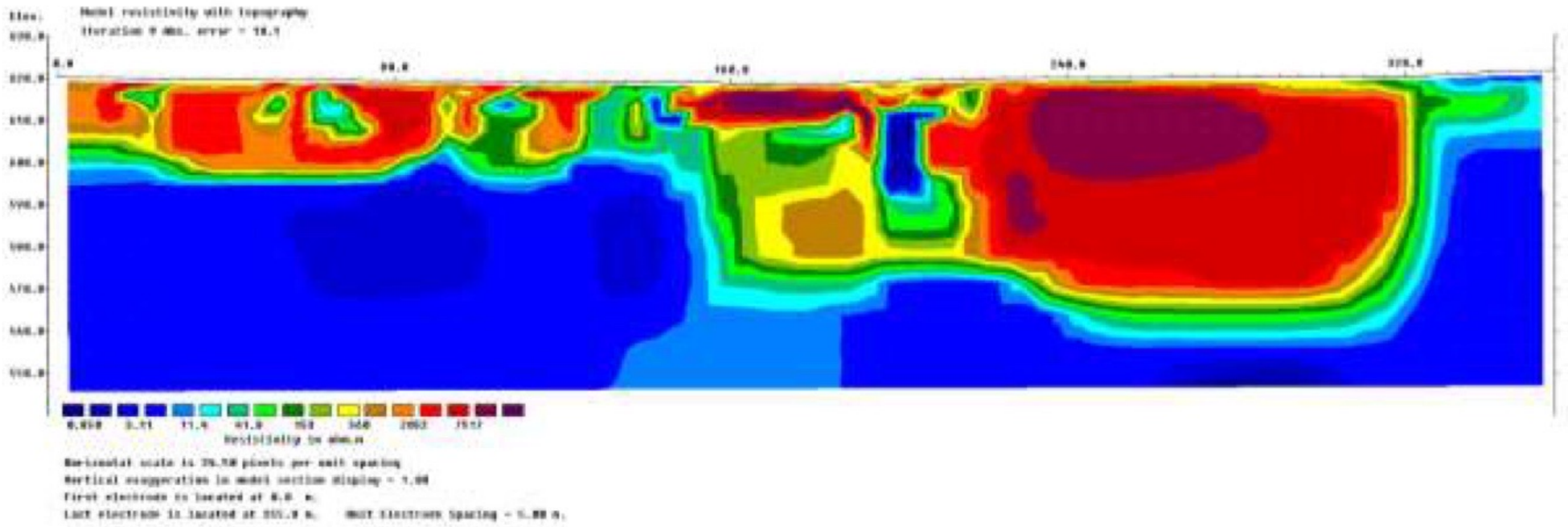


Figure 17 2D- electrical resistivity imaging map for Line 2

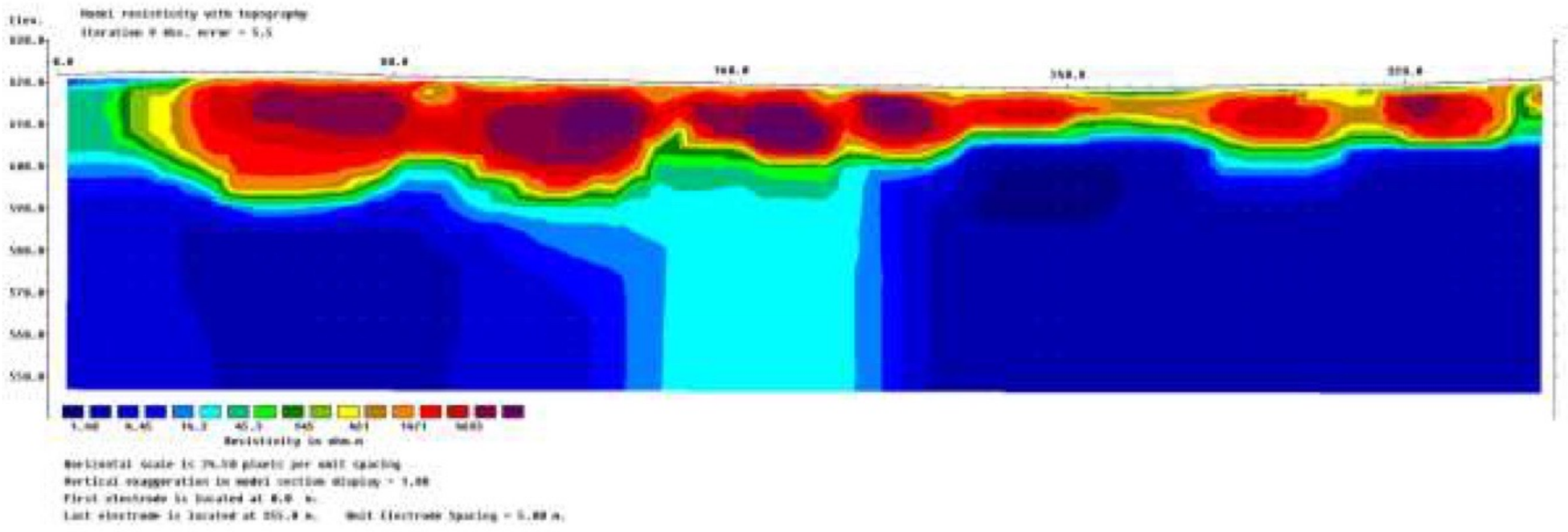


Figure 18 2D- electrical resistivity imaging map for Line 3

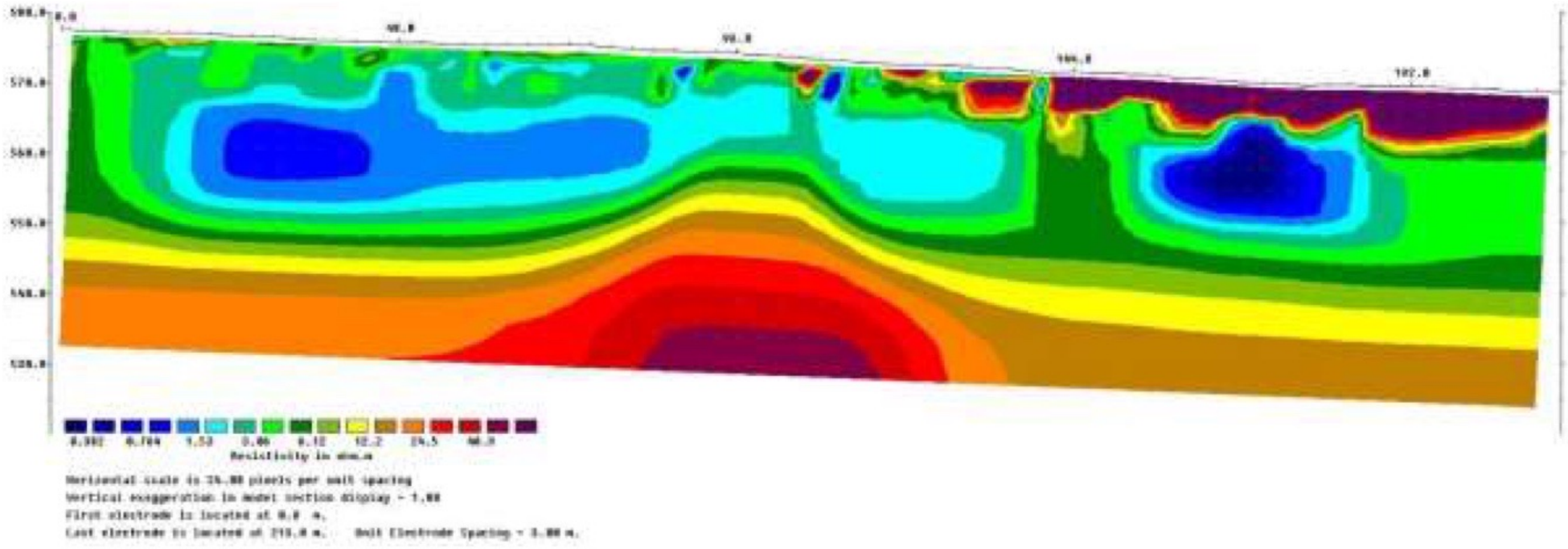


Figure 19 2D- electrical resistivity imaging map for Line 4

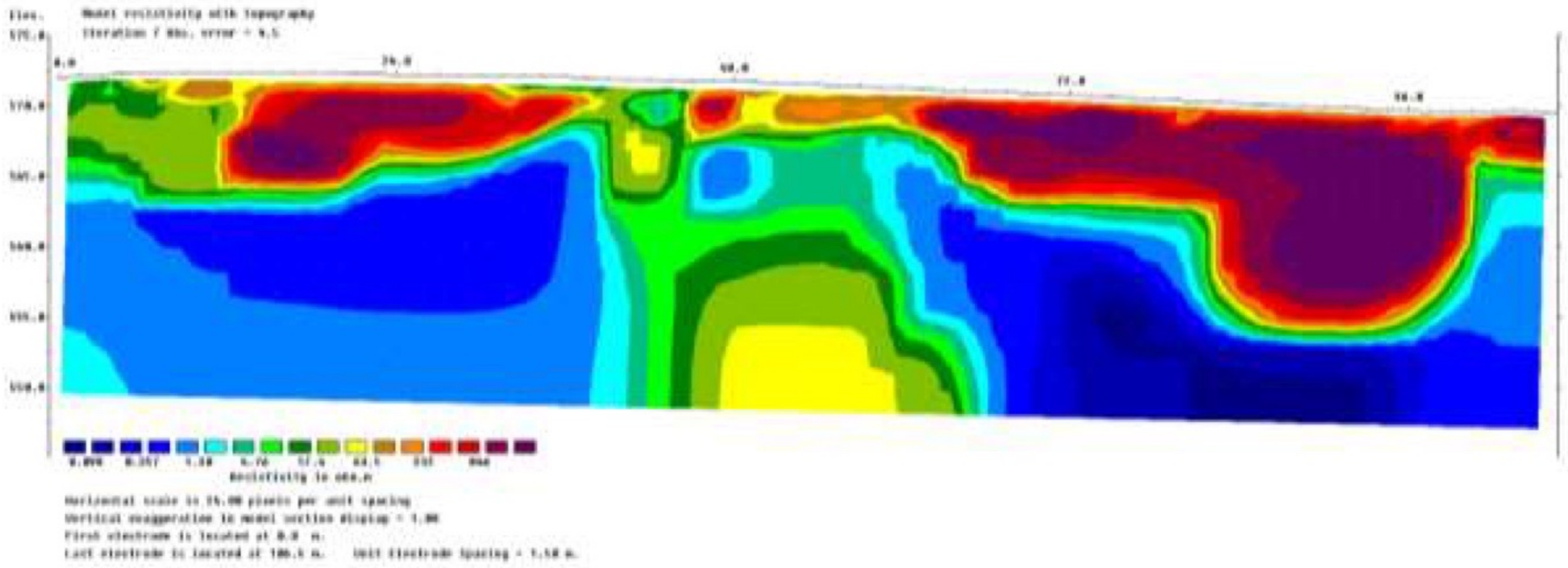


Figure 20 2D- electrical resistivity imaging map for Line 6

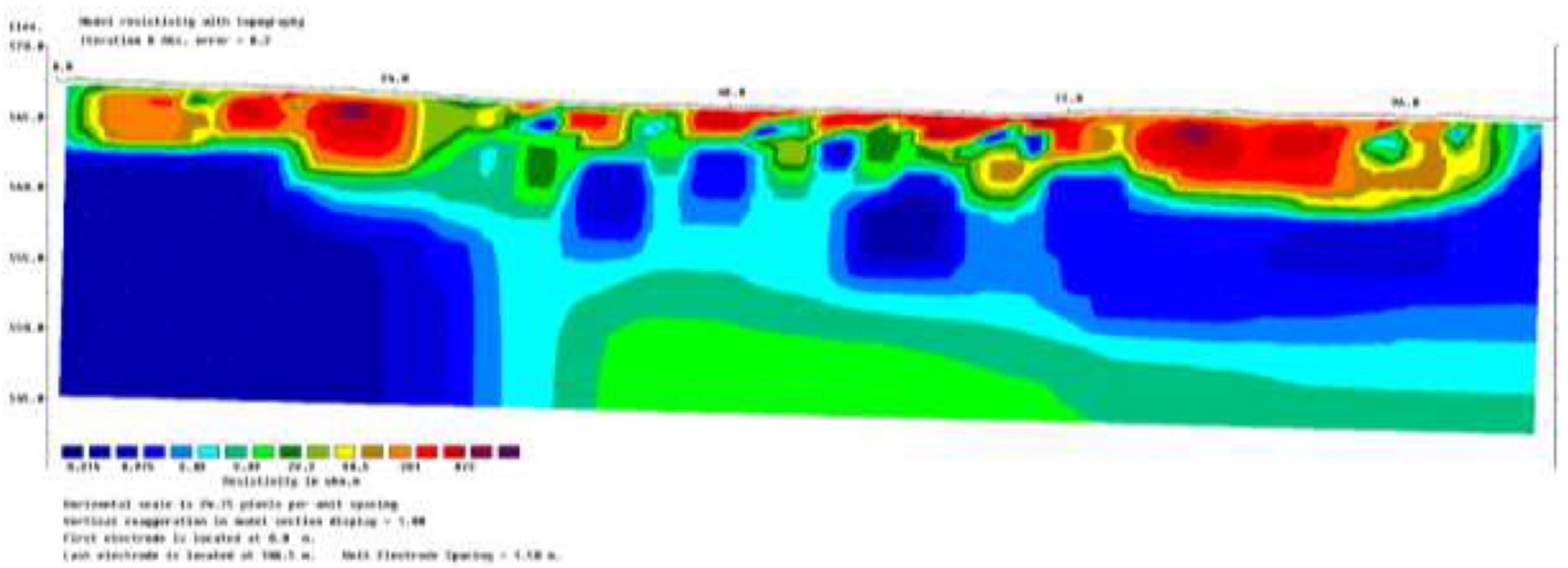


Figure 21 2D- electrical resistivity imaging map for Line 7

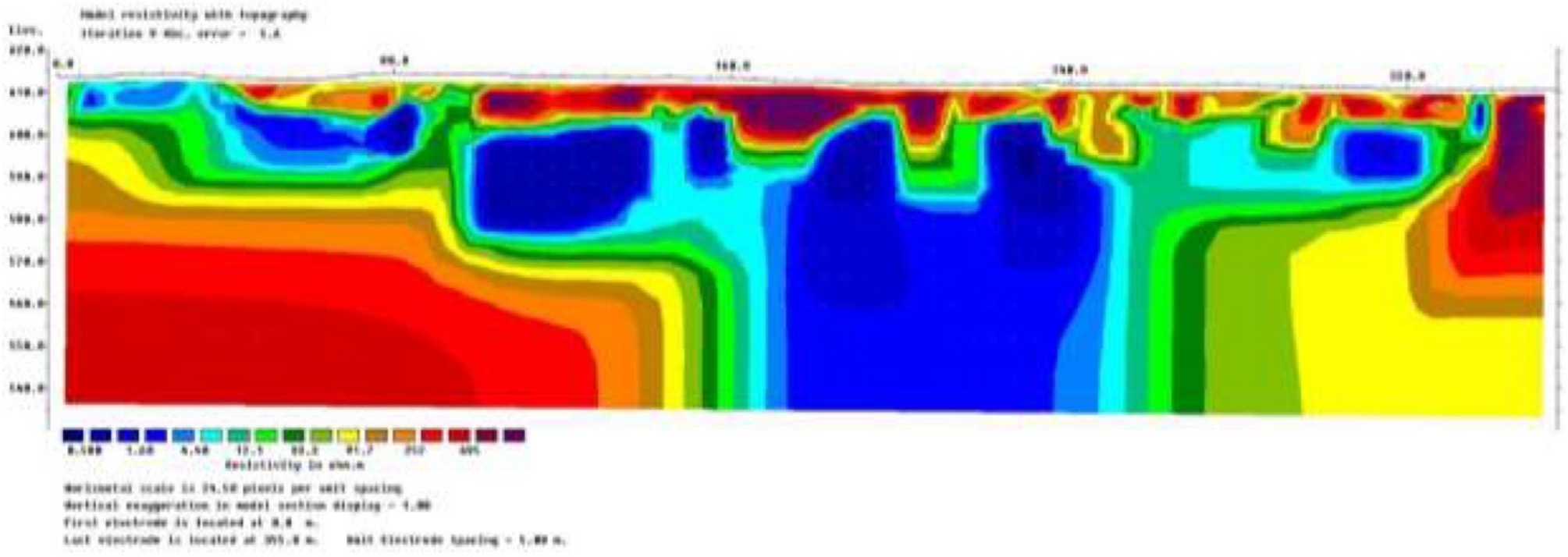


Figure 22 2D- electrical resistivity imaging map for Line 8

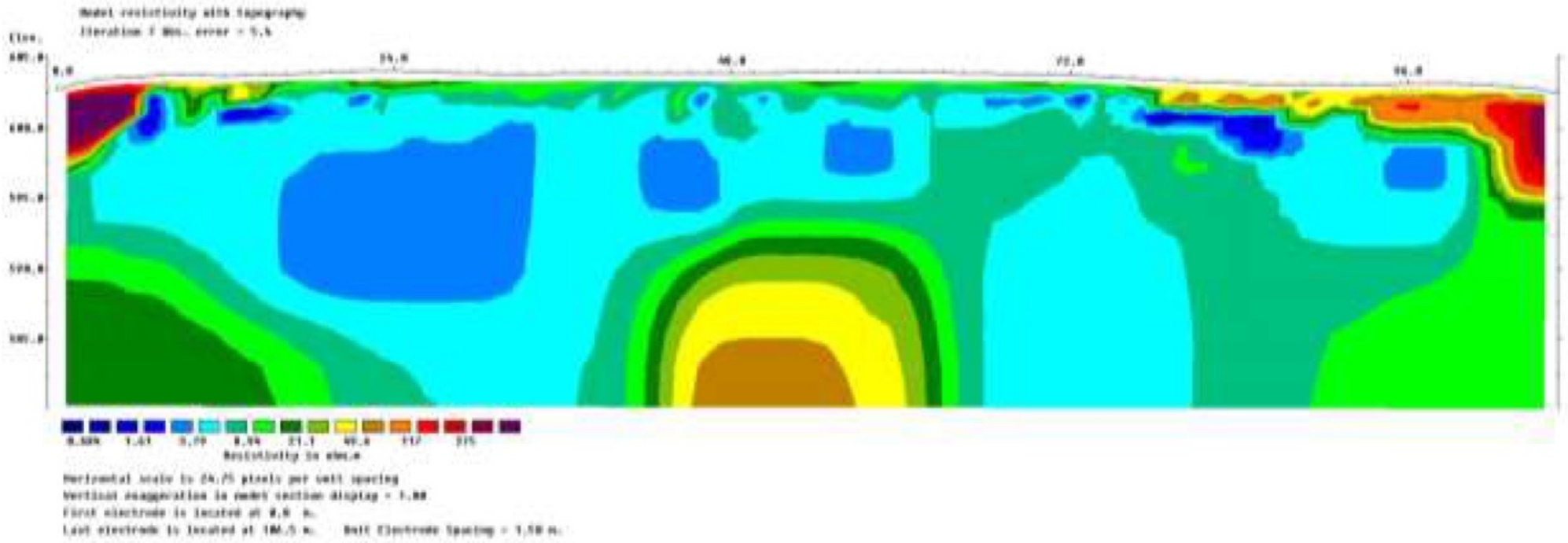


Figure 23 2D- electrical resistivity imaging map for Line 9

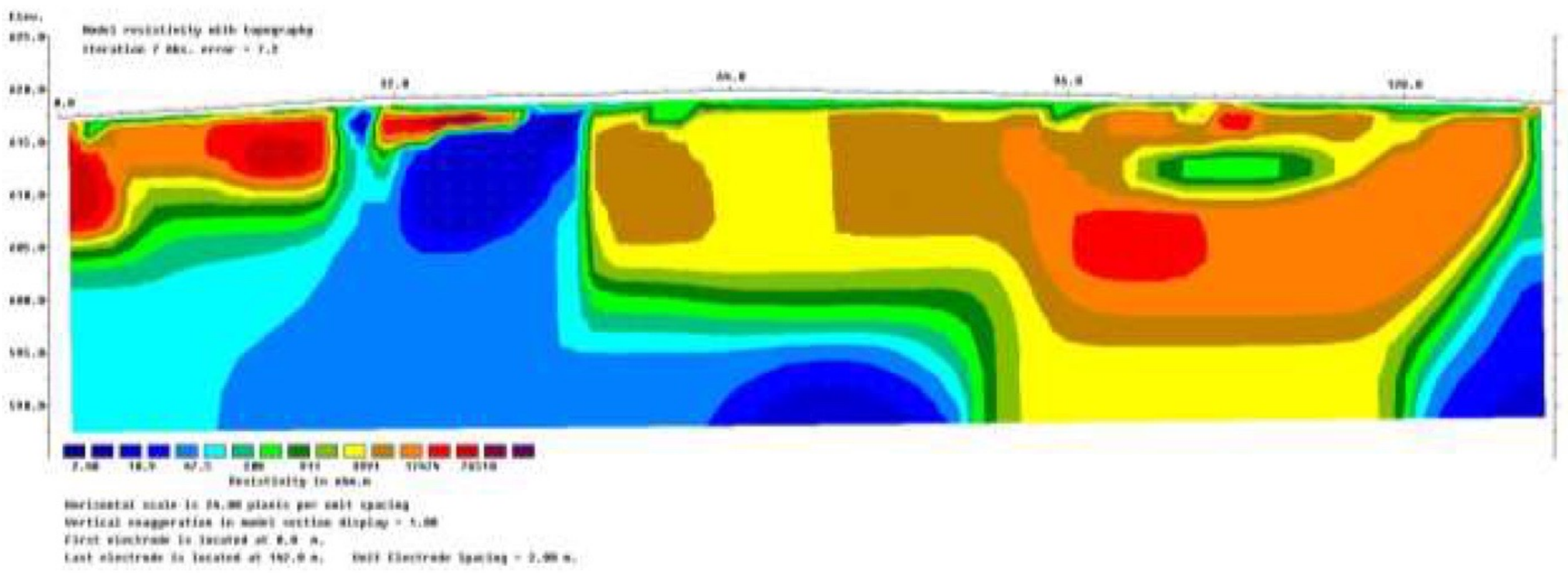


Figure 24 2D- electrical resistivity imaging map for Line 10

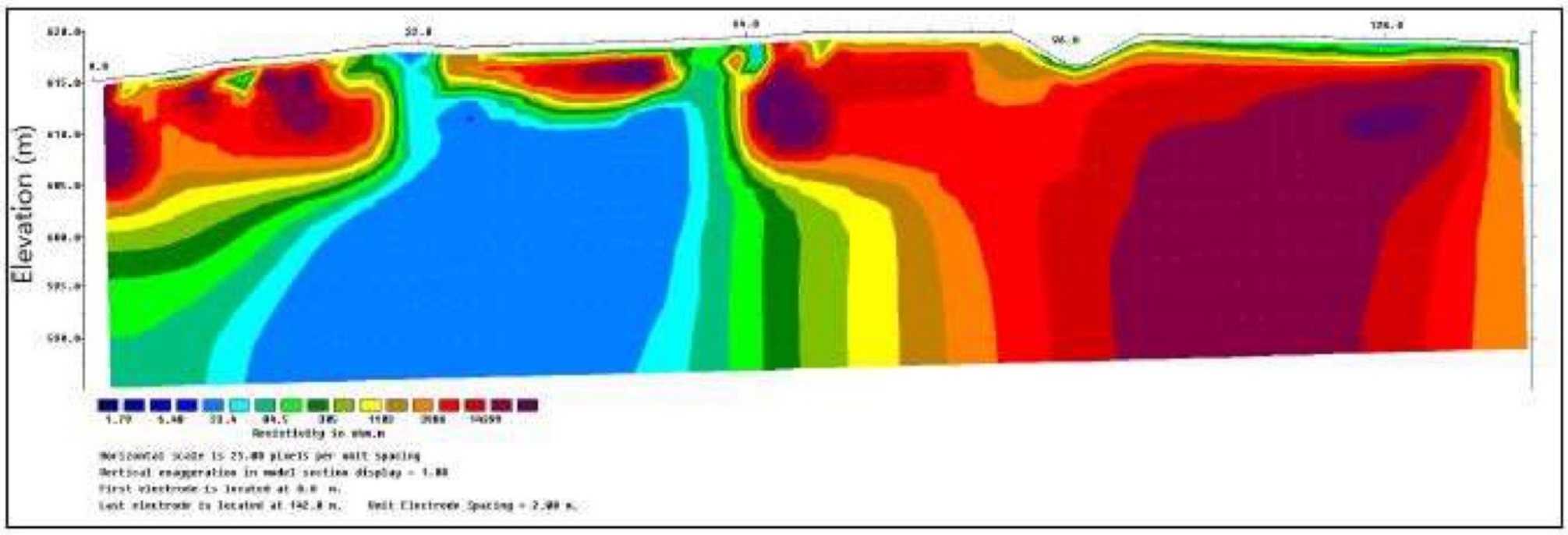


Figure 25 2D- electrical resistivity imaging map for Line 11

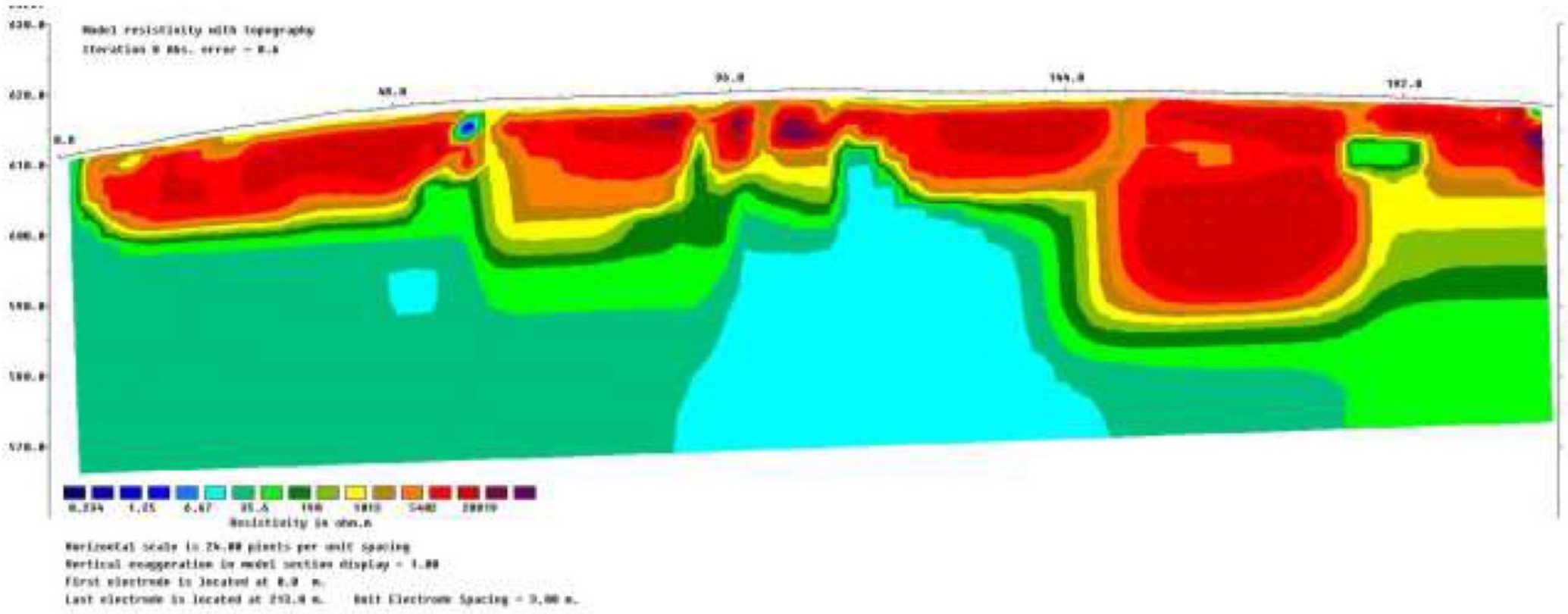


Figure 26 2D- electrical resistivity imaging map for Line 12

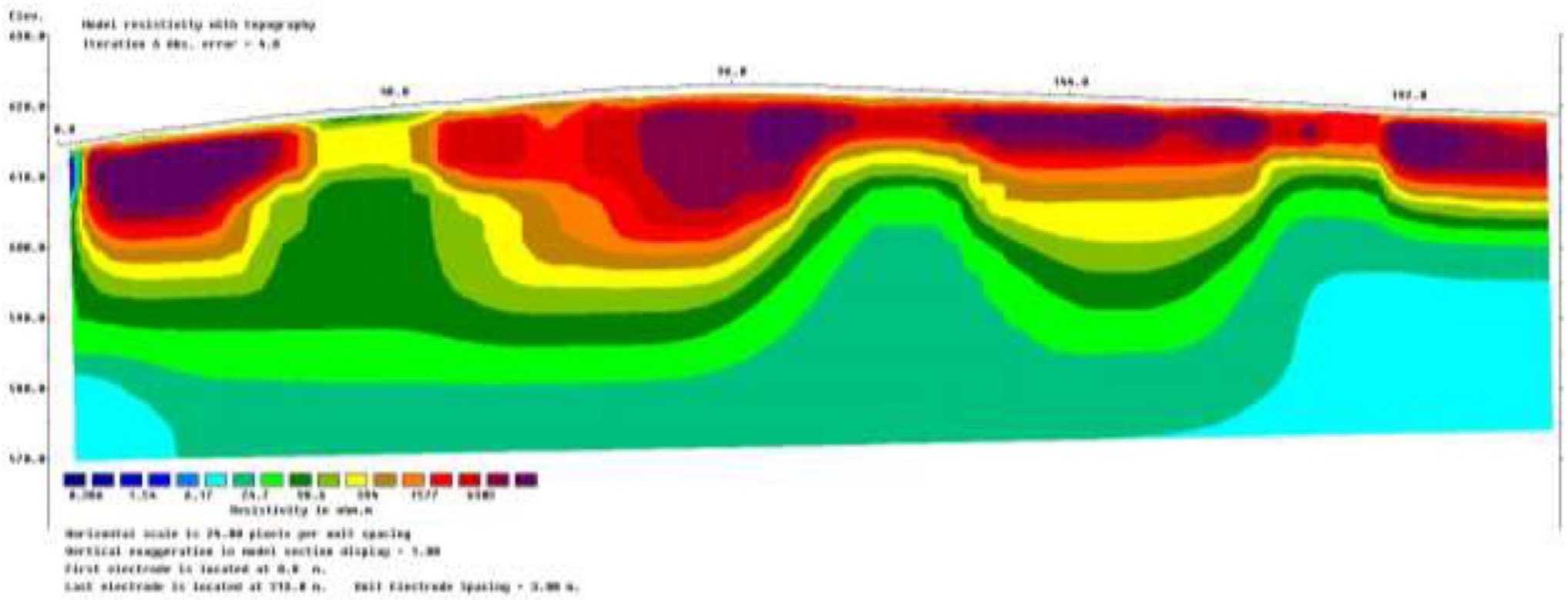


Figure 27 2D- electrical resistivity imaging map for Line 13

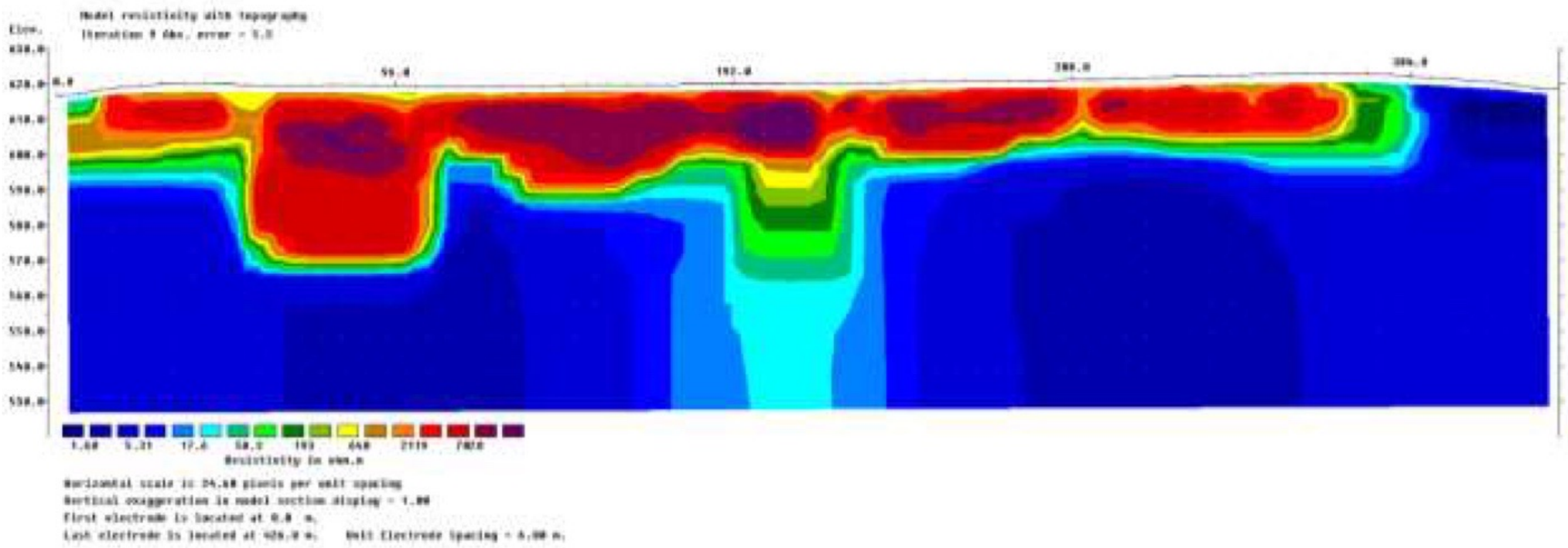


Figure 28 2D- electrical resistivity imaging map for Line 14

Based on the 2D ERT imaging results presented in Figures 16 to 28, it can be observed that the MSW at most of the locations of JLH possesses low electrical resistivity, which is indicative of the presence of saturated MSW with different salts and dissolved compounds. Moreover, Figures 16, 17, 19, 20-24 depict that the JLH consists of several isolated locations wherein the extremely low electrical resistivity. Such isolated low-electrical resistivity locations could be due to the saturated MSW, which is prone to decompose in due course, or conductive materials such as metals. This state of MSW will also be a root cause for the generation of combustible gases such as methane.

6. Details of the decomposed MSW sampling and on-site segregation

Initially, the soil cover, followed by geotextile, was removed carefully to avoid damage to the landfill cover system. Subsequently, a flight auger of ≈165 mm diameter attached to a drilling machine was inserted in the specific borehole location (refer to Figure 29a). Samples were collected at each 3 m depth until the hard strata or no-sample could be retrieved due to the high moisture content present at a certain depth of the borehole. Details of the borehole locations, termination depth, and the number of samples collected are mentioned in Table 3. A total of 16 boreholes were dug to retrieve 150 samples. The samples thus obtained were removed manually from the auger (refer to Figure 29b-d). Then, the samples were sieved through a 10 mm sieve until no further change in retaining (read as coarse) and passed (read as fine) fractions were found (refer to Figure 30a). Subsequently, the coarse- and fine-fraction weights were noted (refer to Table 4), and both fractions were packed in airtight press-lock bags to prevent further moisture loss (refer to Figures 30b and 30c). The airtight bags were then packed safely and transported to IIT Bombay for further sample characterization (Figures 30d and 30e). The borehole drilling and sample collection were monitored by the GHMC team (refer to Figure 30f). On the other hand, the boreholes were closed as per the procedure after retrieving samples. Please refer to Figure 31 for before and after the closure of the borehole. Incidentally, during the process of sampling, a few of the boreholes released liquid foam (refer to Figure 32a). Moreover, the bubbling of gas through the foam (refer to Figures 32b and 32c). The above observations indicate the presence of active leachate, which is generated by the decomposition of MSW and the release of landfill gas.

Table 3 Details of the borehole location, termination depth and number of samples collected

BH No.	Location	Termination Depth (ft)	Depth till Sample Collected (ft)	Termination depth (m)	Nos. of Samples Retrieved
BH-1	Near Line 13 End	85.50	80	26.06	8
BH-2	Near Line 14 End	105.50	100	32.16	10
BH-3	Near Line 1 End	88.25	80	26.90	8
BH-4	Near Line 2 End	124.50	120	37.95	12
BH-5	Near Line 13 Start	104.50	100	31.85	10
BH-6	Near Line 12 Start	126.25	120	38.48	12
BH-7	Near Line 10 Start	127.50	120	38.86	12
BH-8	Near Line 14 Start	15.75	15	4.80	3
BH-9	Near Line 3 Start	15.50	15	4.72	3
BH-10	Near Line 2 Start / Centre	139.00	139	42.37	14
BH-11	Near Line 1 Start	138.50	130	42.21	13
BH-12	Near Line 10 End / Line 8 Centre	139.00	139	42.37	14
BH-13	Near Line 9 Centre	112.25	120	34.21	13
BH-14	Near Line 9 End	19.25	15	5.87	3
BH-15	Near Line 4 Centre	111.50	110	33.99	12
BH-16	Near Line 4 End	23.50	20	7.16	3
			Total depth	449.96	150



(a) **(b)**



(c)



(d)

Figure 29 Photographs depicting the flight auger used and sample collection procedure



(a)



(b)



(c)



(d)



(e)



(f)

Figure 30 Photographs depicting sample on-site segregation, weighing and packing and GHMC team at the site

Table 4 Weight percentage of coarse and fine samples obtained from in-situ segregation

Sample No.	Depth (m)	Weight of sample (kg)			Percentage weight	
		Total	>10mm	<10mm	>10 mm	<10 mm
Borehole-01						
1	3	4.64	3.89	0.75	83.84	16.16
2	6	4.86	4.02	0.84	82.72	17.28
3	9	4.06	3.60	0.46	88.67	11.33
4	12	7.28	6.30	0.98	86.54	13.46
5	15	4.28	3.52	0.76	82.24	17.76
6	18	6.24	5.02	1.22	80.45	19.55
7	21	3.88	2.99	0.89	77.06	22.94
8	24	6.80	5.35	1.45	78.68	21.32
Borehole-02						
9	3	8	6.89	1.11	86.13	13.88
10	6	8.96	7.62	1.34	85.04	14.96
11	9	6.22	5.4	0.82	86.82	13.18
12	12	6.2	5.36	0.84	86.45	13.55
13	15	6.56	5.58	0.98	85.06	14.94
14	18	6.72	6.05	0.67	90.03	9.97
15	21	6.82	5.55	1.27	81.38	18.62
16	24	6.4	4.95	1.45	77.34	22.66
17	27	6.31	4.68	1.63	74.17	25.83
18	30	4.88	3.79	1.09	77.66	22.34
Borehole-03						
19	3	6.18	5.35	0.83	86.57	13.43
20	6	5.95	4.88	1.07	82.02	17.98
21	9	3.16	2.55	0.61	80.70	19.30
22	12	3.68	2.98	0.7	80.98	19.02
23	15	4.82	3.85	0.97	79.88	20.12

24	18	5.13	4.05	1.08	78.95	21.05
25	21	3.95	3.09	0.86	78.23	21.77
26	24	3.96	3.05	0.91	77.02	22.98
Borehole-04						
27	3	3.1	2.75	0.35	88.71	11.29
28	6	3.05	2.56	0.49	83.93	16.07
29	9	5.31	4.51	0.8	84.93	15.07
30	12	5.22	4.39	0.83	84.10	15.90
31	15	3.82	3.25	0.57	85.08	14.92
32	18	4.48	3.69	0.79	82.37	17.63
33	21	5.04	4.05	0.99	80.36	19.64
34	24	6.02	4.96	1.06	82.39	17.61
35	27	5.25	4.22	1.03	80.38	19.62
36	30	4.32	3.52	0.8	81.48	18.52
37	33	4.25	3.32	0.93	78.12	21.88
38	36	5.92	4.55	1.37	76.86	23.14
Borehole-05						
39	3	6.11	5.15	0.96	84.29	15.71
40	6	5.75	4.78	0.97	83.13	16.87
41	9	3.25	2.68	0.57	82.46	17.54
42	12	3.78	3.05	0.73	80.69	19.31
43	15	4.25	3.35	0.9	78.82	21.18
44	18	5.03	3.96	1.07	78.73	21.27
45	21	5.02	4.01	1.01	79.88	20.12
46	24	4.15	3.29	0.86	79.28	20.72
47	27	4.6	3.58	1.02	77.83	22.17
48	30	5.78	4.48	1.3	77.51	22.49
Borehole-06						
49	3	5.88	4.98	0.9	84.69	15.31
50	6	3.09	2.58	0.51	83.50	16.50
51	9	3.11	2.56	0.55	82.32	17.68
52	12	4.88	3.98	0.9	81.56	18.44
53	15	5.08	4.25	0.83	83.66	16.34
54	18	3.96	3.23	0.73	81.57	18.43
55	21	5.07	4.09	0.98	80.67	19.33
56	24	4.89	3.88	1.01	79.35	20.65
57	27	5.42	4.29	1.13	79.15	20.85
58	30	5.02	4.05	0.97	80.68	19.32
59	33	3.65	2.88	0.77	78.90	21.10
60	36	4.36	3.41	0.95	78.21	21.79
Borehole-07						
61	3	4.25	3.69	0.56	86.82	13.18

62	6	5.12	4.38	0.74	85.55	14.45
63	9	5.88	5.04	0.84	85.71	14.29
64	12	5.16	4.36	0.8	84.50	15.50
65	15	4.55	3.79	0.76	83.30	16.70
66	18	3.89	3.25	0.64	83.55	16.45
67	21	5.88	4.85	1.03	82.48	17.52
68	24	4.96	4.01	0.95	80.85	19.15
69	27	4.02	3.25	0.77	80.85	19.15
70	30	5.95	4.68	1.27	78.66	21.34
71	33	5.68	4.49	1.19	79.05	20.95
72	36	4.25	3.35	0.9	78.82	21.18
Borehole-08						
73	1.5	3.52	2.17	1.35	61.65	38.35
74	3	5.18	1.25	3.93	24.13	75.87
75	4.5	4.30	0.80	3.50	18.60	81.40
Borehole-09						
76	5	5.27	2.16	3.11	40.99	59.01
77	10	6.56	2.16	4.40	32.93	67.07
78	15	7.25	2.80	4.45	38.62	61.38
Borehole-10						
79	3	7.24	6.25	0.99	86.33	13.67
80	6	3.38	2.89	0.49	85.50	14.50
81	9	3.30	2.75	0.55	83.33	16.67
82	12	2.82	2.38	0.44	84.40	15.60
83	15	2.65	2.25	0.40	84.91	15.09
84	18	4.32	3.89	0.43	90.05	9.95
85	21	3.32	2.78	0.54	83.73	16.27
86	24	4.44	3.76	0.68	84.68	15.32
87	27	5.62	4.62	1.00	82.21	17.79
88	30	7.15	5.79	1.36	80.98	19.02
89	33	7.05	5.58	1.47	79.15	20.85
90	36	5.92	4.65	1.27	78.55	21.45
91	39	6.44	4.99	1.45	77.48	22.52
92	41.7	2.65	2.05	0.60	77.36	22.64
Borehole-11						
93	3	4.42	3.80	0.62	85.97	14.03
94	6	5.65	4.75	0.90	84.07	15.93
95	9	5.80	4.88	0.92	84.14	15.86
96	12	4.82	3.95	0.87	81.95	18.05
97	15	6.02	4.96	1.06	82.39	17.61
98	18	5.62	4.88	0.74	86.83	13.17
99	21	4.42	3.91	0.51	88.46	11.54

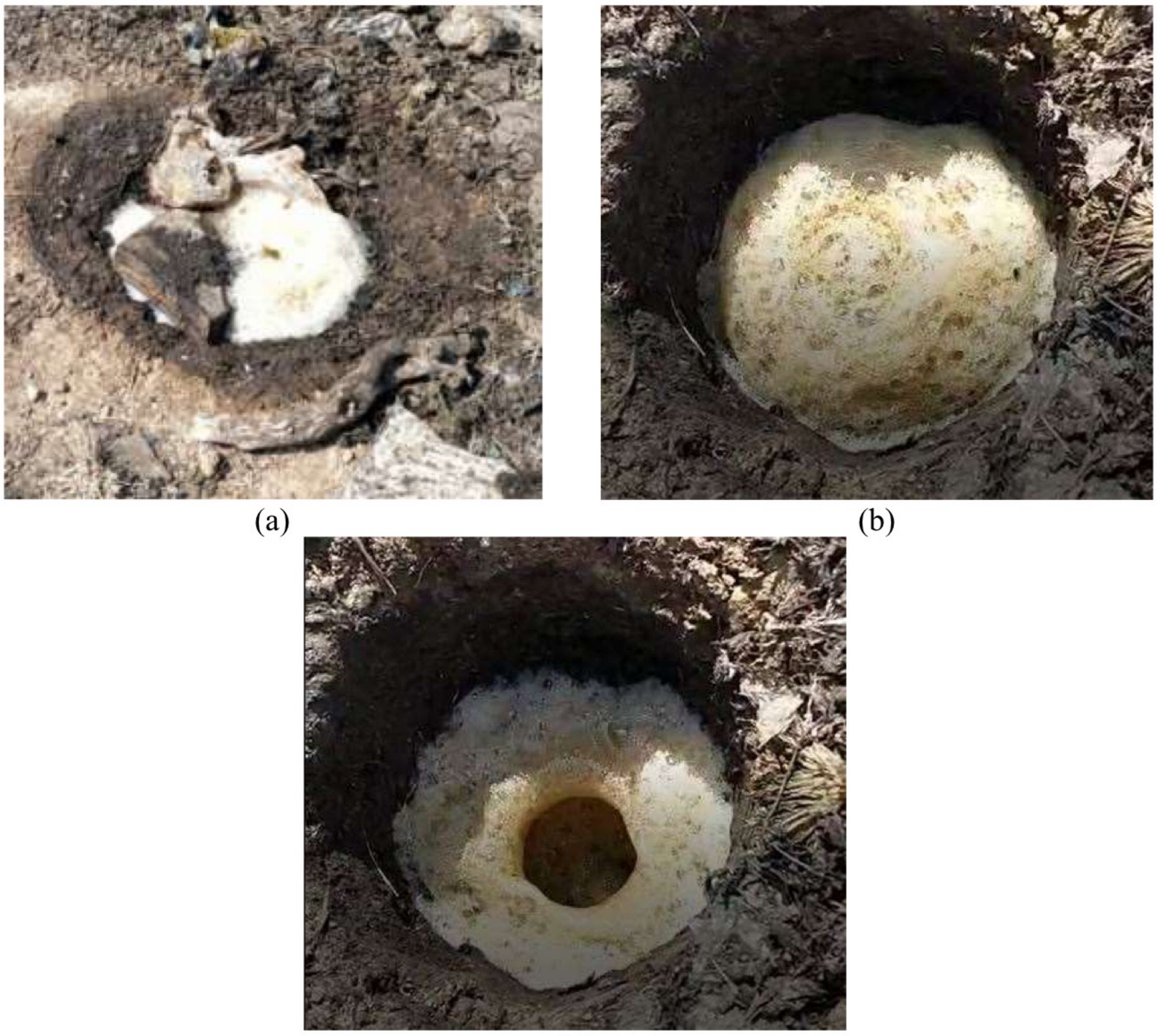
100	24	5.98	4.90	1.08	81.94	18.06
101	27	4.85	3.85	1.00	79.38	20.62
102	30	5.60	4.68	0.92	83.57	16.43
103	33	6.44	5.05	1.39	78.42	21.58
104	36	4.42	3.39	1.03	76.70	23.30
105	39	5.86	4.36	1.50	74.40	25.60
Borehole-12						
106	3	6.26	5.41	0.85	86.42	13.58
107	6	6.36	5.25	1.11	82.55	17.45
108	9	6.65	5.65	1.00	84.96	15.04
109	12	5.85	4.98	0.87	85.13	14.87
110	15	5.96	5.08	0.88	85.23	14.77
111	18	4.48	3.95	0.53	88.17	11.83
112	21	4.78	3.99	0.79	83.47	16.53
113	24	6.62	5.54	1.08	83.69	16.31
114	27	4.45	3.79	0.66	85.17	14.83
115	30	6.80	5.32	1.48	78.24	21.76
116	33	5.30	4.25	1.05	80.19	19.81
117	36	7.98	6.25	1.73	78.32	21.68
118	39	6.41	5.22	1.19	81.44	18.56
119	41.7	6.84	5.44	1.40	79.53	20.47
Borehole-13						
120	3	5.68	5.04	0.64	88.73	11.27
121	6	5.25	4.36	0.89	83.05	16.95
122	9	4.35	3.79	0.56	87.13	12.87
123	12	3.88	3.25	0.63	83.76	16.24
124	15	5.25	4.65	0.60	88.57	11.43
125	18	6.25	5.58	0.67	89.28	10.72
126	21	6.62	5.65	0.97	85.35	14.65
127	24	7.02	5.78	1.24	82.34	17.66
128	27	5.22	4.22	1.00	80.84	19.16
129	30	3.89	3.18	0.71	81.75	18.25
130	31.5	5.11	4.15	0.96	81.21	18.79
131	33	4.78	3.85	0.93	80.54	19.46
132	33.6	5.88	4.65	1.23	79.08	20.92
Borehole-14						
133	1.5	9.02	2.81	6.21	31.15	68.85
134	3	6.34	2.78	3.56	43.85	56.15
135	4.5	7.96	3.96	4.00	49.75	50.25
Borehole-15						
136	3	4.11	3.69	0.42	89.78	10.22
137	6	5.11	4.38	0.73	85.71	14.29

138	9	5.62	5.04	0.58	89.68	10.32
139	12	3.65	3.15	0.50	86.30	13.70
140	15	4.18	3.59	0.59	85.89	14.11
141	18	5.01	4.19	0.82	83.63	16.37
142	21	4.29	3.72	0.57	86.71	13.29
143	24	6.11	5.02	1.09	82.16	17.84
144	27	3.65	3.02	0.63	82.74	17.26
145	30	5.42	4.38	1.04	80.81	19.19
146	33	4.45	3.55	0.90	79.78	20.22
147	33.6	3.98	3.09	0.89	77.64	22.36
Borehole-16						
148	10	3.05	2.75	0.30	90.16	9.84
149	15	3.12	2.75	0.37	88.14	11.86
150	20	4.35	3.85	0.50	88.51	11.49



(a) **(b)**

Figure 31 Photographs depicting the borehole before and after closure



(a) (b)

(c)

Figure 32 Photographs depicting leachate and bubble formation and bursting by landfill gas emission

7. Laboratory segregation and characterization

The coarse fraction, i.e., >10 mm obtained from the site, was further segregated into plastics, textiles, residues (such as fine dirt and mixed waste), and stones and the weights of each fraction were measured. For this purpose, 1/3rd of the total samples available from each borehole were selected randomly. Segregation of coarse fraction is particularly useful for subsequent estimation of calorific values. The photographs depicting the laboratory segregation process are mentioned in Figure 33. Subsequently, each fraction's total weight and percentage are mentioned in Table 5. From Table 5, it can be observed that a significant fraction of the coarse fraction is plastics, followed by residues and stones. However, it can be observed that combining all together (i.e., coarse and fine fractions), fine fractions and residues will be a large fraction that is prone to decomposition. Hence, subsequent characterization of these fractions is a must.



(a)



(b)



(c)



(d)



(e)

Figure 33 Photographs depicting the laboratory segregation process of coarse fractions

Table 5 Results laboratory segregation of coarse fraction from different boreholes

Borehole No	Depth (m)	Weight (g)					Percentage weight			
		Plastic	Textile	Residue	Stone	Total	Plastic	Textile	Residue	Stone
BH-01	12	234	157	772	0	1163	20.12	13.50	66.38	0.00
	15	308	163	890	0	1361	22.63	11.98	65.39	0.00
	24	445	177	1243	0	1865	23.86	9.49	66.65	0.00
	Avg	**329**	**166**	**968**	**0**	**1463**	**22.20**	**11.66**	**66.14**	**0.00**
BH-02	3	158	100	679	0	937	16.86	10.67	72.47	0.00
	6	263	202	858	0	1323	19.88	15.27	64.85	0.00
	9	437	104	463	0	1004	43.53	10.36	46.12	0.00
	12	411	104	333	0	848	48.47	12.26	39.27	0.00
	Avg	**317**	**128**	**583**	**0**	**1028**	**32.18**	**12.14**	**55.68**	**0.00**
BH-03	3	284	32	283	32	631	45.01	5.07	44.85	5.07
	21	364	108	30	0	502	72.51	21.51	5.98	0.00
	24	274	221	115	0	610	44.92	36.23	18.85	0.00
	Avg	**307**	**120**	**143**	**11**	**581**	**54.15**	**20.94**	**23.23**	**1.69**
BH-04	15	259	99	298	7	663	39.06	14.93	44.95	1.06
	27	333	79	6	0	418	79.67	18.90	1.44	0.00
	30	226	98	490	79	893	25.31	10.97	54.87	8.85
	36	194	385	87	0	666	29.13	57.81	13.06	0.00
	Avg	**253**	**165**	**220**	**22**	**660**	**43.29**	**25.65**	**28.58**	**2.48**
BH-05	15	245	96	322	0	663	36.95	14.48	48.57	0.00
	27	270	243	315	0	828	32.61	29.35	38.04	0.00
	30	292	57	58	0	407	71.74	14.00	14.25	0.00
	33	361	0	29	0	390	92.56	0.00	7.44	0.00
	Avg	**292**	**99**	**181**	**0**	**572**	**58.47**	**14.46**	**27.07**	**0.00**
BH-06	6	320	20	623	4	967	33.09	2.07	64.43	0.41
	9	244	30	667	149	1090	22.39	2.75	61.19	13.67
	18	659	34	56	0	749	87.98	4.54	7.48	0.00
	36	460	0	56	8	524	87.79	0.00	10.69	1.53
	Avg	**421**	**21**	**351**	**40**	**833**	**57.81**	**2.34**	**35.95**	**3.90**
BH-07	3	227	126	190	0	543	41.80	23.20	34.99	0.00
	12	362	37	822	52	1273	28.44	2.91	64.57	4.08
	18	329	84	723	141	1277	25.76	6.58	56.62	11.04
	27	606	87	152	0	845	71.72	10.30	17.99	0.00
	Avg	**381**	**84**	**472**	**48**	**985**	**41.93**	**10.75**	**43.54**	**3.78**
BH-08	15	22	7	315	431	775	2.84	0.90	40.65	55.61
BH-10	3	231	194	467	16	908	25.44	21.37	51.43	1.76
	6	24	816	23	0	863	2.78	94.55	2.67	0.00
	9	273	29	190	25	517	52.80	5.61	36.75	4.84
	15	178	53	264	41	536	33.21	9.89	49.25	7.65
	18	214	66	130	0	410	52.20	16.10	31.71	0.00
	Avg	**184**	**232**	**215**	**16**	**647**	**33.29**	**29.50**	**34.36**	**2.85**

BH-11	15	204	21	533	85	843	24.20	2.49	63.23	10.08
	18	167	189	475	0	831	20.10	22.74	57.16	0.00
	33	211	49	595	0	855	24.68	5.73	69.59	0.00
	36	232	80	715	0	1027	22.59	7.79	69.62	0.00
	Avg	**204**	**85**	**580**	**21**	**889**	**22.89**	**9.69**	**64.90**	**2.52**
BH-12	9	316	158	347	0	821	38.49	19.24	42.27	0.00
	15	340	59	169	0	568	59.86	10.39	29.75	0.00
	18	188	293	73	6	560	33.57	52.32	13.04	1.07
	24	189	212	354	0	755	25.03	28.08	46.89	0.00
	42	395	182	147	0	724	54.56	25.14	20.30	0.00
	Avg	**286**	**181**	**218**	**1**	**686**	**42.30**	**27.03**	**30.45**	**0.21**
BH-13	6	208	12	462	56	738	28.18	1.63	62.60	7.59
	21	427	61	111	0	599	71.29	10.18	18.53	0.00
	30	309	241	99	0	649	47.61	37.13	15.25	0.00
	39	483	110	223	0	816	59.19	13.48	27.33	0.00
	Avg	**357**	**106**	**224**	**14**	**701**	**51.57**	**15.61**	**30.93**	**1.90**
BH-14	6	270	92	255	3	620	43.55	14.84	41.13	0.48
	9	342	50	296	0	688	49.71	7.27	43.02	0.00
	21	433	64	111	0	608	71.22	10.53	18.26	0.00
	Avg	**348**	**69**	**221**	**1**	**639**	**54.82**	**10.88**	**34.14**	**0.16**
BH-15	12	164	432	137	29	762	21.52	56.69	17.98	3.81
	33	401	100	90	4	595	67.39	16.81	15.13	0.67
	Avg	**283**	**266**	**114**	**17**	**679**	**44.46**	**36.75**	**16.55**	**2.24**
BH-16	6	298	26	273	32	629	47.38	4.13	43.40	5.09
	9	330	56	31	0	417	79.14	13.43	7.43	0.00
	Avg	**314**	**41**	**152**	**16**	**523**	**63.26**	**8.78**	**25.42**	**2.54**
Avg							**42.74**	**16.68**	**37.80**	**2.78**

7.1. Characterization of the fine fractions

7.1.1 Moisture content determination

Moisture content was determined by keeping the samples in an oven at 110±5°C. The weight loss undergone by the samples was recorded intermittently. This procedure was followed until no further weight loss was observed as per the ASTM guidelines and previous study recommendations (ASTM International, 2020; Goli et al., 2022). The results obtained from moisture content determination for all samples are mentioned in Table 6. Further, detailed experimental results were mentioned in Tables A1 to A16

Table 6 Borehole-wise variation in the moisture content of fine fractions

Borehole No	Moisture content (%)		
	Avg (±SD)	Max	Min
BH-01	73.6±38.7	107.6±111.4	48.7±10.7
BH-02	62.4±28.3	75.7±22.2	43.4±7.3
BH-03	40.5±7.4	49.6±3.3	33.2±2
BH-04	50.4±12.3	72.6±2.6	34.7±2.2
BH-05	33.8±11.4	54.7±1.2	19.1±0.9
BH-06	30.7±12.1	55±1.2	20.6±1.1
BH-07	47.0±12.8	63.5±9.0	23.5±0.1
BH-08	10.50±5.80	15.6±1.20	4.30±0.30
BH-09	4.6±0.6	5.1±0.4	4.2±0.4
BH-10	42.5±11.5	60.9±3.6	29.4±3.5
BH-11	43.9±4.9	51.2±2.3	39.0±0.6
BH-12	50.5±7.5	63.1±6.3	41.6±8.7
BH-13	54.9±12.4	67.9±5.2	43.5±2.6
BH-14	20.6±9.3	25.8±0.9	7.4±9.6
BH-15	31.5±6.1	24.4±1.6	39.3±3.8
BH-16	31.2±10.2	42.0±1.6	21.7±9.4

From Table 6, it can be observed that the moisture content in the fines fraction varies between 4.6 and 73.6%. Further, the moisture content in most of the samples is found to be very high (as 108%), which can be attributed to the presence of a very high amount of organic matter in it. Samples with such high moisture content will be prone to decomposition (Patil et al., 2017).

7.1.2 Specific gravity

Specific gravity of the oven-dried fine fraction of the MSW was measured by employing a helium gas pycnometer, as per the ASTM standard (ASTM D 5550, 2006). Approximately 20 g of the sample was transferred into a pycnometer cell and He gas was purged to measure the volume of the solids. The average specific gravity of the fine fraction collected from each borehole is listed in Table 7, while the results for each sample are given in Tables B1 to B10.

Table 7 Borehole-wise variation in the specific gravity of fine fractions

Borehole No	Specific gravity		
	Average (±SD)	Max	Min
BH-01	2.26±0.03	2.36±0.02	2.15±0.04
BH-2	2.18±0.02	2.38±0.02	1.92±0.01
BH-3	2.23±0.01	2.34±0.01	2.07±0.01
BH-4	2.21±0.01	2.30±0.00	2.05±0.01
BH-5	2.31±0.02	2.47±0.02	2.13±0.04
BH-6	2.36±0.01	2.47±0.01	2.17±0.04
BH-7	2.28±0.01	2.41±0.02	2.17±0.02
BH-8	2.61±0.02	2.65±0.02	2.58±0.02
BH-9	2.67±0.01	2.69±0.01	2.66±0.01
BH-10	2.32±0.01	2.47±0.00	1.92±0.04
BH-11	2.30±0.01	2.37±0.00	2.18±0.01
BH-12	2.23±0.02	2.30±0.01	2.17±0.02
BH-13	2.26±0.01	2.31±0.02	2.19±0.01
BH-14	2.48±0.01	2.63±0.00	2.40±0.01
BH-15	2.48±0.00	2.46±0.00	2.38±0.00
BH-16	2.33±0.00	2.39±0.01	2.29±0.01

It can be observed that the overall average specific gravity of the fine fraction is 2.30±0.13, which is much lower as compared to the sands, silty clays, and moorum that are being used for structural fill applications. As such, the utilization of fine fractions as structural fill for the low-lying areas is not recommended. The reasons being this material will not be getting properly compacted and will always be prone to long term degardation.

8. Conclusions and way forward

- MASW results indicate the presence of saturated and loosely compacted MSW up to greater depths, which confirms the presence of MSW that is yet to stabilize.
- ERT results indicate the presence of low-resistivity pockets in the MSW, which can be attributed to the presence of saturated or moist MSW (read the yet-to-decompose waste).
- The segregation of DMSW samples indicates the presence of a dominant fraction of plastics and fine fractions (i.e., ≈40 % each).
- The moisture content of the fine fraction is high (>100 %), which is most probably due to the presence of high organic matter that would decompose in the long run.
- The specific gravity of the fine fractions is around 2.30, which makes it an unsuitable material for structural filling.
- Further, the leachate and foam generation and the emission of landfill gas indicate the ongoing active decomposition of MSW in JLH. Hence, going for biomining at its present status is not recommended.

However, the environmental suitability of the fine fractions is yet to be established, which would also indicate the suitability of this material for agricultural applications.

Also, the suitability of coarse fractions as refuse-derived fuel is also being investigated.

Appendix A

Table A 1 Moisture content analysis results for Borehole-01

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content (%)
3	1A	23.0141	28.5036	26.3922	62.5	58.8±8.8
	1B	24.7351	30.3825	28.5304	48.8	
	1C	22.6975	26.6573	25.0961	65.1	
6	2A	22.88	28.9786	25.9686	97.5	89.8±11.4
	2B	23.8615	29.3205	26.9513	76.7	
	2C	22.675	26.3825	24.5732	95.3	
9	3A	20.9924	28.31	25.4194	65.3	64.7±14.5
	3B	35.2328	40.189	38.004	78.8	
	3C	19.9535	24.8708	23.2339	49.9	
12	4A	22.5275	26.7153	24.9718	71.3	72.0±12.5
	4B	22.1807	25.4436	24.2211	59.9	
	4C	22.7181	26.918	24.9909	84.8	
15	5A	21.6395	25.6654	23.8223	84.4	85.9±6.3
	5B	24.7954	29.7046	27.3419	92.8	
	5C	24.6294	26.8324	25.8499	80.5	
18	6A	21.7304	26.9361	25.5481	36.4	48.7±10.7
	6B	22.4375	26.404	24.9912	55.3	
	6C	25.8997	29.8728	28.4734	54.4	
21	7A	21.9983	27.6564	25.3611	68.3	61.2±11.7
	7B	21.8802	26.002	24.6708	47.7	
	7C	22.4107	25.7266	24.389	67.6	
24	8A	22.9285	27.7696	26.3621	41.0	107.6±111.4
	8B	21.4934	26.6167	25.0103	45.7	
	8C	22.9745	29.4849	24.9106	236.3	
				Avg (±SD)	**73.6±38.7**	

Table A 2 Moisture content analysis results for Borehole-02

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content(%)
3	1A	22.7543	28.088	26.3217	49.5	57.0±10.9
	1B	22.603	30.2407	27.6255	52.1	
	1C	22.2721	28.0885	25.7044	69.5	
6	2A	34.7565	42.58	37.6844	167.2	74.5±84.2
	2B	33.2517	39.8726	39.6922	2.8	
	2C	35.2927	44.8228	41.5	53.5	
9	3A	35.3512	56.7546	51.9865	28.7	53.4±24.0
	3B	37.0828	62.3602	53.4011	54.9	
	3C	34.1621	61.3062	49.5353	76.6	
12	4A	36.0935	57.407	48.9071	66.3	73.8±10.2
	4B	36.5967	59.357	48.8747	85.4	
	4C	22.9872	35.2747	30.23	69.7	
15	5A	23.8466	37.295	32.7936	50.3	52.6±2.5
	5B	23.3262	40.8417	34.6017	55.3	
	5C	20.46	36.4673	30.9749	52.2	
18	6A	22.6256	37.2592	30.219	92.7	75.7±22.2
	6B	22.116	39.5269	33.6816	50.5	
	6C	23.6275	40.119	32.5975	83.9	
21	7A	27.3109	44.1229	35.1564	114.3	73.4±35.6
	7B	16.0768	26.3264	22.9233	49.7	
	7C	16.7481	33.5053	27.4733	56.2	
24	8A	22.4698	41.6338	36.6417	35.2	43.4±7.3
	8B	22.7358	41.3066	35.505	45.4	
	8C	22.5681	47.0771	38.9733	49.4	
27	9A	22.3423	37.8464	31.9479	61.4	63.5±9.1
	9B	21.0221	33.4347	28.1794	73.4	
	9C	24.8264	42.3107	36.0578	55.7	
30	10A	16.8995	36.2668	29.6096	52.4	56.5±4.7
	10B	23.0305	42.7348	35.6946	55.6	
	10C	20.5216	35.5506	29.8183	61.7	
				Avg (±SD)	**62.4±28.3**	

Table A 3 Moisture content analysis results for Borehole-03

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content(%)
3	1A	21.7526	35.0801	30.6535	49.7	49.1±2.1
	1B	24.7966	38.926	34.4219	46.8	
	1C	23.8913	36.4252	32.2035	50.8	
6	2A	19.9752	32.0418	28.0701	49.1	45.8±3.0
	2B	21.5135	35.9945	31.6396	43.0	
	2C	22.2106	35.867	31.5985	45.5	
9	3A	22.9134	38.0824	34.745	28.2	32.1±4.8
	3B	22.7185	32.718	29.9936	37.4	
	3C	22.0353	34.9654	31.9373	30.6	
12	4A	22.9465	39.2998	34.8862	37.0	37.2±1.6
	4B	22.7075	35.0714	31.816	35.7	
	4C	22.4415	33.8967	30.6913	38.9	
15	5A	21.0123	38.9282	33.9121	38.9	41.5±2.3
	5B	23.0336	40.1606	34.9926	43.2	
	5C	24.7549	40.378	35.7166	42.5	
18	6A	21.6597	41.145	36.3541	32.6	33.2±2.0
	6B	22.9944	39.9862	35.9046	31.6	
	6C	22.4613	40.7391	35.9499	35.5	
21	7A	22.7403	37.3554	32.8605	44.4	35.5±7.7
	7B	22.5471	41.9222	37.3659	30.7	
	7C	25.9201	42.2445	38.337	31.5	
24	8A	24.6524	45.3125	38.1639	52.9	49.6±3.3
	8B	21.9135	37.4181	32.2955	49.3	
	8C	35.2508	58.4521	51.0982	46.4	
				Avg (±SD)	**40.5±7.4**	

Table A 4 Moisture content analysis results for Borehole-04

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content(%)
3	1A	23.6188	42.482	38.4596	27.1	27.7±0.5
	1B	22.7564	39.4384	35.8045	27.9	
	1C	22.9771	38.1733	34.8475	28.0	
6	2A	20.4587	37.2216	32.2907	41.7	39.9±1.6
	2B	27.3067	45.1525	40.1944	38.5	
	2C	16.7813	35.7151	30.3526	39.5	
9	3A	22.1011	39.5589	35.2714	32.6	34.7±2.2
	3B	22.5981	40.1089	35.6122	34.6	
	3C	23.8373	40.8477	36.2638	36.9	
12	4A	37.0857	64.4791	56.3575	42.1	43.3±1.1
	4B	35.2943	71.2744	60.2413	44.2	
	4C	36.0917	63.8508	55.4218	43.6	
15	5A	34.1648	66.9404	55.1365	56.3	56.8±5.5
	5B	33.2698	64.6072	52.5567	62.5	
	5C	36.6003	69.7667	58.4895	51.5	
18	6A	34.7567	65.8648	54.9148	54.3	52.0±2.0
	6B	35.3533	73.0014	60.3709	50.5	
	6C	16.0992	28.7229	24.4454	51.3	
21	7A	23.3527	42.2793	35.9762	49.9	54.1±3.6
	7B	22.3023	41.7365	34.7707	55.9	
	7C	22.6492	40.0691	33.7753	56.6	
24	8A	21.7599	38.6323	33.0992	48.8	48.9±1.8
	8B	24.8194	44.2426	37.7022	50.8	
	8C	23.9213	48.5542	40.6486	47.3	
27	9A	21.5355	41.9038	35.0348	50.9	54.4±5.1
	9B	23.0358	42.5615	35.8676	52.2	
	9C	21.9483	42.3074	34.6507	60.3	
30	10A	24.6811	49.6005	40.709	55.5	60.0±4.5
	10B	22.078	42.417	34.4424	64.5	
	10C	23.3745	49.0575	39.4306	60.0	
33	11A	23.8815	45.7116	36.5949	71.7	72.6±2.6
	11B	22.5077	50.594	38.9742	70.6	
	11C	22.8113	51.7833	39.3094	75.6	
36	12A	27.3397	50.11	41.3304	62.8	60.0±2.4
	12B	25.9537	46.7318	39.0836	58.3	
	12C	23.0743	52.562	41.626	58.9	
				Avg (±SD)	**50.4±12.3**	

Table A 5 Moisture content analysis results for Borehole-05

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content(%)
3	1A	22.7058	39.5641	33.6459	54.1	54.7±1.2
	1B	21.0078	38.6205	32.2913	56.1	
	1C	22.2104	40.4001	34.034	53.8	
6	2A	24.7631	46	39	47.9	46.4±2.5
	2B	23.9123	40.377	35.3818	43.6	
	2C	22.7165	42.6786	36.2183	47.8	
9	3A	21.5151	38.7482	33.953	38.6	38.5±3.2
	3B	24.6481	45.1384	39.8035	35.2	
	3C	23.028	41.3535	35.9681	41.6	
12	4A	22.9253	39.8986	35.4757	35.2	38.2±3.7
	4B	22.0437	38.9769	34.085	40.6	
	4C	22.9415	42.0961	36.7485	38.7	
15	5A	25.9264	43.3252	38.193	41.8	39.5±2.6
	5B	19.978	39.5651	34.3126	36.6	
	5C	22.542	38.5602	33.9781	40.1	
18	6A	22.4411	49.0135	44.0309	23.1	24.1±1.4
	6B	21.9107	43.039	38.716	25.7	
	6C	22.9884	49.062	44.0859	23.6	
21	7A	22.4411	48.6192	44.5969	18.2	19.1±0.9
	7B	21.6787	54.9548	49.5916	19.2	
	7C	21.7553	50.2087	45.4774	19.9	
24	9A	22.459	46.9105	42.2408	23.6	21.8±2.5
	9B	24.791	49.0473	45.1868	18.9	
	9C	35.2474	69.0473	62.7794	22.8	
27	10A	36.1738	84.4257	72.4503	33.0	29.6±7.4
	10B	35.3121	82.5923	74.3576	21.1	
	10C	35.3472	85.6367	72.7005	34.6	
30	11A	36.6764	79.4012	70.7877	25.3	26.0±0.8
	11B	34.8008	79.289	69.8948	26.8	
	11C	37.1428	81.615	72.4794	25.9	
				Avg (±SD)	33.8±11.4	

Table A 6 Moisture content analysis results for Borehole-06

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) Moisture Content(%)
3	1A	22.7782	48.0404	40.4059	43.3	41.2±2.0
	1B	27.3199	47.2166	41.5902	39.4	
	1C	23.6319	46.7435	40.0429	40.8	
6	2A	34.1866	73.9916	64.9202	29.5	26.5±2.9
	2B	35.3156	75.4505	67.7416	23.8	
	2C	37.1055	75.7065	67.7245	26.1	
9	3A	23.003	49.3762	43.9506	25.9	24.7±1.2
	3B	20.4852	43.9247	39.2825	24.7	
	3C	22.6567	48.7251	43.7498	23.6	
12	4A	35.3759	83.9971	75.5348	21.1	21.1±0.2
	4B	33.2965	78.7545	70.9119	20.8	
	4C	34.7814	82.1641	73.8355	21.3	
15	5A	22.1193	46.6754	42.4441	20.8	20.7±0.4
	5B	23.3461	51.8793	47.0672	20.3	
	5C	22.3132	46.8256	42.5687	21.0	
18	6A	36.1161	82.6035	74.3207	21.7	21.6±0.0
	6B	36.6235	85.5882	76.8903	21.6	
	6C	16.105	35.7051	32.2148	21.7	
21	7A	16.8139	44.6477	39.8849	20.6	20.6±1.1
	7B	23.8556	54.1245	49.1992	19.4	
	7C	22.6223	47.075	42.7324	21.6	
24	8A	33.3313	66.7261	54.7926	55.6	55.0±1.2
	8B	35.4099	78.584	63.5151	53.6	
	8C	34.2069	79.5237	63.3164	55.7	
27	9A	21.6895	49.8334	43.239	30.6	30.4±1.4
	9B	22.1422	46.7002	41.1847	29.0	
	9C	22.7248	42.6655	37.8654	31.7	
30	10A	22.2364	45.3517	41.6587	19.0	20.8±5.4
	10B	16.1509	31.424	29.2647	16.5	
	10C	22.6502	45.2463	40.4715	26.8	
33	11A	19.9981	45.5117	38.4333	38.4	43.8±4.9
	11B	23.6708	45.4285	38.6912	44.9	
	11C	22.6718	47.2817	39.291	48.1	
36	12A	22.6883	54.115	43.6293	50.1	48.2±1.8
	12B	22.9871	49.3012	40.9523	46.5	
	12C	22.6719	39.2918	33.8912	48.1	
				Avg (±SD)	31.2±12.3	

Table A 7 Moisture content analysis results for Borehole-07

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) Moisture Content(%)
3	1A	22.7865	37.3811	31.7757	62.4	59.2±3.0
	1B	22.991	40.2434	33.8506	58.9	
	1C	24.656	41.2075	35.2426	56.3	
6	2A	19.9769	34.2501	28.7135	63.4	56.3±7.0
	2B	24.7614	41.7006	35.5971	56.3	
	2C	20.9974	43.7832	36.2541	49.3	
9	3A	22.5383	41.082	34.7915	51.3	48.4±2.6
	3B	24.7904	41.9872	36.4887	47.0	
	3C	21.7614	41.0842	34.9314	46.7	
12	4A	21.5079	37.8315	31.8066	58.5	51.9±5.9
	4B	22.935	40.9278	34.9525	49.7	
	4C	22.1989	37.7401	32.7425	47.4	
15	5A	21.6741	43.9275	36.7242	47.9	45.6±2.0
	5B	22.0519	37.6444	32.8419	44.5	
	5C	22.4463	44.1689	37.4841	44.5	
18	6A	23.0566	43.4895	39.5989	23.5	23.5±0.1
	6B	23.9049	40.1166	37.0136	23.7	
	6C	21.9203	42.8992	38.9164	23.4	
21	7A	22.7139	40.9717	35.8092	39.4	41.2±2.6
	7B	22.7044	45.206	38.7817	40.0	
	7C	25.9303	47.775	41.0756	44.2	
24	8A	22.9373	46.0465	37.0127	64.2	58.7±5.8
	8B	22.4644	39.7672	33.3282	59.3	
	8C	35.2523	70.356	58.2602	52.6	
27	9A	25.9517	53.9387	46.4474	36.6	36.4±0.6
	9B	23.9358	49.8046	42.9908	35.8	
	9C	21.0132	45.7936	39.1167	36.9	
30	10A	22.7405	43.3797	35.1665	66.1	63.5±9.0
	10B	22.517	44.5641	36.8785	53.5	
	10C	24.6892	46.4074	37.3965	70.9	
33	11A	23.0721	51.3421	45.1078	28.3	28.2±1.9
	11B	23.3925	44.5066	39.6352	30.0	
	11C	22.8136	44.6192	40.0799	26.3	
36	12A	22.4863	45.3401	37.1197	56.2	51.3±5.4
	12B	22.7347	48.224	40.2566	45.5	
	12C	24.8372	46.5446	39.0956	52.2	
				Avg (±SD)	**47.0±12.8**	

Table A 8 Moisture content analysis results for Borehole-08

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) Moisture content(%)
1.5	1A	23.8609	30.5421	29.6327	15.8	11.5±6.0
	1B	22.7751	46.3128	45.259	4.7	
	1C	22.6316	34.0722	32.65	14.2	
3	2A	34.1902	49.2778	47.1583	16.3	15.6±1.2
	2B	35.3214	46.04	44.5463	16.2	
	2C	35.2583	47.929	46.3573	14.2	
4.5	3A	22.0595	35.1272	34.627	4.0	4.3±0.3
	3B	22.9991	34.0691	33.5873	4.6	
	3C	21.6743	30.6672	30.2958	4.3	
				Avg (±SD)	**10.5±5.8**	

Table A 9 Moisture content analysis results for Borehole-09

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content(%)
1.5	1A	23.0251	45.8412	44.8465	4.6	4.2±0.4
	1B	20.4984	30.4833	30.083	4.2	
	1C	34.7813	47.901	47.4254	3.8	
4.5	2A	23.6567	31.9341	31.5005	5.5	5.1±0.4
	2B	22.3171	30.7715	30.3916	4.7	
	2C	23.3479	36.9222	36.2697	5.0	
				Avg (±SD)	**4.6±0.6**	

Table A 10 Moisture content analysis results for Borehole-10

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content(%)
3	1A	22.7451	27.3936	25.5777	64.1	60.9±3.6
	1B	24.66	31.7149	29.1536	57.0	
	1C	37.1195	44.0012	41.3761	61.7	
6	2A	21.7646	30.3849	28.2343	33.2	43.7±9.1
	2B	22.975	30.3614	27.8913	50.2	
	2C	23.0125	29.1134	27.1475	47.5	
9	3A	22.2032	29.047	27.2211	36.4	41.7±5.1
	3B	22.4456	40.0693	34.4748	46.5	
	3C	23.9117	38.6524	34.2829	42.1	
12	4A	22.6711	43.8782	38.3538	35.2	36.0±1.9
	4B	22.1217	43.2464	37.8157	34.6	

	4C	19.9824	42.2991	36.1389	38.1	
15	5A	22.5501	48.6873	42.6158	30.3	29.5±0.6
	5B	24.7879	51.7922	45.7138	29.0	
	5C	23.0636	47.5327	41.9871	29.3	
18	6A	21.0116	39.6541	34.9528	33.7	33.1±0.9
	6B	27.3356	46.1843	41.4598	33.4	
	6C	25.9284	45.3347	40.6293	32.0	
21	7A	22.4856	45.5637	38.4757	44.3	42.3±4.8
	7B	21.926	45.5876	39.2142	36.9	
	7C	16.8424	32.7492	27.7547	45.8	
24	8A	21.5217	44.1124	38.6287	32.1	29.6±3.3
	8B	22.7097	45.8009	40.3341	31.0	
	8C	24.7815	53.6647	47.7391	25.8	
27	9A	16.1358	34.6496	28.1981	53.5	45.7±10.3
	9B	36.6406	56.298	49.7801	49.6	
	9C	33.3185	55.613	49.949	34.1	
30	10A	36.1386	62.4607	56.739	27.8	29.4±3.5
	10B	35.3866	64.0132	56.8395	33.4	
	10C	22.7099	45.3177	40.5238	26.9	
33	11A	22.3461	43.349	35.9944	53.9	41.9±12.7
	11B	14.8392	40.403	34.7265	28.5	
	11C	24.6859	44.2507	38.3435	43.3	
36	12A	23.0842	48.2155	40.2601	46.3	59.5±11.5
	12B	20.5508	33.5097	28.4087	64.9	
	12C	22.524	40.5588	33.2981	67.4	
39	13A	22.8207	43.8885	36.6675	52.1	50.0±5.2
	13B	23.3929	42.3244	35.7038	53.8	
	13C	22.0955	41.1214	35.307	44.0	
41.7	14A	21.0179	40.67	34.196	49.1	51.1±11.7
	14B	23.8804	41.322	35.318	52.5	
	14C	21.5378	41.332	34.5931	51.6	
				Avg (±SD)	**42.5±11.5**	

Table A 11 Moisture content analysis results for Borehole-11

Depth (m)	**Sample No.**	**W1 (g)**	**W2 (g)**	**W3 (g)**	**Moisture content (%)**	**Avg. (±SD) moisture content(%)**
3	1A	22.3432	46.2247	39.5647	38.7	40.5±2.1
	1B	23.3718	48.2903	40.8195	42.8	
	1C	22.7247	39.2291	34.5014	40.1	
6	2A	23.0804	48.8022	41.4714	39.9	39.0±0.8
	2B	20.5151	39.6242	34.2829	38.8	

	2C	25.9372	46.2954	40.6477	38.4	
9	3A	23.9227	41.8718	36.1473	46.8	46.2±1.0
	3B	21.0287	40.4923	34.3049	46.6	
	3C	22.2308	43.457	36.8672	45.0	
12	4A	21.9504	40.2341	34.3192	47.8	46.8±2.1
	4B	22.0733	42.1109	35.955	44.3	
	4C	16.8912	33.8902	28.367	48.1	
15	5A	22.1358	47.4271	39.6053	44.8	39.2±5.0
	5B	21.7596	45.7008	39.506	34.9	
	5C	24.8055	48.3716	41.8833	38.0	
18	6A	22.4698	40.0157	35.1001	38.9	39.0±0.6
	6B	23.6811	46.3934	40.0795	38.5	
	6C	22.6543	43.7366	37.7482	39.7	
21	7A	20.0011	41.4513	35.4956	38.4	39.7±1.8
	7B	23.0257	41.8926	36.3353	41.8	
	7C	24.8086	43.3213	38.1234	39.0	
24	8A	23.6669	44.4613	38.0704	44.4	43.7±0.9
	8B	21.5479	42.1502	35.9852	42.7	
	8C	22.3455	45.3536	38.3366	43.9	
27	9A	37.1423	65.4286	55.825	51.4	50.6±4.5
	9B	34.3134	63.1509	54.0924	45.8	
	9C	35.4158	67.6082	56.2327	54.6	
30	10A	34.8092	65.649	55.3511	50.1	48.2±1.9
	10B	35.3167	60.4754	52.3157	48.0	
	10C	36.4894	71.7621	60.5941	46.3	
33	11A	22.0881	43.8204	37.2099	43.7	42.3±1.7
	11B	23.0378	46.5181	39.502	42.6	
	11C	20.0123	38.0387	32.8467	40.5	
36	12A	21.7581	39.9256	34.694	40.4	44.6±5.7
	12B	22.9527	46.9185	38.8093	51.1	
	12C	35.3499	63.8061	55.348	42.3	
39	13A	36.1835	70.782	59.0946	51.0	51.2±2.3
	13B	25.3899	45.9272	39.1724	49.0	
	13C	36.674	77.3206	63.1448	53.6	
				Avg (±SD)	**43.9±4.9**	

Table A 12 Moisture content analysis results for Borehole-12

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content (%)
3	1A	22.7174	40.6545	35.0138	45.9	49.5±4.0
	1B	23.0055	39.885	34.3478	48.8	
	1C	21.6846	38.9101	32.8918	53.7	
6	2A	23.7659	38.6994	33.4936	53.5	50.5±2.6
	2B	24.8116	40.4576	35.3366	48.7	
	2C	22.2309	45.1723	37.5988	49.3	
9	3A	21.0233	41.4961	34.3842	53.2	50.6±2.3
	3B	21.5309	42.0877	35.3076	49.2	
	3C	19.9787	42.5037	35.0616	49.3	
12	4A	22.4955	43.6306	37.1549	44.2	44.8±1.6
	4B	24.6626	46.7472	39.7216	46.7	
	4C	22.3383	43.222	36.8783	43.6	
15	5A	22.1265	42.4077	35.9685	46.5	48.3±4.2
	5B	23.0683	44.9908	37.3945	53.0	
	5C	23.6621	51.475	42.8051	45.3	
18	6A	22.9427	46.4147	39.2012	44.4	51.5±6.4
	6B	21.7624	41.7262	34.7938	53.2	
	6C	22.7219	42.8535	35.555	56.9	
21	7A	22.8078	42.8661	36.2225	49.5	47.4±2.1
	7B	23.8693	47.1835	39.9208	45.2	
	7C	16.1463	29.7411	25.3643	47.5	
24	8A	34.2013	70.7238	59.5932	43.8	43.4±1.2
	8B	35.3401	69.0701	58.7163	44.3	
	8C	36.6815	79.156	66.6013	42.0	
27	9A	23.9367	46.4754	39.0516	49.1	51.4±2.5
	9B	23.6719	45.9685	38.4441	50.9	
	9C	25.956	50.8543	42.1193	54.0	
30	10A	22.9926	45.5655	37.4766	55.8	63.1±6.3
	10B	22.7355	46.7677	37.2368	65.7	
	10C	22.6947	46.5968	36.9538	67.6	
33	11A	21.7602	41.7519	34.3886	58.3	62.0±5.5
	11B	22.7309	40.6745	33.3932	68.3	
	11C	22.5676	44.4663	36.3144	59.3	
36	12A	27.3429	44.8033	38.0087	63.7	59.2±4.6
	12B	21.6849	47.8451	38.6187	54.5	
	12C	20.0022	38.4363	31.5695	59.4	
39	13A	35.3201	68.301	58.9798	39.4	41.6±8.7
	13B	37.144	70.6923	62.155	34.1	
	13C	34.8038	73.8886	60.6581	51.2	

41.7	14A	33.3305	75.2114	62.2517	44.8	44.6±0.9
	14B	35.3523	72.6185	60.9912	45.4	
	14C	35.4169	73.7821	62.1448	43.5	
				Avg (±SD)	50.5±7.5	

Table A 13 Moisture content analysis results for Borehole-13

Depth (m)	**Sample No.**	**W1 (g)**	**W2 (g)**	**W3 (g)**	**Moisture content (%)**	**Avg. (±SD) moisture content (%)**
3	1A	22.9979	44.7393	37.9846	45.1	44.0±1.0
	1B	23.352	48.1598	40.6948	43.0	
	1C	22.5533	44.2461	37.6201	44.0	
6	2A	25.9318	46.3131	39.5669	49.5	45.6±3.4
	2B	22.6778	45.4142	38.5242	43.5	
	2C	22.6438	45.1602	38.3027	43.8	
9	3A	20.5089	41.113	34.9149	43.0	43.5±2.6
	3B	24.7872	44.574	38.3136	46.3	
	3C	22.0757	46.1568	39.1312	41.2	
12	4A	21.9352	43.5378	36.7566	45.8	45.5±1.6
	4B	22.4591	39.8535	34.5575	43.8	
	4C	23.0364	43.2715	36.8098	46.9	
15	5A	16.8535	38.4764	32.0572	42.2	45.0±2.8
	5B	27.3296	47.181	40.7561	47.9	
	5C	23.9163	43.4634	37.4174	44.8	
18	6A	33.3249	78.3486	63.9138	47.2	47.5±1.0
	6B	37.1267	80.0761	66.0198	48.6	
	6C	35.2888	81.7107	66.939	46.7	
21	7A	35.3924	74.9892	63.1344	42.7	46.1±3.1
	7B	35.7939	71.8322	60.3873	46.5	
	7C	36.1615	76.7906	63.451	48.9	
24	8A	22.9953	44.4158	35.3264	73.7	67.9±5.2
	8B	16.9282	43.987	33.2076	66.2	
	8C	22.1487	38.819	32.3317	63.7	
27	9A	22.5681	43.6895	35.5166	63.1	64.0±1.0
	9B	23.0242	43.9584	35.7947	63.9	
	9C	23.5393	57.6789	44.2193	65.1	
30	10A	23.8799	56.8831	44.6618	58.8	56.2±5.7
	10B	27.3397	60.6942	49.6304	49.6	
	10C	20.5464	44.5025	35.5109	60.1	
31.5	11A	22.6537	49.395	39.891	55.1	55.6±2.4
	11B	34.2047	75.9577	60.5833	58.3	
	11C	35.8379	67.5931	56.524	53.5	

33	12A	21.944	38.0673	30.6895	84.4	80.0±4.8
	12B	22.826	41.7289	33.279	80.8	
	12C	24.8147	61.9149	46.0298	74.9	
33.6	13A	16.1504	38.9652	29.1566	75.4	72.3±2.8
	13B	21.6815	50.3021	38.529	69.9	
	13C	22.2404	53.7487	40.605	71.6	
				Avg (±SD)	54.9±12.4	

Table A 14 Moisture content analysis results for Borehole-14

Depth (m)	**Sample No.**	**W1 (g)**	**W2 (g)**	**W3 (g)**	**Moisture content (%)**	**Avg. (±SD) moisture content (%)**
1.5	1A	34.1947	93.0883	88.0143	9.4	22.6±12.8
	1B	35.391	99.1964	82.6399	35.0	
	1C	33.327	88.881	78.3742	23.3	
3	2A	37.1318	91.4846	79.9985	26.8	25.8±0.9
	2B	36.1784	94.9417	83.0053	25.5	
	2C	34.7977	94.7665	82.72	25.1	
4.5	3A	35.4053	87.2033	77.9933	21.6	21.7±0.4
	3B	36.6788	93.1165	83.1689	21.4	
	3C	35.294	92.7995	82.3817	22.1	
6	4A	21.6903	49.7983	44.1829	25.0	25.6±0.8
	4B	23.8762	49.1995	43.8967	26.5	
	4C	22.6852	48.1379	42.9962	25.3	
9	5A	27.3411	57.1303	56.6819	1.5	7.4±9.6
	5B	22.985	48.0727	44.1641	18.5	
	5C	22.7703	61.5918	60.7676	2.2	
				Avg (±SD)	20.6±9.3	

Table A 15 Moisture content analysis results for Borehole-15

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content (%)
3	1A	36.4947	90.9247	80.0536	25.0	24.4±1.6
	1B	35.8457	84.3994	74.4919	25.6	
	1C	34.3155	89.2792	79.1265	22.7	
6	2A	25.395	54.4718	48.6878	24.8	27.3±2.5
	2B	22.8297	52.1787	45.915	27.1	
	2C	20.6341	46.912	40.8679	29.9	
9	3A	23.544	52.1218	45.1063	32.5	30.5±1.8
	3B	22.955	49.646	43.5178	29.8	
	3C	22.7762	52.9943	46.191	29.1	
12	4A	21.9467	46.674	40.4508	33.6	36.2±2.2
	4B	22.4778	46.9811	40.3297	37.3	
	4C	22.0839	44.2673	38.1884	37.7	
15	5A	23.0188	47.0204	40.7034	35.7	39.3±3.8
	5B	16.919	41.9598	34.9457	38.9	
	5C	23.0371	45.1819	38.4817	43.4	
				Avg (±SD)	31.5±6.1	

Table A 16 Moisture content analysis results for Borehole-16

Depth (m)	Sample No.	W1 (g)	W2 (g)	W3 (g)	Moisture content (%)	Avg. (±SD) moisture content (%)
3	1A	22.5007	48.2774	43.6031	22.2	21.7±9.4
	1B	23.038	50.4603	47.5107	12.1	
	1C	22.9466	47.181	41.4555	30.9	
4.5	2A	21.5403	40.2906	34.7318	42.1	42.0±1.6
	2B	22.564	46.4861	39.2353	43.5	
	2C	22.8126	48.9444	41.4269	40.4	
6	3A	22.7417	46.0403	41.0999	26.9	29.9±3.2
	3B	24.6746	49.795	43.5323	33.2	
	3C	16.1477	32.9691	29.119	29.7	
				Avg (±SD)	**31.2±10.2**	

Appendix B

Table B 1 Specific gravity results for fine fraction retrieved from Borehole-01

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.1823	2.2633	2.2779	2.24±0.05
6	2.1097	2.1953	2.1514	2.15±0.04
9	2.2524	2.2719	2.2931	2.27±0.02
12	2.2933	2.3177	2.3343	2.32±0.02
15	2.1557	2.1947	2.1974	2.18±0.02
18	2.2251	2.3115	2.322	2.29±0.05
21	2.3442	2.3861	2.3618	2.36±0.02
24	2.2463	2.2634	2.2635	2.26±0.01

Table B 2 Specific gravity results for fine fraction retrieved from Borehole-02

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.366	2.3931	2.3934	2.38±0.02
6	2.1813	2.2411	2.2399	2.22±0.03
9	2.0974	2.1486	2.1605	2.14±0.03
12	2.2192	2.2441	2.2573	2.24±0.02
15	2.2042	2.2363	2.2407	2.23±0.02
18	2.0842	2.0939	2.0963	2.09±0.01
21	2.2336	2.2531	2.2537	2.25±0.01
24	2.2087	2.2313	2.2389	2.23±0.02
27	1.9099	1.9312	1.9292	1.92±0.01
30	2.0814	2.0964	2.1088	2.10±0.01

Table B 3 Specific gravity results for fine fraction retrieved from Borehole-03

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.217	2.2426	2.2477	2.24±0.02
6	2.1283	2.1628	2.1821	2.16±0.03
9	2.2641	2.2927	2.3006	2.29±0.02
12	2.1348	2.162	2.1643	2.15±0.02
15	2.0573	2.0694	2.0811	2.07±0.01
18	2.331	2.3456	2.3514	2.34±0.01
21	2.2793	2.2942	2.2905	2.29±0.01
24	2.278	2.2808	2.2814	2.28±0.00

Table B 4 Specific gravity results for fine fraction retrieved from Borehole-04

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.3019	2.3034	2.3025	2.30±0.00
6	2.2361	2.2485	2.2447	2.24±0.01
9	2.2489	2.2514	2.2584	2.25±0.00
12	2.1569	2.1708	2.1728	2.17±0.01
15	2.1172	2.1271	2.1252	2.12±0.01
18	2.1441	2.147	2.1464	2.15±0.00
21	2.0351	2.0573	2.0592	2.05±0.01
24	2.2405	2.2696	2.2791	2.26±0.02
27	2.2118	2.2439	2.2491	2.23±0.02
30	2.2584	2.2773	2.2821	2.27±0.01
33	2.1905	2.2077	2.276	2.22±0.05
36	2.2043	2.218	2.2279	2.22±0.01

Table B 5 Specific gravity results for fine fraction retrieved from Borehole-05

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.0898	2.1428	2.1567	2.13±0.04
6	2.1727	2.2042	2.2162	2.20±0.02
9	2.1993	2.2261	2.2342	2.22±0.02
12	2.233	2.2641	2.2762	2.26±0.02
15	2.1671	2.2087	2.2194	2.20±0.03
18	2.4195	2.445	2.4511	2.44±0.02
21	2.4534	2.477	2.4828	2.47±0.02
27	2.4218	2.4411	2.4486	2.44±0.01
30	2.4184	2.4383	2.446	2.43±0.01
33	2.335	2.3596	2.3656	2.35±0.02

Table B 6 Specific gravity results for fine fraction retrieved from Borehole-06

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.2984	2.2963	2.3007	2.30±0.00
6	2.3046	2.3263	2.3299	2.32±0.01
9	2.425	2.4555	2.435	2.44±0.02
12	2.4431	2.4512	2.4716	2.46±0.01
15	2.4583	2.4701	2.4716	2.47±0.01
18	2.4496	2.4587	2.4619	2.46±0.01
21	2.4434	2.4537	2.4576	2.45±0.01
24	2.1798	2.1882	2.191	2.19±0.01
27	2.3808	2.395	2.3994	2.39±0.01
30	2.3527	2.3767	2.3882	2.37±0.02
33	2.2949	2.3259	2.34	2.32±0.02
36	2.2149	2.1428	2.1567	2.17±0.04

Table B 7 Specific gravity results for fine fraction retrieved from Borehole-07

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.1515	2.1787	2.1768	2.17±0.02
6	2.1753	2.1991	2.2001	2.19±0.01
9	2.2321	2.242	2.2484	2.24±0.01
12	2.1833	2.2118	2.2232	2.21±0.02
15	2.1833	2.2071	2.211	2.20±0.01
18	2.3279	2.3416	2.3446	2.34±0.01
21	2.3056	2.3235	2.3358	2.32±0.02
24	2.2676	2.28	2.2469	2.26±0.02
27	2.3977	2.4108	2.4177	2.41±0.01
30	2.2551	2.2829	2.2826	2.27±0.02
33	2.3936	2.4149	2.4229	2.41±0.02
36	2.2836	2.3019	2.3077	2.30±0.01

Table B 8 Specific gravity results for fine fraction retrieved from Borehole-08

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
1.5	2.5968	2.6125	2.6205	2.61±0.01
3	2.5539	2.5849	2.5935	2.58±0.02
4.5	2.6205	2.658	2.6608	2.65±0.02

Table B 9 Specific gravity results for fine fraction retrieved from Borehole-09

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
1.5	2.6498	2.6641	2.6618	2.66±0.01
4.5	2.6772	2.6908	2.6943	2.69±0.01

Table B 10 Specific gravity results for fine fraction retrieved from Borehole-10

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	1.8837	1.9304	1.953	1.92±0.04
6	2.3814	2.4044	2.4035	2.40±0.01
9	2.3609	2.3703	2.3664	2.37±0.00
12	2.348	2.3541	2.354	2.35±0.00
15	2.4684	2.4775	2.4732	2.47±0.00
18	2.3786	2.4033	2.4072	2.40±0.02
21	2.3294	2.3354	2.3416	2.34±0.01
24	2.4301	2.446	2.4475	2.44±0.01
27	2.2335	2.2653	2.2579	2.25±0.02
30	2.357	2.4214	2.4221	2.40±0.04
33	2.3085	2.3438	2.3452	2.33±0.02
36	2.2342	2.2356	2.2501	2.24±0.01
39	2.2509	2.2614	2.2646	2.26±0.01
41.7	2.2518	2.2724	2.2861	2.27±0.02

Table B 11 Specific gravity results for fine fraction retrieved from Borehole-11

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.3384	2.348	2.3564	2.35±0.01
6	2.2801	2.3009	2.3075	2.30±0.01
9	2.1547	2.1953	2.2057	2.19±0.03
12	2.166	2.1851	2.1898	2.18±0.01
15	2.3221	2.3487	2.3543	2.34±0.02
18	2.308	2.3054	2.343	2.32±0.02
21	2.2778	2.3049	2.3199	2.30±0.02
24	2.3737	2.3712	2.3733	2.37±0.00
27	2.3081	2.3131	2.3135	2.31±0.00
30	2.2668	2.2717	2.2744	2.27±0.00
33	2.3149	2.3419	2.3498	2.34±0.02
36	2.3044	2.3196	2.3225	2.32±0.01
39	2.3431	2.3404	2.34	2.34±0.00

Table B 12 Specific gravity results for fine fraction retrieved from Borehole-12

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.1674	2.191	2.2009	2.19±0.02
6	2.1499	2.1837	2.1905	2.17±0.02
9	2.2335	2.2358	2.2365	2.24±0.00
12	2.2382	2.2648	2.2738	2.26±0.02
15	2.2115	2.2507	2.2642	2.24±0.03
18	2.185	2.2091	2.221	2.21±0.02
21	2.2183	2.2474	2.2556	2.24±0.02
24	2.2238	2.2479	2.2556	2.24±0.02
27	2.2861	2.3029	2.3106	2.30±0.01
30	2.1749	2.2136	2.2272	2.21±0.03
33	2.169	2.1898	2.2026	2.19±0.02
36	2.1754	2.2131	2.2228	2.20±0.03
39	2.257	2.2847	2.2717	2.27±0.01
41.7	2.2568	2.2616	2.2672	2.26±0.01

Table B 13 Specific gravity results for fine fraction retrieved from Borehole-13

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.2162	2.2391	2.2411	2.23±0.01
6	2.2048	2.2226	2.2269	2.22±0.01
9	2.3085	2.3144	2.3187	2.31±0.01
12	2.2666	2.2882	2.2926	2.28±0.01
15	2.2367	2.248	2.2524	2.25±0.01
18	2.2624	2.2729	2.2759	2.27±0.01
21	2.1854	2.2131	2.2229	2.21±0.02
24	2.2625	2.2838	2.2895	2.28±0.01
27	2.2764	2.2853	2.2878	2.28±0.01
30	2.2685	2.2846	2.2956	2.28±0.01
31.5	2.2895	2.3239	2.3305	2.31±0.02
33	2.2267	2.2492	2.257	2.24±0.02
33.6	2.1783	2.1967	2.2068	2.19±0.01

Table B 14 Specific gravity results for fine fraction retrieved from Borehole-14

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
1.5	2.5024	2.5078	2.5082	2.51±0.00
3	2.4233	2.4328	2.4356	2.43±0.01
4.5	2.4554	2.461	2.4603	2.46±0.00
6	2.3861	2.4031	2.4063	2.40±0.01
9	2.6213	2.6275	2.6275	2.63±0.00

Table B 15 Specific gravity results for fine fraction retrieved from Borehole-15

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.461	2.4545	2.4537	2.46±0.00
6	2.4671	2.462	2.4608	2.46±0.00
9	2.3824	2.3834	2.3766	2.38±0.00
12	2.7061	2.7048	2.7047	2.71±0.00
15	2.3825	2.3818	2.3826	2.38±0.00

Table B 16 Specific gravity results for fine fraction retrieved from Borehole-16

Depth (m)	Specific gravity			Avg. (±SD) Specific gravity
	Trail-1	Trail-2	Trail-3	
3	2.3332	2.3221	2.3242	2.33±0.01
4.5	2.273	2.29	2.2922	2.29±0.01
6	2.379	2.39	2.3933	2.39±0.01

References

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Goli, V.S.N.S., Singh, P., Singh, D.N., Tak, L.K., 2022. Investigations on characteristics of landfill-mined-soil-like-fractions and their dependency on organic matter. Process Safety and Environmental Protection 162, 795–812. https://doi.org/10.1016/j.psep.2022.04.052

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GOVERNMENT OF TELANGANA
MUNICIPAL ADMINISTRATION & URBAN DEVELOPMENT (Plg.II) DEPARTMENT

Memo No.11013/Plg.II/2022 Dated:08.12.2022.

Sub: MA & UD Dept., - HGCL - Erection of 132 KV line from 132 KV LILO point to M/s. Dundigal Waste 2 Energy Pvt. Ltd by making LILO of existing 132 KV Gummadidala - DP Pally line - Approval for laying of 132 KV line along the service road of ORR from Dundigal circle to Shambipur village - Request - Reg.

Ref: 1.From Chief Engineer, Construction, TS TRANSCO, Vidyut Soudha, Lr.No.CPT 140/SE-Const/F.DW2EPL/D.No.522/2022, Dt:16.7.2022.
2.Govt.Memo.No.11013/Plg.II/2022, Dt:26.7.2022.
3.From the Chief General Manager (T)-II, HGCL, Lr.No1216/CGM(T)/HGCL/DGM(T)-I/2022-23, Dt:05.08.2022.

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The attention of the Managing Director, Hyderabad Growth Corridor Limited, Hyderabad is invited to the references cited. He is informed that as per Govt. Memo.No.7198/Plg.II/2020, Dated:19.9.2020 utilities within RoW/Buffer Zone of ORR shall be underground.

2. Therefore, laying of 132 KV along the ORR service road from Dundigal circle to Shambipur village by TS TRANSCO shall be underground only.

3. The Managing Director, Hyderabad Growth Corridor Limited, Hyderabad shall take necessary action accordingly.

ARVIND KUMAR
SPECIAL CHIEF SECRETARY TO GOVERNMENT

To
The Managing Director, Hyderabad Growth Corridor Limited, Hyderabad.
Sf/Sc.

//FORWARDED :: BY ORDER//

SECTION OFFICER

GOVERNMENT OF TELANGANA
MUNICIPAL ADMINISTRATION & URBAN DEVELOPMENT (Plg.II) DEPARTMENT

Memo No.11013/Plg.II/2022 **Dated:28.01.2023.**

Sub: MA & UD Dept., - HGCL - Erection of 132 KV line from 132 KV LILO point to provide Grid Connectivity to proposed 14.5 MW waste to Energy Plant of M/s. Dundigal Waste 2 Energy Pvt. Ltd., at Dundigal area in Medchal District - Permission to lay overhead lines all along the service road of Outer Ring Road - Reg.

Ref: 1.From the Chief Engineer, Construction (I/c.), Transmission Corporation of Telangana Limited, Vidyut Soudha, Hyderabad, dt.16.07.2022.
2.Govt. Memo No.11013/Plg.II/2022, dt.26.07.2022.
3.From the CGM, HGCL, Hyderabad, Lr.No.1216/CGM(T)/HGCL/DGM(T)-I/2022-23, Dt:05.08.2022.
4.Govt. Memo No.11013/Plg.II/2022, dt.8.12.2022.
5.Meeting held with Commissioner, GHMC on 28.01.2023.

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The attention of the Managing Director, Hyderabad Growth Corridor Limited, Hyderabad is invited to the references cited. He is informed that Government after careful reconsideration of the matter have considered the request of Chief Engineer (Construction), Telangana State TRANSCO to permit them to lay overhead lines all along the service road of Outer Ring Road for providing Grid Connectivity to the proposed 14.5 MW waste to Energy Plant of M/s. Dundigal Waste 2 Energy Pvt. Limited at Dundigal area in Medchal District.

2. The above orders are issued in supersession of earlier orders issued in the reference 4th cited and the Managing Director, Hyderabad Growth Corridor Limited, Hyderabad is requested to take further action accordingly.

ARVIND KUMAR
SPECIAL CHIEF SECRETARY TO GOVERNMENT

To
The Managing Director, Hyderabad Growth Corridor Limited, Hyderabad.
The Chief Engineer (Construction), Telangana State TRANSCO, Vidyut Souda, Hyderabad.
Sf/Sc.

//FORWARDED :: BY ORDER//

SECTION OFFICER

Annexure

Progress of work of erection of Power Evacuation Line for the 14.5 MW Dundigal Waste to Energy Project









GOVERNMENT OF TELANGANA
FOREST DEPARTMENT

Ref.No.FC1/FC03/24/2022
15221/2018/FCA-1
Dated:07/01/2023

O/o the Prl. Chief Conservator of Forests
(Head of Forest Force),
Telangana, "Aranya Bhavan,
Saifabad, Hyderabad – 500 004.

Sri R M Dobriyal, IFS
Prl. Chief Conservator of Forests &
Head of Forest Force (FAC)

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Sub:- TSFD - FCAct, 1980 – diversion of **0.6228 ha** of forest land for laying approach r d to the proposed Municipal Solid Waste (MSW) treatment and disposal facility o HMC at Nallavelly (V), Nallavelly RF, Sangareddy Dist., in favour of Superintendi Engineer (SWM), GHMC, Hyderabad –**Stage-I approval –working permission –is ed** -Reg.

Ref :-

1. DIGF(C), GoI MoEF&CC, IRO, Hyderabad, F.no.4-TSB244/2022-HYD/475 t.05.05.2022.
2. GoI, MoEF & CC, New Delhi, Lr. F.No. 5-2/2017-FC, dt. 28.03.2019 and ar ndments issued therein.
3. Forest(Conservation)Rules,2022 published vide MoEF&CC, GoI, New De Gazette Number GSR 480 (E), Dt.28.06.2022, communicated vide F.No.F 11/118/2021-FC, Dt.29.06.2022
4. MoEF&CC, GoI, New Delhi F.No.FC-11/118/2021-FC, Dt.18.07.2022.
5. PCCF, Ref.No.15221/2018/FCA-1, Dated:08.05.2022.
6. PCCF, Ref.No.15221/2018/FCA-1, Dated:19.08.2022.
7. District Forest Officer, Sangareddy Lr.No.457/2020/S6, dt.10.11.2022.
8. CF, Charminar Lr.No. 510794/2022/M3, dt.12.12.2022.

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In the reference 1st cited, the IRO, MoEF&CC, GoI, Hyderabad has accorded in-principle (Stage-I) approval for diversion of **0.6228 ha** of forest land for laying approach road to the proposed Municipal Solid Waste (MSW) treatment and disposal facility of GHMC at Nallavelly (V), Nallavelly RF, Sangareddy Dist., in favour of Superintending Engineer (SWM), GHMC, Hyderabad, with certain conditions stipulated therein.

The User Agency i.e., Superintending Engineer (SWM), GHMC, Hyderabad has deposited the following compensatory levies as per the conditions stipulated in the Stage-I approval accorded:

S. No	Description of the Item	Amount to be deposited by the User Agency Amount in Rs.	Remarks
1	Cost towards NPV	5,96,505	Deposited the following amount through e-payment mode against F. No. FP/TG/ROAD/46627/2020, and the same is reflected as paid on the Ministrys portal.

2	Cost towards raising and maintenance of CA in DFL	16,93,687	
3	Cost of SMC	10,00,000	
	Total	**32,90,192**	
1	Big RCC Pillars –Small RCC pillars	Rs. 78,000	Deposited into the CA PD Account o f District Forest Officer, Sangareddy (D)
2	Extraction of trees growth charges as per FSR –	Rs.3,43,310	
3	Cost of erecting barrier at the entry of the road and a gate of solid water treatment & disposal facility –	Rs.5,00,000	
4	Administrative charges @5%-	Rs.2,38,765	
5	Extraction of chain link fencing both sides of the approach road Part-II (1020 M) –	Rs.37,74,000	
	Total	**:50,14,075**	

The Conservator of Forests, Charminar Circle, Hyderabad vide ref 8th cited has submitted condition-wise compliance for further necessary action.

The Stage-I approvals has been published in vernacular news papers in Telugu on and other one in English by the user agency (Copies enclosed). Further, the User Agency through the District Forest Officer., Sangareddy vide 7th cited has requested for according working permission.

Further, with regard to issue of working permission, it is informed that as per the clarification issued in ref 4th cited on the applicability of the Forest(Conservation) Rules, 2022 issued in ref 3th cited that “provisions of Forest (Conservation) Rules, 2003 shall apply to the proposals submitted online through Parivesh Portal and which have been accepted by the Nodal Officer before 28.06.2022”. In the instant case the proposals have already been accepted by the Nodal Officer/ Prl. Chief Conservator of Forests (HoFF) and the Stage-I approval has been granted. Hence, the guidelines issued in ref 2nd cited in the form of Handbook and amendments issued therein and issued till that time are applicable.

At Para 11.2 of the Handbook issued by the Ministry in F.No.5-2/2017- FC, Dt.28.03.2019, and amendments issued therein and the guidelines issued in F.No.11-306/2014-FC (pt),

Dt.28.08.2015, detailed procedure about grant of permission for tree cutting and commencement of work of a linear project in forest land (such as laying of new roads, widening of existing highways, transmission lines, water supply lines, optic fiber cabling, railway lines etc., in which the in-principle approval under the Forest (Conservation) Act, 1980 is accorded), for a period of one year is given, to facilitate speedy execution of projects. Such orders shall be passed only after full realization of funds for compensatory Afforestation, Net Present Value (NPV), wildlife conservation plan, plantation of dwarf species of medicinal plants, and all such other compensatory levies, specified in the Stage I (in-principle) approval from the UA, and where ever applicable, transfer and mutation of non-forest/ revenue forest land in favour of State Forest Department.

Further, the State Government vide Memo No.3983/For.I(1)/2016-2,Dt.15.10.2016 has authorized the Prl. Chief Conservator of Forests & Head of Forest Force to issue working permission to the User Agency for tree cutting and commencement of work of linear projects, for a period of one year, subject to the conditions stipulated in the in-principle approval and their compliance, which is in accordance with the guidelines issued by Ministry of Environment and Forests & Climate Change, Government of India in F.No.11-306/2014 -FC(pt.), dt.28.08.2015.

In exercise of the powers delegated to the undersigned by the State Government & with reference to Handbook of F(C) Act, 1980, F(C)Rules, 2003, Guidelines & Clarifications in F.No.5-2/2017-FC, Dt.28.03.2019 and F.No.11-306/2014-FC(pt.), Dt.28.08.2015 and amendments issued therein issued by Ministry of Environment and Forests & Climate Change (MoEF&CC), Government of India, and **working permission is hereby accorded** in favour of the SE (SWM), GHMC, Hyderabad, for **tree cutting / translocation of trees and commencement of work** in the forest land proposed to be diverted from the date of entering into agreement with the District Forest Officer, Sangareddy District for a period upto **one year**, **subject to the following conditions:**

1. The SE (SWM), GHMC, Hyderabad **i.e., User Agency** shall report to the District Forest Officer, Sangareddy and obtain further permission from him before starting the work and works should be carried out under the supervision of the DFO.
2. The User Agency shall publish the working permission now granted in verbatim language along with the conditions and safe–guards imposed by the Central Government in Stage–I approval in two widely circulated daily newspapers, one in vernacular language and the other in English language, so as to make people aware of the permission granted to the project proponent for use of forest land for non–forest purposes. (C.No.vii of F.No.11-306/2014–FC(pt) dt: 28.08.2015).
3. The SE (SWM), GHMC, Hyderabad shall enter into an agreement with the District Forest Officer, Sangareddy agreeing to perform all conditions as stipulated in Stage-I approval orders as per the para 11.2 of guidelines of the Hand book issued by the GoI, MoEF& CC, New Delhi on 28.03.2019 on F(C)Act, 1980, F(C)Rules, 2003, Guidelines & Clarifications as well as covering letters, Part II/III/IV of Forest Department, inspection note and obtain further permission from the concerned **District Forest Officer's** for commencement of the works.
4. The copies of the Forest Clearance and working permission should also be submitted to the Heads of local bodies, Panchayats and Municipal Bodies by the Second Party in addition to the relevant offices of the Government who in turn has to display the same in 30 days. (C.No. vii of F.No. 11-306/2014 – FC(pt) dt: 28.08.2015).
5. The Forest Department shall dispose all the appeals filed against the order of Deemed Permission issued by the PCCF(HoFF). (C.No.v & vi of F.No.11-306/2014 – FC(pt) dt: 28.08.2015).

6. The User Agency shall agree, bind and undertake to comply any other conditions that may be imposed from time to time by the MoEF&CC, GoI, State Government and PCCF in the interest of conservation, protection & development of forests.
7. The working permission issued is valid **upto one year** from the date of issue of further permission by the concerned District Forest Officer. If the User Agency fails to comply with the conditions stipulated in Stage-I approval within stipulated time, for further extension they should approach MoEF&CC, GoI.
8. The User Agency shall agree, bind and declare that the forest department shall fell all standing trees / translocate trees, if any in the forest area being diverted for the project by the forest department itself and the user agency shall undertake not to touch or fell such trees in any manner.
9. The works should be carried out without any scope for violations under various rules and guidelines envisaged under Forest (Conservation) Act, 1980 and Wildlife (Protection) Act, 1972 and other relevant guidelines and Rules in force.
10. Any other conditions imposed by the concerned District Forest Officer/Chief Conservator of Forests during execution of work in the interest of protection of Forests shall be carried out at the project cost.

The District Forest Officer, Sangareddy is requested to enter into agreement with User Agency for working permission and permitted to take up construction of boundary pillars / translocation of trees from the amount deposited in the CA-PD account of DFO/FDO soon after entering into agreement for working permission. The works shall be included in APO **2022-23** for CA-PD account and should be reported in MPR of CA-PD account.

Signed by Rakesh Mohan Dobriyal
Date: 07-01-2023 12:26:26
Reason: Approved

Prl.Chief Conservator of Forests
& (Head of Forest Force)(FAC)

To,

The District Forest Officer, Sangareddy.

Copy to the Conservator of Forests, Charminar Circle, Hyderabad for information and necessary action.

Copy to the Superintending Engineer (SWM), GHMC, Hyderabad.

Copy to the District Collector, Sangareddy for information.

Copy submitted to Spl. Chief Secretary to Government, Forest Department, Telangana Secretariat, Hyderabad for favour of information.

TELANGANA STATE POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN, A - 3, INDUSTRIAL ESTATE,
SANATHNAGAR, HYDERABAD - 500 018

Phone: 23887500
Fax: 040 – 23815631
Website: www.tspcb.cgg.gov.in

CONSENT ORDER FOR ESTABLISHMENT – RED CATEGORY

Order No. 4258760/ TSPCB/CFE/RO-RCP/SWM/HO/2023 - **Dt.06.02.2023**

Sub: TSPCB – CFE – **M/s. Hyderabad Integrated MSW Ltd., Pyaranagar, Nallavelli Village, Gummadidala Mandal, (GPS Co-ordinates – West side E-78^{0}19'26.49", N-17^{0}43'19.08" and South east – E-78^{0}20'20.68", N-17^{0}42'43.63", South West Side E-78^{0}19'22.92"N-17^{0}42'58.84" Sangareddy District – Consent for Establishment** of the Board under Sec.25 of Water (Prevention & Control of Pollution) Act, 1974 and Under Sec.21 of Air (Prevention & Control of Pollution) Act, 1981 – Issued – Reg.

Ref:
1. CFE application received through TS iPASS on 06.01.2023.
2. RO, RC Puram verification report dated 20.01.2023.
3. CFE Committee meeting held on 24.01.2023
4. Industry's letter submitted on 28.01.2023 & 30.01.2023

* * * * *

1. In the reference 1st cited, an application was submitted to the Board seeking Consent for Establishment (CFE) to set up Integrated Municipal Solid Waste Processing facility comprising of Power Plant, Compost plant, Bio Methanization and RDF etc, as mentioned below, with a cost of Rs. 44,550 Lakhs.

A. **Raw Materials** :

Municipal Solid Waste (MSW)	4000 TPD

B. Products:

Sl. No.	Products	Capacity
1.	Bio-gas	260 TPD
2.	Compost	200 TPD
3.	RDF	*2035 TPD
4.	Recycled Plastics (Granules and LD Bags)	90 TPD

C. **Waste to energy Plant**:

Sl. No.	Products	Capacity
1.	Electricity	15 MW

***The RDF of 1000 TPD shall be used as Raw Material. The remaining 1035 TPD shall be disposed to other waste to energy plants/Cement plants.**

2. As per the application, the above facility is to be located at Pyaranagar, Nallavelli Village, Gummadidala Mandal, Sangareddy District with a total area of Acres 120.12 Guntas.

3. In the reference 2nd cited, the Environmental Engineer, Regional Office, RC Puram, T.S.Pollution Control Board reported that the above site was inspected on 20.01.2023 and observed that the site is surrounded by:

North	Open Land (covered with forest area) followed by Pyaranagar village at a distance of about 850 meters.
South	Nallavelly Reserved forest followed by Hyderabad – Narsapur High Way at a distance of about 500 meters.
East	Forest land followed by agricultural land followed by Nallavelly village at a distance of about 1.92 km.
West	Forest area.

4. The Board, after careful scrutiny of the application and verification report of the Regional Officer and after examining in the CFO Committee meeting held on 24.01.2023, hereby issues **CONSENT FOR ESTABLISHMENT** to your facility under Section 25 of Water (Prevention & Control of Pollution) Act, 1974 and under Section 21 of Air (Prevention & Control of Pollution) Act, 1981 and the rules made there under. **This order is issued to the facility as mentioned at Para (1) only.**

5. This Consent Order now issued is subject to the conditions mentioned in Schedule 'A' and Schedule 'B'.

6. This order is issued from pollution control point of view only. Zoning and other regulations are not considered.

Encl: Schedule 'A'
Schedule 'B'

Sd/-
MEMBER SECRETARY

To,
M/s. Hyderabad Integrated MSW Ltd.,
Pyaranagar, Nallavelli Village, Gummadidala Mandal,
(GPS Co-ordinates – West side E-78^{0}19'26.49", N-17^{0}43'19.08"
and South east – E-78^{0}20'20.68", N-17^{0}42'43.63",
South West Side E-78^{0}19'22.92"N-17^{0}42'58.84"
Sangareddy District.

//T.C.F.B.O//

06/02/2023

Senior Environmental Engineer

SCHEDULE – A

1. **This order is valid for a period of 5 years from the date of issue.** Progress on implementation of the project shall be reported to the concerned Regional Office, T.S. Pollution Control Board once in six months. The consent of the Board shall be exhibited in the factory premises at a conspicuous place for information of the inspecting officers.

2. The proponent shall obtain Consent for Operation (CFO) from TSPCB, as required Under Sec.25/26 of the Water (Prevention and Control of Pollution) Act, 1974 and under sec. 21/22 of the Air (Prevention and Control of Pollution) Act, 1981, before commencement of the activity.

3. The proponent shall ensure that there shall not be any change in the process technology and scope of working without prior approval from the Board.

4. Good housekeeping shall be maintained.

5. The industry is liable to pay compensation for any environmental damage caused by it, as fixed by the Hon'ble Courts, Collector and District Magistrate as Civil liability.

6. The rules and regulations notified under Environmental Acts by the MOEF&CC and by the Ministry of Law and Justice, GOI, regarding the Public Liability Insurance Act, 1991 shall be followed.

7. Notwithstanding anything contained in this consent order, the Board hereby reserves the right and powers under Section 27(2) of the Water (Prevention & Control of Pollution) Act, 1974 and under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and amendments thereof, to review any and/or all the conditions imposed herein, to modify conditions or stipulate any further conditions and to take action including revocation of this order in the interest of public health and environment.

8. Any person aggrieved by an order made by the State Board under Section 25, Section 26, Section 27 of Water Act, 1974 or Section 21 of Air Act, 1981 may within thirty days from the date on which the order is communicated to him, prefer an appeal as per the State Water Rules, 1976 and Air Rules,1982, to such authority (hereinafter referred to as the Appellate Authority) constituted under Section 28 of Water (Prevention and Control of Pollution) Act,1974 and Section 31 of the Air (Prevention and Control of Pollution) Act, 1981.

SCHEDULE – B

Water Consumption:

1. The source of water is Borewell. The maximum water consumption shall not exceed the following:

Sl. No.	Purpose	Quantity (KLD)
1.	Process	140
2.	Boiler feed/make up	68
3.	Washing	20
4.	Domestic	35
5.	Cooling water makeup	150
6.	Greenbelt	130 (Recycled water)
7.	Other Flue gas cleaning	50 (Recycled water)
8.	Ash quenching	150 (Recycled water)
9.	Odour Control	100
	Total	**843 KLD**

2. The maximum waste water generation shall not exceed the following::

Sl. No.	Effluent	Quantity (KLD)	Mode of final disposal
1.	Boiler blow down	40	After treatment shall be used for Ash Quenching
2.	Cooling bleed off	110	
3.	Domestic	30	Shall be treated in STP of 50 KLD capacity and the treated water shall be utilized for on land for gardening duly meeting the standards
4.	Washings (Floor and Vehicle)	18	ZLD treatment system: After treatment in ETP shall be passed through stripper – 600 KLD and then subjected to Mechanical Vapour Recompression Technology of capacity 600 KLD. The permeates of 480 KLD shall be used for the process and the rejects – 120 KLD shall be subject to paddle dryer and salt shall be disposed to waste to energy plant.
5.	Leachate	600	

3. The disposal of treated Leachate shall follow the following standards:

Sl.No.	Parameter	Standards
i.	Suspended solids, mg/l, max	100
ii.	Dissolved solids(inorganic), mg/l, max	2100
iii.	pH value	5.5 to 9.0
iv.	Ammonical Nitrogen (as N), mg/l, max	50
v.	Total kjeldahl nitrogen (as N), mag/l, max.	100
vi.	Biochemical Oxygen Demand (3 days at 27°C. mg/l, max.	30
vii.	Chemical Oxygen Demand, mg/l, max.	250
viii.	Arsenic, (as AS). mg/l. max.	0.2
ix.	Mercury (as Hg), mg/l, max	0.01
x.	Lead (as Pb), mg/l, max	0.1
xi.	Cadmium (as Cd), mg/l, max	2.0
xii.	Total Chromium (as Cr), mg/l, max	2.0
xiii.	Copper (as Cu), mg/l, max	3.0
xiv.	Zinc (as Zn), mg/l, max	5.0
xv.	Nickel (as Ni), mg/l, max	3.0
xvi.	Cyanide (as CN), mg/l, max	0.2
xvii.	Chloride (as Cl), mg/l, max	1000
xviii.	Fluoride (as F), mg/l, max	2.0
xix.	Phenolic compounds (as C6H5OH), mg/l, max	1.0

4. **The facility shall obtain NOC from Air Force Academy Dundigal before applying of CFO of the Board.**
5. **The facility shall submit survey no's of the site before applying of CFO of the Board..**
6. **The facility shall not carry any land fill activity within the processing facility as committed by the industry.**
7. The Sewage Treatment Plant (STP) shall be constructed and commissioned along with the commissioning of the activity. All the units of the STP shall be impervious to prevent ground water pollution.

8. The domestic effluents shall be treated in the STP to the on land for irrigation standards, stipulated under Environment (Protection) Rules, 1986, notified and published by Ministry of Environment and Forests, Government of India as specified in schedule VI vide G.S.R.422 (E), dt.19.05.1993 and its amendments thereof.

9. The industry shall construct ETP consisting of pre-treatment tank and neutralization pit for treating of boiler blow-down and cooling tower bleed off and the treated water shall be used for ash-quenching.
10. In case of compost plant, the windrow area shall be covered with shed and provided with impermeable base. Such a base shall be made of concrete or compacted clay, 50 cm thick, having permeability coefficient less than 10–7 cm/sec. The base shall be provided with 1 to 2 per cent slope and circled by lined drains for collection of leachate or surface run-off.

11. Composting shall be carried out in a closed shed so as to avoid odour nuisance to the surrounding area.

Air:

12. The facility shall comply with the following for controlling air pollution:

S. No	Details of Stack	Stack 1	Stack 2
a)	Attached to	Boilers	DG Sets
b)	Capacity	2 x 21 TPH	2 x 500 KVA
c)	Fuel	MSW RDF	HSD
d)	Fuel quantity	1000 TPD	--
e)	Stack height (m)	60 meters	15 mtrs
f)	Details of Air Pollution Control Equipment	Bag filters	Acoustic enclosures
g)	Standards to be complied	SPM – 115 mg/Nm3	SPM – 115 mg/Nm3

13. The facility shall install stack of 60 m height for boiler and shall install bagfilters as air pollution control equopment to control the emissions.
The facility shall meet the emisisons standards as as prescribed in Schedule – II (C) of the Solid waste Management Rules, 2016 i.e, Particulate matter – 50 mg/Nm^3 , HCl – 50 mg/Nm^3 ,SO2 – 200 mg/Nm^3 , CO –100 mg/Nm^3 , Total Organic Carbon - 20 mg/Nm^3 , HF – 4 mg/Nm^3 ,NOx - 400 mg/Nm^3 (Standard refers to half hourly average)
Total dioxins and furancs – 0.1 ngTEQ/Nm^3 , Cd+Th+ their compounds – 0.05mg/Nm^3 and Sb+As +Pb+ Cr+Co+Cu+Mn+Ni+V+ their compounds – 0.05mg/Nm^3

14. The facility shall provide Continues Emission Monitoring System(OCEMS) for the stack attached to the boilers for parameters SPM, SO2, NOx, HCL & CO and shall connect to TSPCB server.
15. The facility shall lay internal cement concrete roads for movements of vehicles within the processing facility.

16. The facility shall transport the MSW in closed vehicles only and ensure that there is no spillage of MSW during transportation.

17. The incoming wastes at site shall be maintained prior to further processing. To the extent possible, the waste storage area should be covered. If, such storage is done in an open area, it shall be provided with impermeable base with facility for collection of leachate and surface water run-off into lined drains leading to a leachate treatment and disposal facility.

18. The proponent shall ensure compliance of the National Ambient Air quality standards notified by MoE&F, GoI vide notification No. GSR 826(E), dated. 16.11.2009 during construction and regular operational phase of the project.

19. Diesel generators shall be installed in a closed area with silencers and suitable noise absorption systems. The ambient noise level shall not exceed 65 dB(A) during day time and 55 dB(A) during night time.

20. Ambient noise levels should conform to the residential standards both during day and night. Incremental pollution loads on the ambient air and noise quality should be closely

monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level during construction phase, so as to conform to the stipulated standards by the CPCB.

21. Vehicles hired to bring construction material to the site should be in a good condition and should conform to ambient air and noise standards and should be operated only during non peak hours.

Solid / Hazardous Waste:

22. The facility shall comply with the following:

Sl. No.	Name of the Waste	Quantity	Disposal option
1.	Waste Oil / Used Oil	200 LPM	Shall be sent to Board's authorized Recyclers /Repressors
2.	Inert	400 TPD	Shall be sent to M/s. Jawahar Nagar dump site for land filling/further processing.
3.	Bottom & fly Ash	250 TPD	

The compost plant and other processing facilities shall follow the conditions as follows:

i. The incoming solid wastes and the wastes storage at site shall be covered.

ii. The facility shall provide a system for collection of leachate and surface water run-off in to lined drains leading to leachate treatment and disposal facility.

iii. Necessary precautions shall be taken to minimize nuisance of odor, flies, rodents bird menace and fire hazard.

iv. In case of breakdown or maintenance of plant, waste intake shall be at stopped and arrangements be worked out for diversion of wastes to the landfill site.

v. Pre-process and post-process rejects shall be removed from the processing facility on regular basis and shall not be allowed to pile at the site. Recyclables shall be routed through appropriate vendors. The non-recyclables shall be sent for well-designed landfill site(s).

vi. In case of compost plant, the windrow area shall be provided with impermeable base. Such a base shall be made of concrete or compacted clay, 50 cm thick, having permeability coefficient less than 10-7cm/sec. The base shall be provided with 1 to 2 percent slope and circled by lined drains for collection of leachate or surface run-off.

vii. Ambient air quality monitoring shall be regularly carried out particularly for checking odour nuisance at down-wind direction on the boundary of processing plant.

viii. In order to ensure safe application of compost, the following specifications for compost quality shall be met, namely:

Parameters	Concentration not to exceed * (mg/kg dry basis, except pH value and C/N ratio
Arsenic	10.00
Cadmium	5.00
Chromium	50.00
Copper	300.00
Lead	100.00
Mercury	0.15
Nickel	50.00
Zinc	1000.00
C/N ratio	20 – 40
PH	5.5 – 8.5

23. The facility shall construct silos for storage of fly ash and the bottom ash shall be transported through closed system only.

24. The solid waste generated shall be properly collected and segregated before disposal to the municipal facility. Waste paper, cartons, thermocol, plastic waste, glass etc., shall be disposed to recycling units. E-Waste shall be disposed to authorized

recycling units. The organic waste shall be composted.

25. All the topsoil excavated during construction activities should be stored for use in horticulture/landscape development within the facility site.

26. **The facility shall take the authorization under Rule-16(1)(c) of the Solid Waste Management Rules, 2016.**

27. The following rules and regulations notified by the MoE&F, GoI shall be implemented.
    a) Solid Waste Management Rules, 2016.
    b) Construction and Demolition Waste Management Rules, 2016.
    c) Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.
    d) The Plastic Waste Management Rules, 2016 and amendments thereof.
    e) Batteries Waste Management Rules, 2022.
    f) E-Waste (Management) Rules, 2016 and its Amendment Rules, 2018.
    g) Bio-Medical Waste Management Rules. 2016 and its Amendment Rules, 2018.

Other Conditions:

28. **The facility shall maintain buffer zone on all the sides as committed and develop green belt of 5 to 8 mtrs width with tall growing trees.**

29. **The Bio-gas generated in the facility after operation shall be maximum utilized for captive consumption and the remaining shall be exported to requisite industries.**

30. **The compostable waste after composting shall be sold as compost and maintain records.**

31. **The recyclable plastic waste shall be used for in house granules making/LD Bags.**

32. **The facility shall develop thick green belt with tall growing trees all along the forest area approach road.**

33. Thick Green belt shall be developed along the boundary of the facility in 33% area. Green belt development shall be started along with the construction activity.
    The facility shall not disturb the existing greenbelt provided.

34. The facility shall take proper measures for control of odour nuisance. In case persistent odour exists, necessary measures shall taken otherwise the facility should go for alternate site.

35. The MSW carrying vehicles shall not pass through the village road.

36. The facility shall obtain Plastic Waste Authorization from the Board & Extended Producer Reasonability '(EPR) Registration in the website https://eprplastic.cpcb.gov.in/#/plastic/home

37. The facility shall obtain necessary permissions for the proposed activity. from the concerned Government departments / concerned authorities.

38. The facility shall ensure that there shall not be any change in the process technology and scope of working without prior approval from the Board.

39. The operator of facility shall submit the Annual report to the local body in Form-III on or before the 30th day of April every year

40. The facility shall comply with all the directions issued by the Board from time to time.

41. **The facility shall submit the Survey Nos. after obtaining from the concerned department.**

42. **The industry shall allocate a minimum of 1% of its project cost towards CSR (Corporate Social Responsible) activities during construction period and 0.20% of the project cost per year during operational period for 10 years.**

43. **The proponent shall lay internal cement concrete roads for movement of vehicles within the dump yard.**

44. **The proponent shall provide G.I. sheets for covering for the belt conveyor and**

also install adequate dust suppression equipment at all around the stockpiles.

45. **The proponent shall take adequate measures to control self-ignition of municipal solid waste.**

46. **The proponent shall regularly conduct ground water, ambient air monitoring around the dump site regularly.**

47. **The vehicles transporting municipal solid waste shall be covered with tarpaulin covers.**

48. The facility shall provide compound wall /fencing to avoid entering of animals etc,.

49. The facility should comply with the Solid Waste Management Rules, 2016 and its amendments.

50. The Board may stipulate/delete any other conditions if necessary.

51. Concealing the factual data or submission of false information / fabricated data and failure to comply with any of the conditions mentioned in this order may result in withdrawal of this order and attract action under the provisions of relevant pollution control Acts.

Sd/-
MEMBER SECRETARY

To,
M/s. Hyderabad Integrated MSW Ltd.,
Pyaranagar, Nallavelli Village, Gummadidala Mandal,
(GPS Co-ordinates – West side E-78^{0}19'26.49", N-17^{0}43'19.08"
and South east – E-78^{0}20'20.68", N-17^{0}42'43.63",
South West Side E-78^{0}19'22.92"N-17^{0}42'58.84"
Sangareddy District.

//T.C.F.B.O//

M.Pranee 08/02/2023

Senior Environmental Engineer

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL SOUTHERN ZONE,CHENNAI

ORIGINAL APPL No.199 OF 2021

IN THE MATTER OF:

Shri Shankar Narayanan Bala Krishnan

..Applicant

Vs

State of Telangana
Rep. by its Chief Secretary Hyderabad
and Ors.

...Respondents

STATUS REPORT FILED BY THE 6 RESPONDENT

M/s.D. SREENIVASAN
V.JAIHARISUDHAN

COUNSEL FOR THE 6th RESPONDENT