REPORT

ON

IDENTIFICATION OF DIFFERENT LITHO UNITS USING GROUND PENETRATION RADAR (GPR)

FOR

UNDERGROUND TUNNEL

CHANDPOLE METRO STATION to BADI CHAUPAR METRO STATION, JAIPUR METRO RAIL

FOR

CONTINENTAL ENGINEERING CORPORATION (CEC) SECTION OF JMRC

Advanced Technology & Engineering Services
(A division of Aimil Ltd.)
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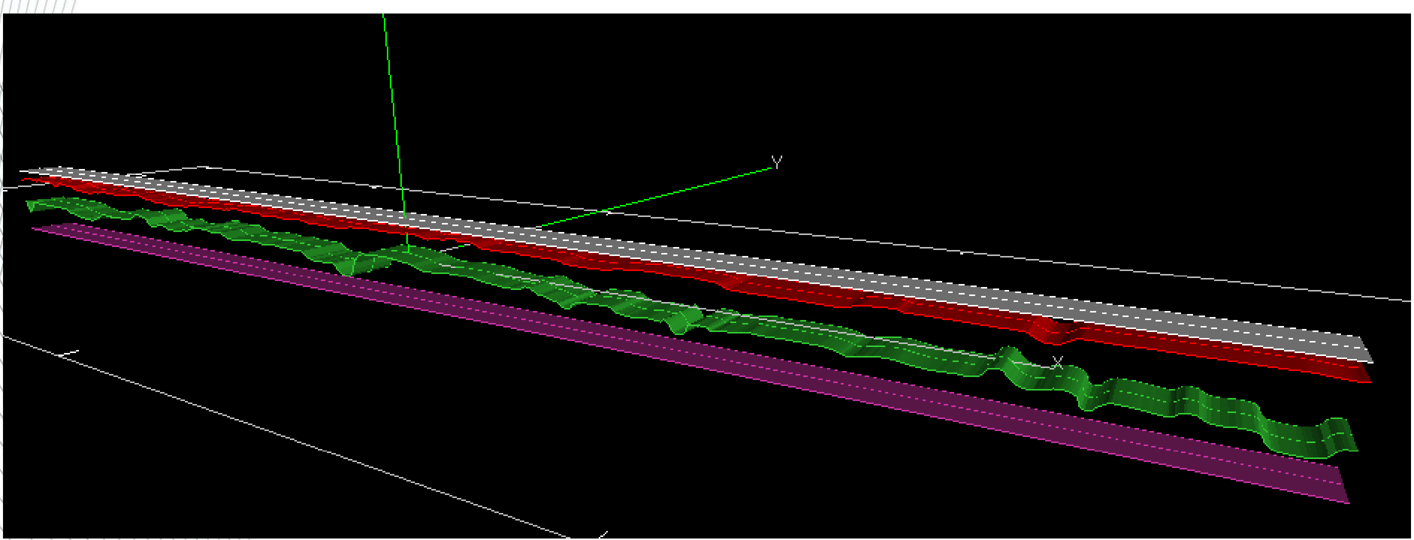

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Advanced Technology & Engineering Services,
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PRACTICING ATES PROFESSIONALS

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REPORT ON GROUND PENETRATION SURVEY FOR PROPOSED TUNNEL BETWEEN CHANDPOLE AND BADI CHAUPAR (JAIPUR)

1.0 INTRODUCTION

Ground penetrating radar survey is a nondestructive geophysical method that produces a continuous cross-sectional profile or record of subsurface features, without drilling, probing, or digging. Ground penetrating radar (GPR) profiles are used for evaluating the location and depth of buried objects and to investigate the presence and continuity of natural subsurface conditions and features. It is a high-resolution geophysical method, which is based on the propagation of high frequency electromagnetic waves. The GPR method images structures in the ground that are related to changes in dielectric properties. In sediments, the water content primarily causes the changes in dielectric properties.

Ground penetrating radar operates by transmitting pulses of ultra high frequency radio waves (microwave electromagnetic energy) down into the ground through a transducer (also called an antenna). The transmitted energy is reflected from various buried objects or distinct contacts between different earth materials. The antenna then receives the reflected waves and stores them in the digital control unit.

It provides 3-D pseudo image of the subsurface with accurate depth estimations. The GPR technique is being extensively used for engineering, geological, archeological, sedimentological and other near surface investigations like hydrological and geotechnical purposes GPR can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures. It can detect objects, changes in material, and voids and cracks.

The depth range of GPR is limited by the electrical conductivity of the ground, and the transmitting frequency. As conductivity increases, the penetration depth also decreases. This is because the electromagnetic energy is more quickly dissipated into heat energy, causing a loss in signal strength at depth. Higher frequencies do not penetrate as far as lower frequencies, but give better resolution. Optimal depth penetration is achieved in dry sandy soils or massive dry materials such as granite, limestone, and concrete. In moist and/or clay laden soils and soils with high electrical conductivity, penetration is sometimes only a few centimeters. The resolution depends upon the frequency of the antenna used and the electrical properties of the rocks in the subsurface.

Ground-penetrating radar antennae are generally in contact with the ground for the strongest signal strength; however, GPR horn antennas can be used 0.3 to 0.6 m above the ground.

GPR uses the principle of scattering of electromagnetic waves to locate buried objects. The basic principles and theory of operation for GPR have evolved through the disciplines of electrical engineering and seismic exploration, and practitioners of GPR tend to have backgrounds either in geophysical exploration or electrical engineering. The fundamental principle of operation is the same as that used to detect aircraft overhead, but with GPR that antennas are moved over the surface rather than rotating about a fixed point. This has led to the application of field operational principles that are analogous to the seismic reflection method.

The practical result of the radiation of electromagnetic waves into the subsurface for GPR measurements is shown by the basic operating principle that is illustrated in Figure 1.

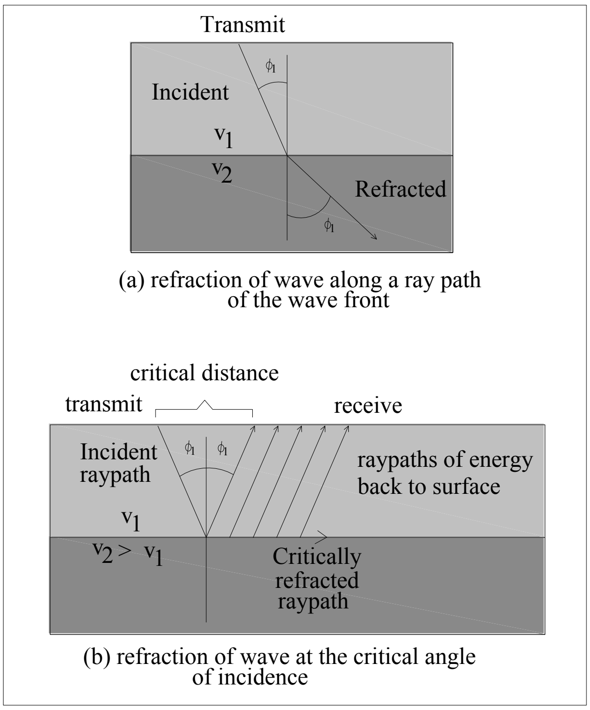


Figure 1: Transmitted electromagnetic wave front scattered from a buried Object with a contrasting permittivity

The electromagnetic wave is radiated from a transmitting antenna, travels through the material at a velocity, which is determined primarily by the permittivity of the material. The wave spreads out and travels downward until it hits an object that has different electrical properties from the surrounding medium, is scattered from the object, and is detected by a receiving antenna. The surface surrounding the advancing wave is called a wavefront. A straight line drawn from the transmitter to the edge of the wavefront is called a ray. Rays are used to show the direction of travel of the wavefront in any direction away from the transmitting antenna. If the wave hits a buried object, then part of the waves energy is "reflected" back to the surface, while part of its energy continues to travel downward. The wave that is reflected back to the surface is captured by a receive antenna, and recorded on a digital storage device for later interpretation.

The equipment used for the scanning includes SIR-3000 (GPR) of Geophysical Survey Systems Inc. (GSSI), USA, 100 MHz paired antenna with other peripherals as shown in the Figure 2.

SIR-3000

100 MHz antenna

Figure 2: Equipments used for GPR survey

Continental Engineering Corporation (CEC) entrusted us to carry out subsurface survey to identify sub surface lithological variation as well as to locate artifacts in the proposed tunnel from Chandpole Metro Station to Badi Chaupar Metro Station using trench less survey viz., Survey using Ground Penetration Radar (GPR). The objective of the survey was to identify lithological variations and artifacts of considerable dimension in order to see if rock or any artifacts are intercepted during the course of excavation done by TBM. It is understood that the Tunnel Boring Machine (TBM) being used for carrying out tunnel work has the capability for cutting soil and it would not be possible to cut rock using the present TBM. It is therefore, becomes imperative to know the subsurface details before excavating and if the GPR scan indicates rock, the alignment would be required to be looked into for any change.

This report presents the GPR scanning results for Underground Metro Line between proposed Chandpole Metro Station to Badi Chaupar Metro Station.

2.0 STUDY AREA

In order to prioritize the scanning work, the entire stretch between Chandpole & Badi Chaupar has been sub-divided into following sectors:

Sector-1: **Along the tunnel alignment for the stretch between Chandpole Metro station to Chhoti Chaupar.**

Sector-2: **Chhoti Chaupar Metro station.**

Sector-3: **Along the tunnel alignment for the stretch between Chhoti Chaupar to Badi Chaupar.**

Figure 3 presents the location of entire stretch between Chandpole Metro Station to Badi Chaupar Metro station. Survey was carried out drawing two longitudinal lines on the roads on both the sides of the divider. Transverse profiles were also taken at 50m interval in order to see if there are any artifacts. The present report is aimed to provide the scanning results for the whole alignment.

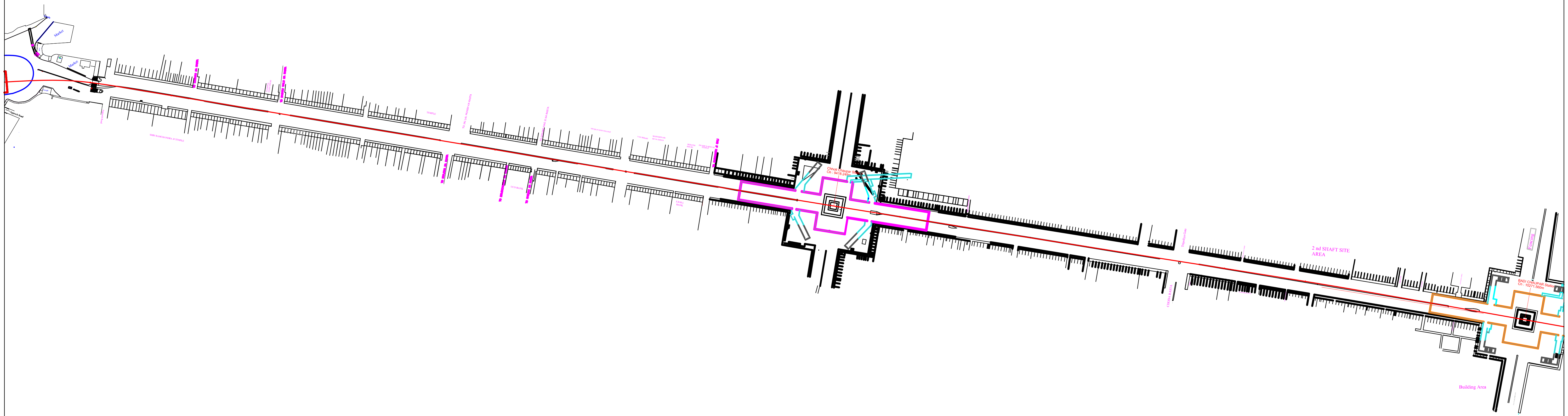


Figure 3: Location Map for GPR Survey

3.0 METHODOLOGY

GPR model SIR-3000 of GSSI, USA was used for the survey along with 100 MHz paired antenna (with fiber optic) for scanning down to depth of 22m or so as it was indicated that the average depth of the tunnel bottom would be around 16m or so. The use of 100 MHz pair antenna provides good resolution down to a depth of 22-25m but it does not provide good resolution in the upper layers where there could be a number of utilities. The resolution within first 5m or so becomes poor using 100 MHz pair antenna alone and therefore, nothing can be inferred down to a depth of 5m. It becomes imperative to use 400 MHz to detect utilities which are normally available within first 3-4m. The same was also demonstrated during the survey. A part of the entire stretch was also taken up for utility survey. The results of the same have also been provided towards the end of the report. As the objective of the work was to scan the subsurface for different litho units down to a depth between 15-22m, 100 MHZ paired antenna was used.

The methodology adopted for the study includes:

- Geophysical survey using Ground Penetration Radar (GPR) with 100 MHz paired antennae for subsurface scanning
- Processing and assimilation of GPR surveys using RADAN software of the scans collected using 100 MHz pair antennae

Methodology for GPR scanning

A survey sheet of the proposed alignment between Chandpole and Badi Chaupar Metro station was provided by Continental Engineering Corporation (CEC). The scanning was planned to be carried out as follows:

- Along two longitudinal lines on both the sides of the road divider with about 4m spacing in between two lines.
- In addition to these the longitudinal lines along the alignment, traverse lines were drawn at every 50m interval.

In all, 102 scans were carried out between Chandpole and Badi Chaupar ranging in length from 8m to as high as 655m. The location of these scans has been indicated on the map provided by CEE

(Figure 4). The raw scans were then processed removing the noise and enhancing the contrasts using processing software called 'RADAN'. These images were then converted to Raster images that could be read and edited using Microsoft Paint or even AutoCAD for digitizing the interface.

The interpretation of all these scans shows that there exist two layers in addition to the made ground. The scans were also studied to locate artifacts although no artifacts beyond about one meter were identified which is the minimum size of the artifact that could be identified by 100 MHz paired antenna. The identification of two layers corroborates with the interpretation made by grain size analysis of the cores collected in core drilling wherein two layers – sandy silt and silty sand have been intersected. The thickness of different layers upto scan depth of 22m is as follows:

Made Ground: 1.60 to 4.69 m

Layer-1: 9.35 to 16.88 m

Layer-2: 5.12 to 10.65 m

As discussed, three distinct layers have been identified through scanning. The upper most layer corresponds to the Made Ground whereas other two layers named as Layer-1 and Layer-2 are identified on the basis of textural difference. The upper layer (Layer-1) corresponds to loose to medium compact soil whereas the lower layer (Layer-2) is dense and more compact. It can be understood that through GPR in isolation the litho units can not be identified but differentiation between different layers can be made, provided there is a marked difference in their characteristics like an interface between soil and hard rock; soils with different compactness etc. The GPR scans coupled with other subsurface information becomes very useful in identifying the nature of subsurface.

In addition to this, a small zone with higher reflectance has been identified near Tripoliya Gate which could be on account of anomalous material such as presence of metallic substance, high moisture content or an object. The location of this anomalous zone is presented at Figure 5 and the scan is presented at Figure 6. The anomalous zone is identified near Tripoliya Gate between chainage 1315.48m to 1319.48m. This is about 10.93m east and 16.9m towards centre of the road from shop number 96 (towards Badi Chaupar). The location of the zone is shown at Figure no. 5. The depth of the anomalous zone which is more reflective is about 17.50m from the surface. This anomaly could be due to a more reflective material such as a metallic substance or object or soil with more moisture. There could be some buried metallic plate or pipe although no continuity could be traced on either side. The object could be of about 1.0 to 1.5m in dimension.

A three dimensional model has been created based on the layer identification and the surfaces of different layers are presented at Figure 7, 8 & 9.

All the scans in the form of Raster Images with layers identified on them have been provided at Figure 9 – Figure 27

Note- The performance capability of GPR is strongly dependent on the soil electrical conductivity at the site which depends upon the soil composition and characteristics. At times Spurious radar echoes (known as "clutter") can also be expected in some areas because of buried debris such as old rails, wire scraps, boulders, and small metal objects.

Although GPR technique gives a fair appraisal of the buried materials, It is worthwhile mentioning here that method alone cannot be relied upon fully and cannot be regarded as conclusive **.**

A small part of the stretch was covered for Utility survey using GPR with 400 MHz antenna. A number of utilities were identified which includes:

* Metallic utility (at a depth of about 0.50m) which may correspond to water pipe line

* Non metallic utility (at a depth of 0.45.m) which very well corresponds to power cable

* A bunch of cables as identified at a depth of 0.75m

* A bigger non-metallic utility at a depth of about 2.20m which corresponds to sewer line.

The utilities as identified through GPR scan is depicted at Figure no. 29.

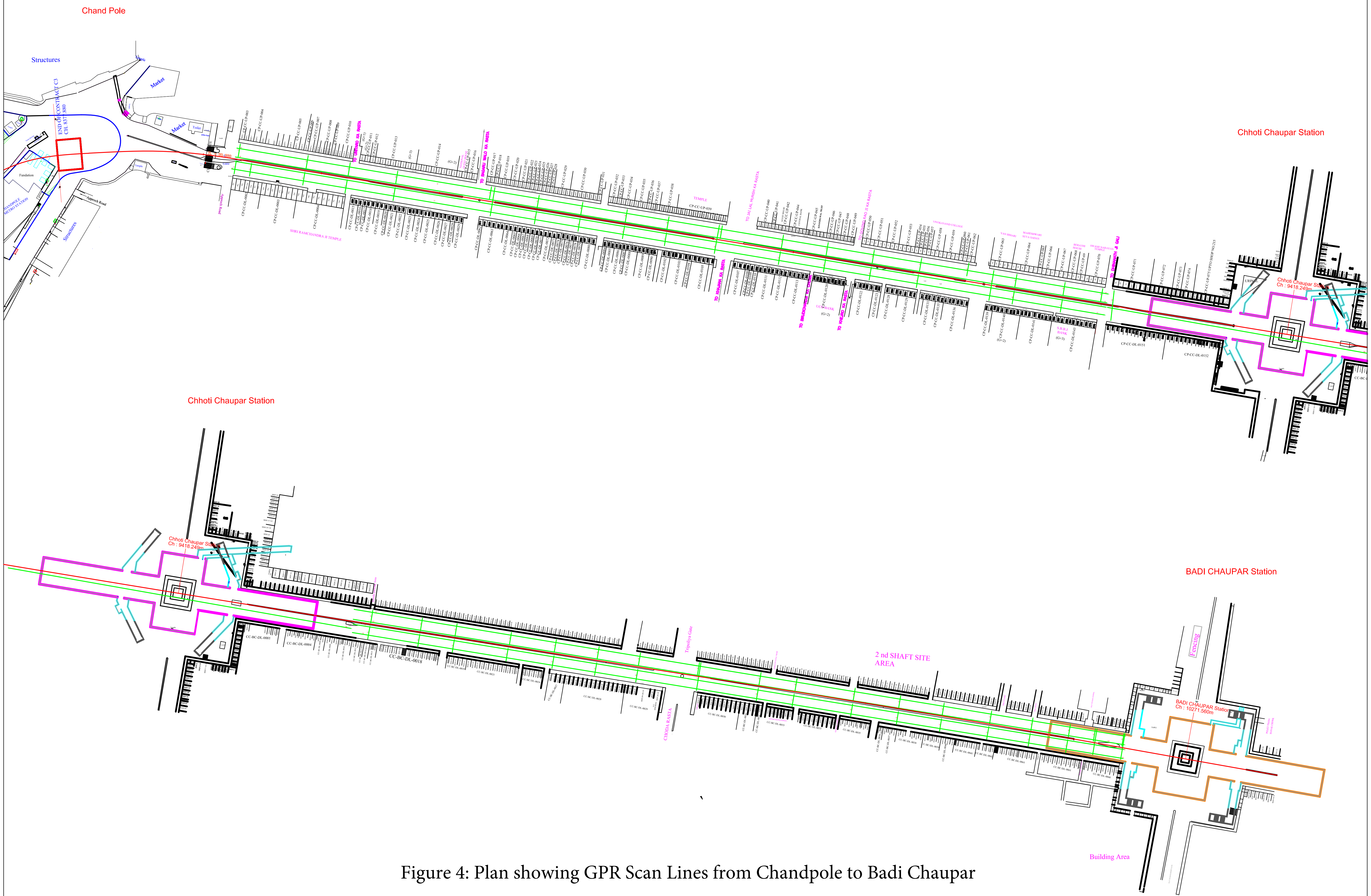


Figure 4: Plan showing GPR Scan Lines from Chandpole to Badi Chaupar

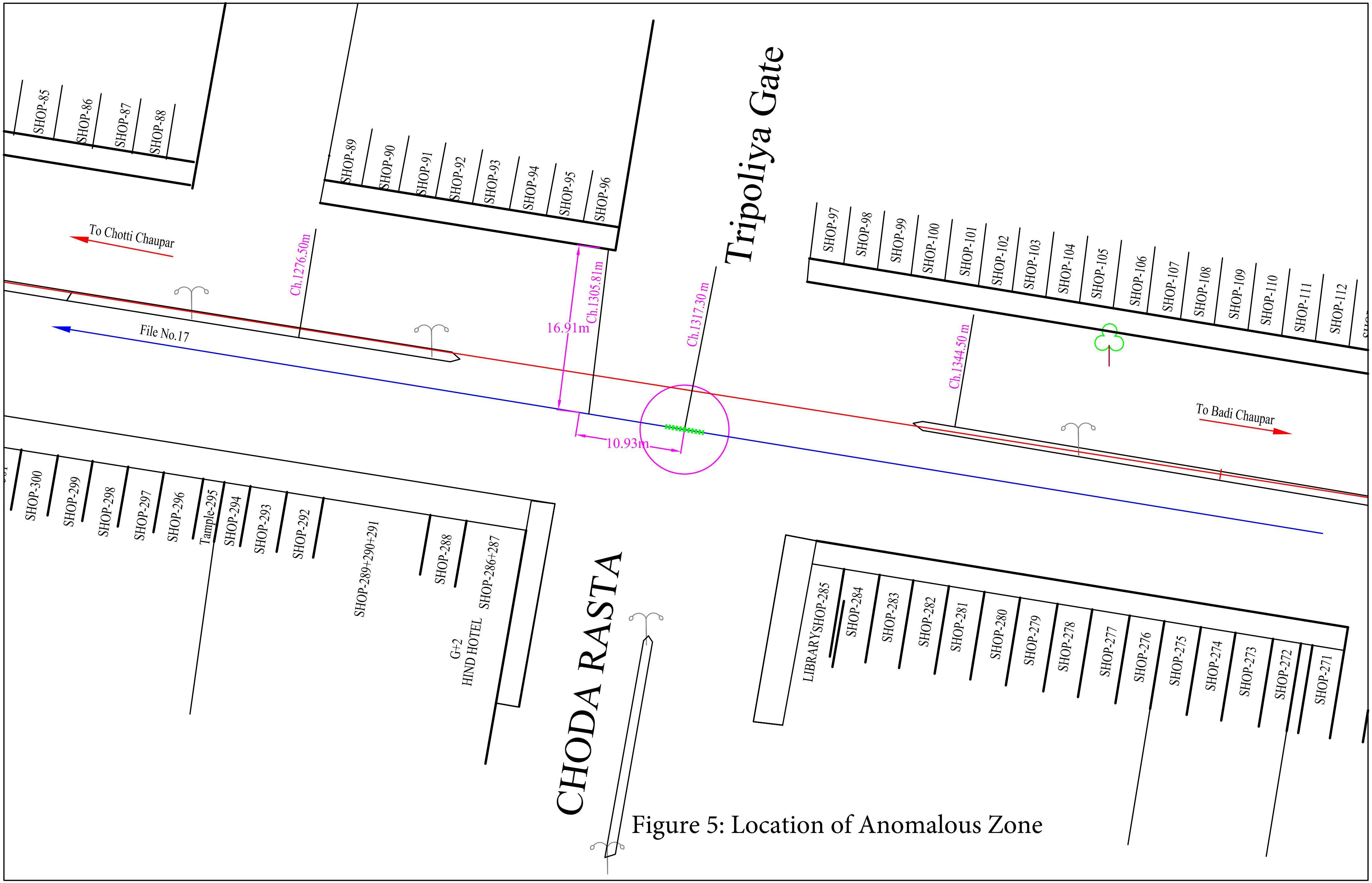
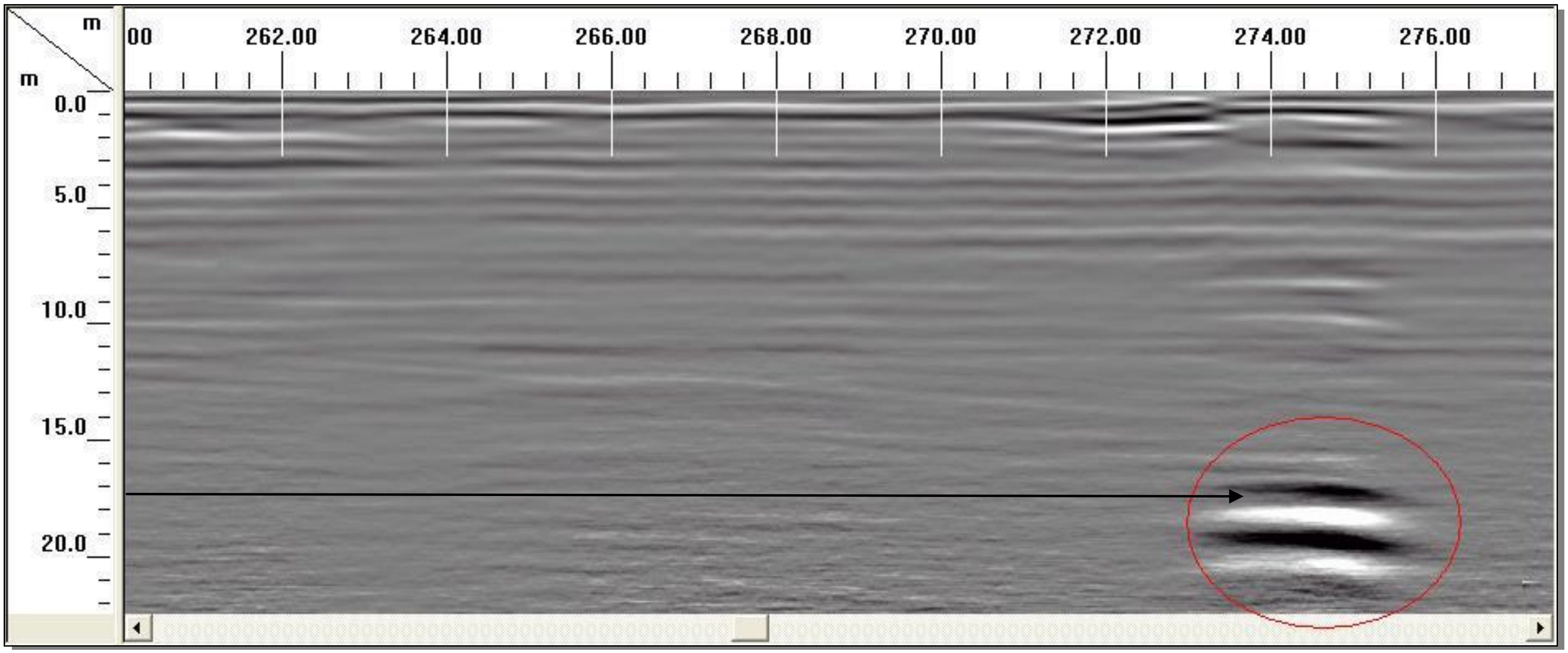


Figure 5: Location of Anomalous Zone



Anomalous Zone

Figure 6: Scan showing Anomalous Zone

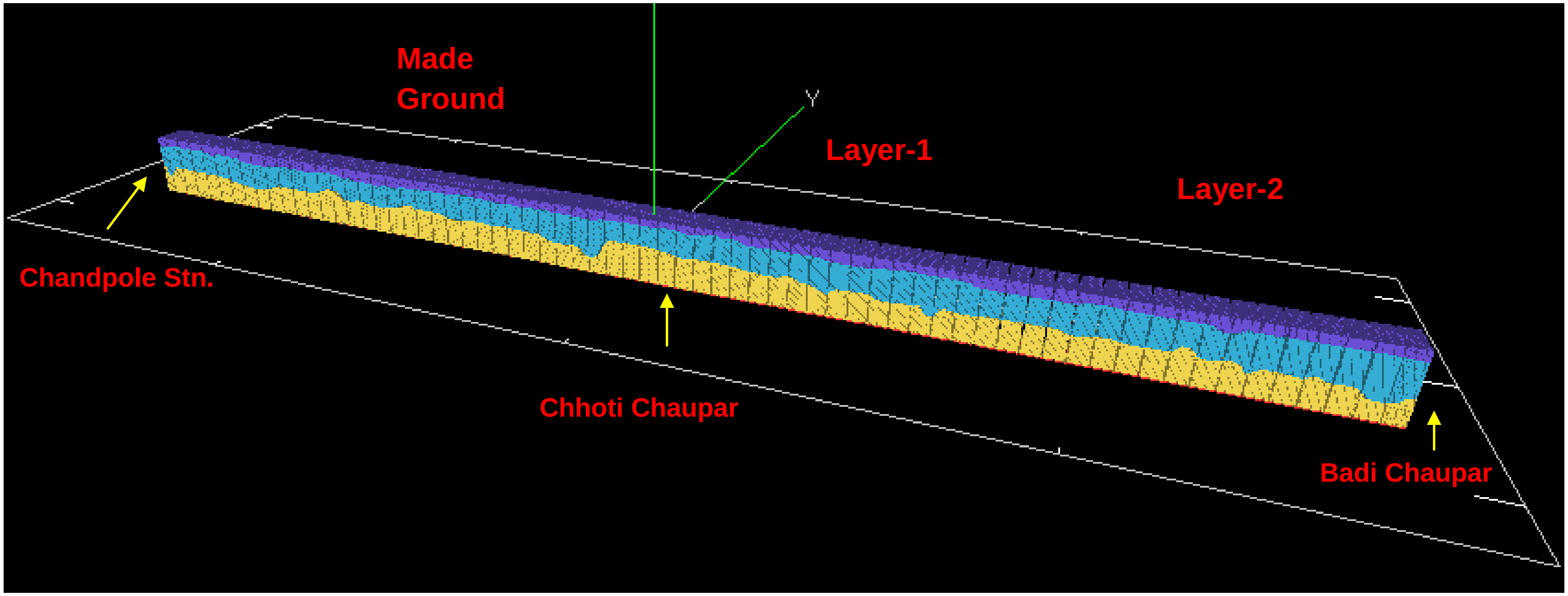


Figure 7: Longitudinal section showing different litho units

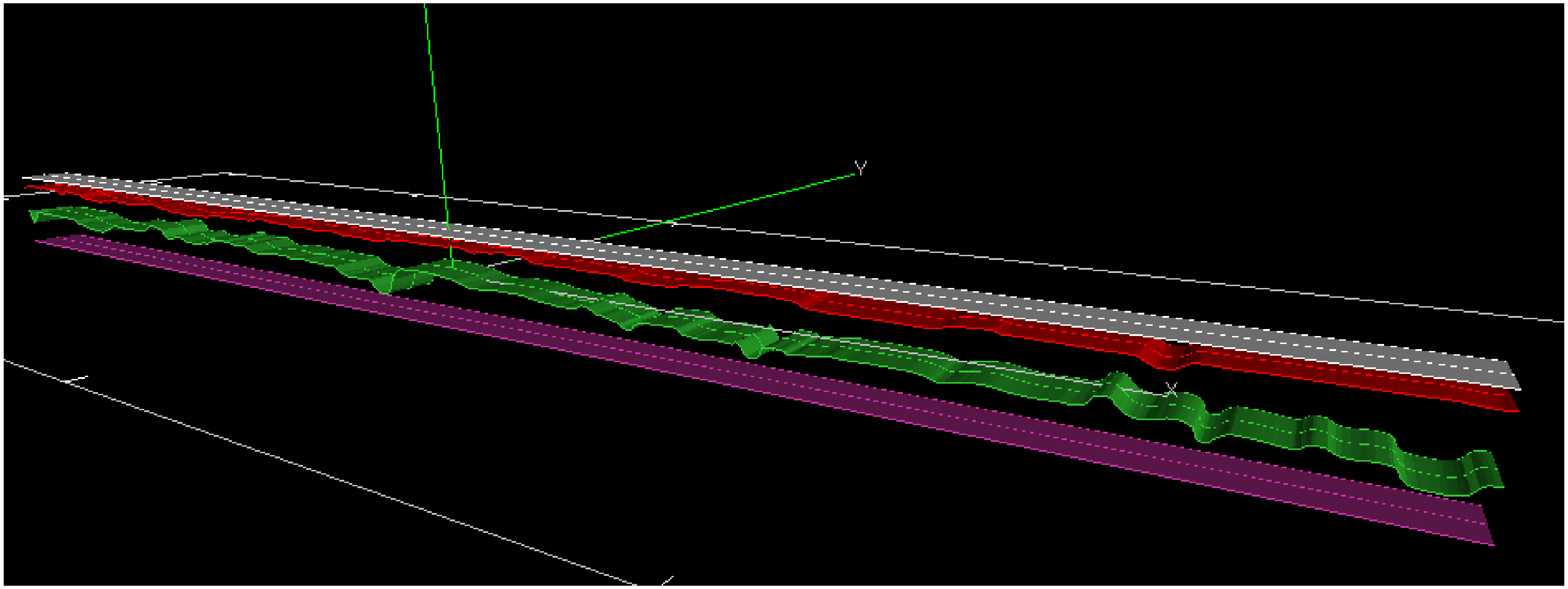


Figure 8: Longitudinal section showing different surfaces

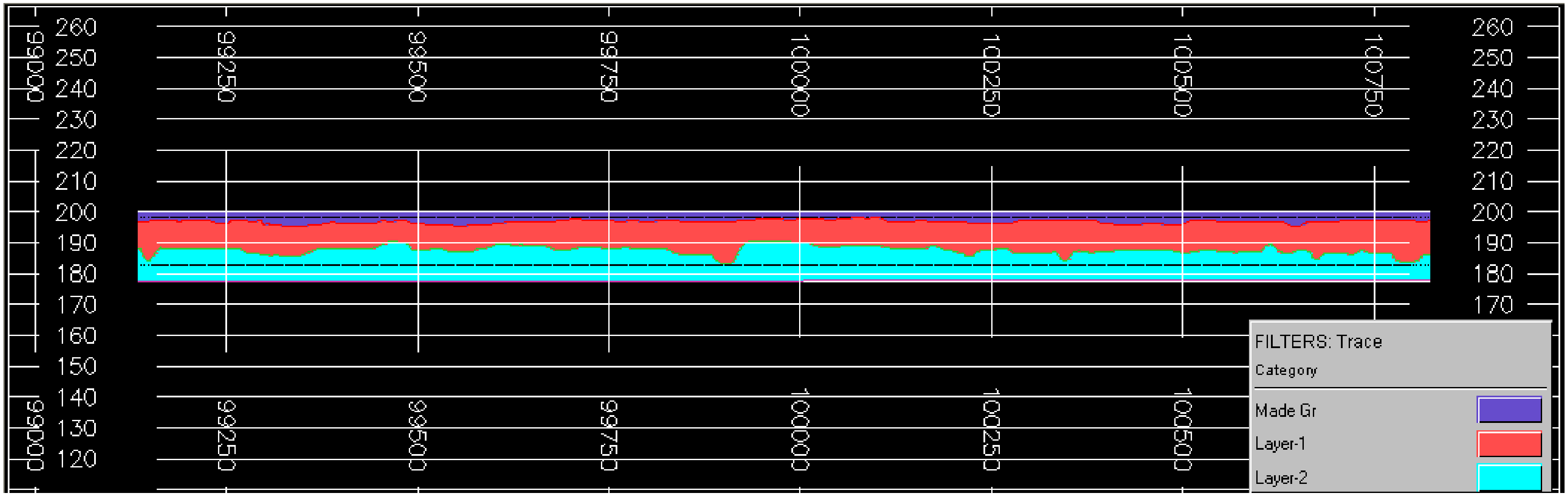


Figure 9: Block Model showing different litho units

4.0 CONCLUSION:

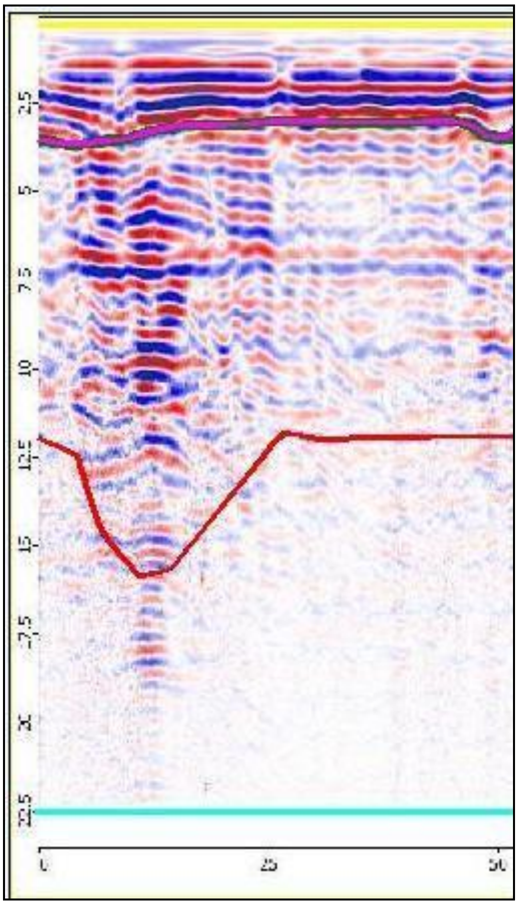
Survey using Ground Penetration Radar with 100 MHz paired antenna has provided scanning down to a depth of 22m.

The interpretation of all these scans shows that two distinct layers exit upto the scanned depth for the entire stretch between Chandpole and Badi Chaupar. This is depicted in the scans provided at Figure 10 to 27. The 3-dimensional model (surface and block) provides variation in terms of depth for the two layers. The drill hole core too in the area indicates presence of two layers of silty sand / sandy silt as defined by grain size analysis of the soil as per geotechnical report. A small portion in the entire stretch indicates more reflective zone which could be on account of anomalous material such as presence of metallic substance, high moisture content or an object.

A part of the entire stretch was also taken up for utility survey. This indicates the importance of GPR survey for locating utilities before excavating the area. This helps in planning the excavation work without damaging the existing utilities.

Scans from Chandpole to Badi Chaupar

With nearest Bore holes

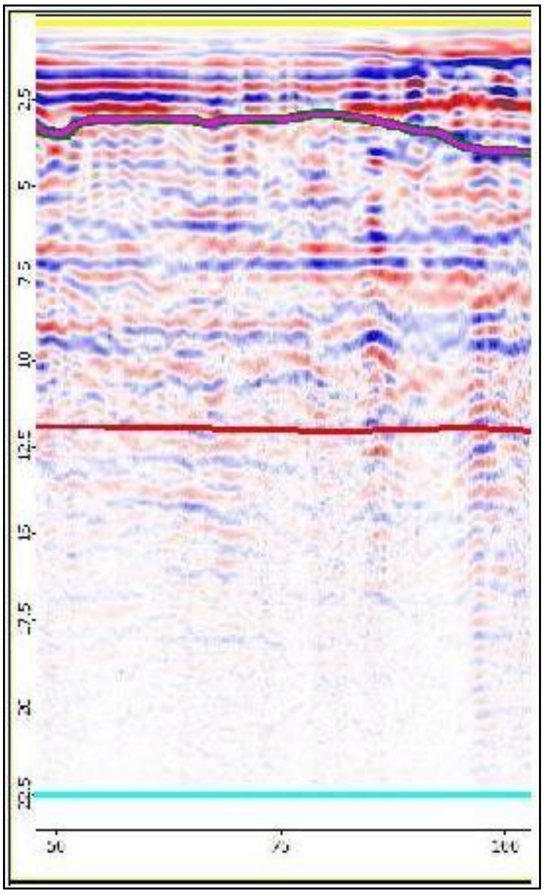


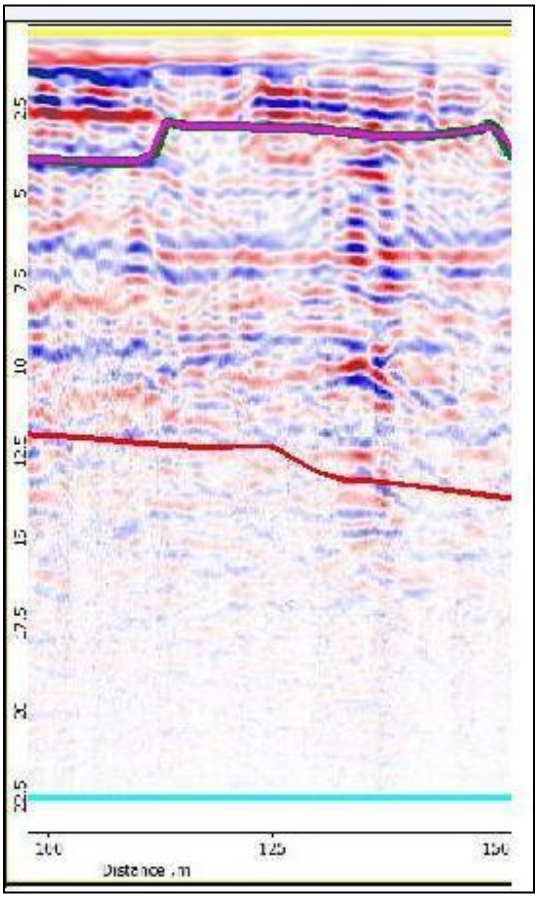
Location: 0-55m

Visual Description of S with IS Classification	Depth	IS Symbol	Analysis: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit
SM-SC: Silty Sand	15.00 15.50		1	63	36	0	N.
SM: Dense Yellowish Silty Sand	17.50						
SM-SC: Dense to Very Dense Yellowish Silty Sand			3	53	40	4	23
			2	50	45	3	22
SM: Very Dense Yellowish Silty Sand	20.50		3	67	30	0	N.
			3	78	19	0	N.
			1	84	15	0	N.
	25.45		1	79	20	0	N.

Table No. - 9 BH-4

Figure 10





8:

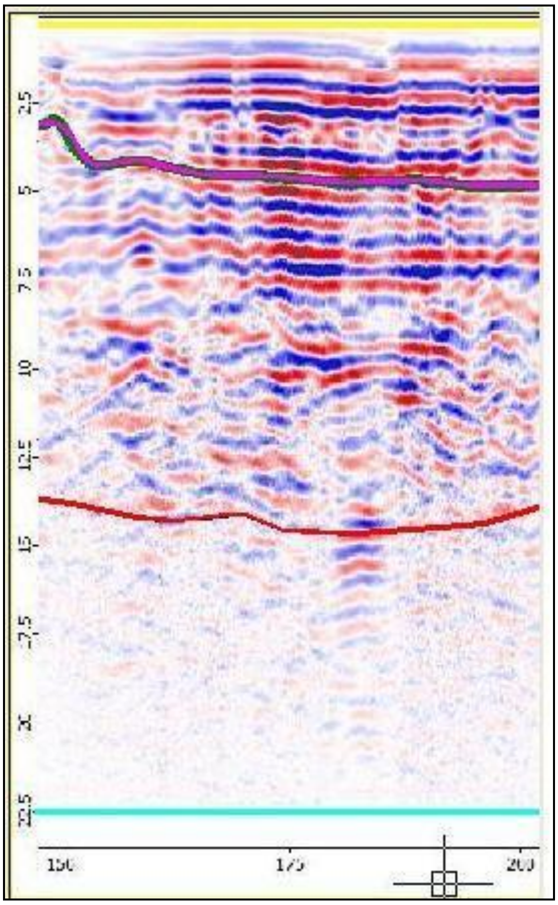
Location: 55-110m

Location: 110-165m

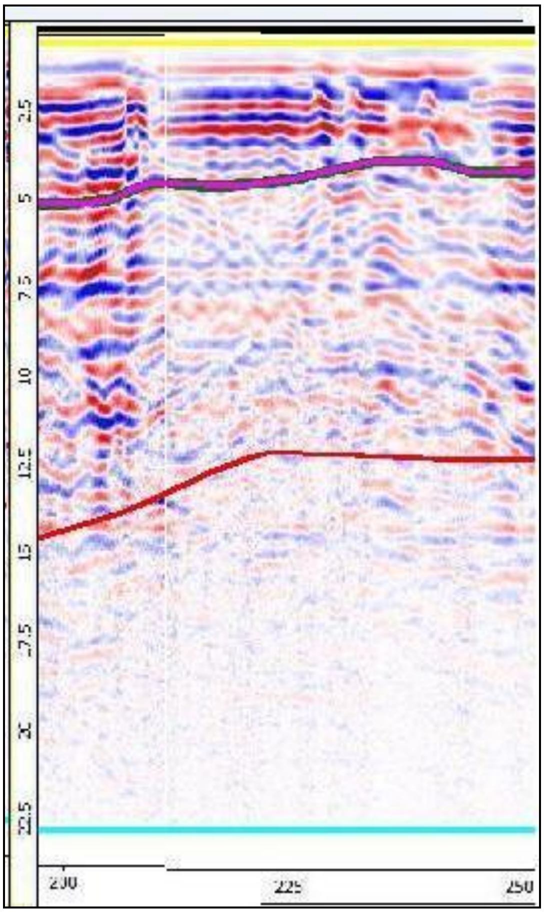
Filled up Soil	0		80	16	4	0	N.
SM: Loose to Medium Yellowish Silty Sand	2.50		0	78	22	0	N.
			0	72	28	0	N.
			0	77	23	0	N.
			2	82	16	0	N.
			3	80	17	0	N.
SM: Dense Yellowish Silty Sand	8.50		2	85	13	0	N.
			2	82	16	0	N.
			1	80	19	0	N.
			0	80	20	0	N.
	15.00						

Table No. - 10 BH-5

Figure 11



Location: 165-220m

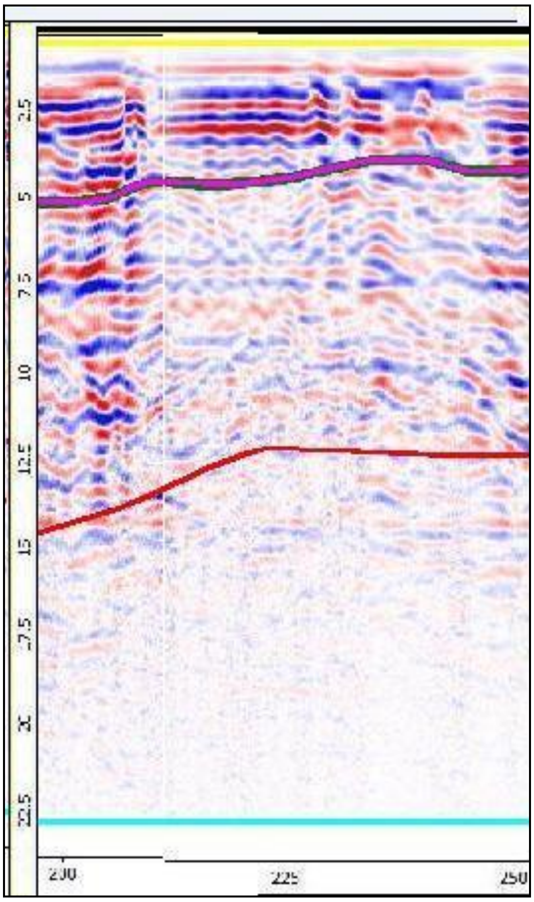


Location: 220-275m

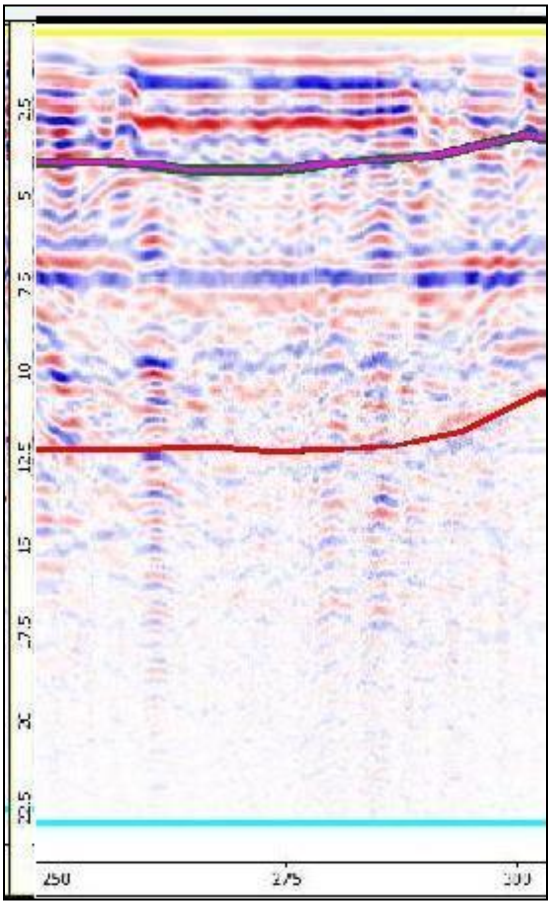
Filled up Soil	0	35	50	15	0
SM: Medium to Dense Yellowish Silty Sand	1.50	0	67	33	0
		0	72	28	0
		0	80	20	0
		0	77	23	0
SP-SM: Very Dense Yellowish Gravelly Sand	7.50	34	56	10	0
SM: Dense Yellowish Silty Sand	8.50	0	84	16	0
		0	85	15	0
	11.50	0	88	12	0
SP-SM: Very Dense Yellowish Silty Sand					
SM: Very Dense Yellowish Silty Sand	13.50	5	50	42	3
		6	51	40	3
	15.00				

Table No. - 14 BH-6A

Figure 12



Location: 275-330m

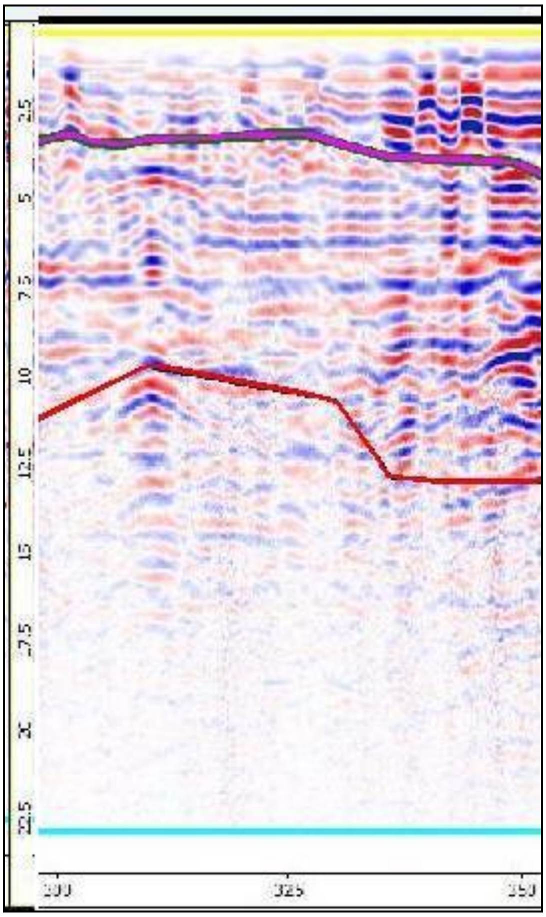


Location: 330-385m

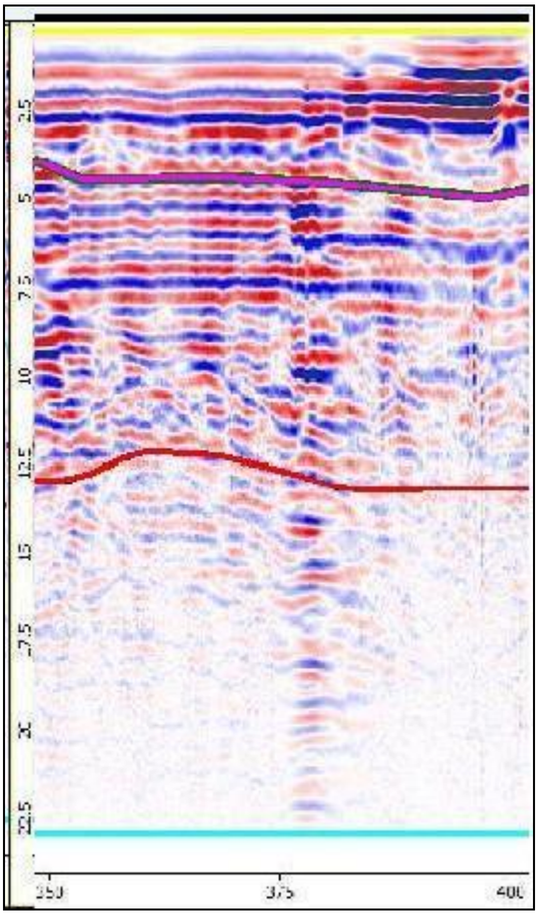
Visual Description of Soil with IS Classification	Depth	IS Symbol	Grain Size Analysis				Co
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit
ML-CL: Hard Yellowish Sandy Silt of Low Plasticity	15.00						
			3	18	75	4	27
			3	30	62	5	25
			2	36	57	5	24
SM: Very Dense Yellowish Silty Sand	20.00		4	64	32	0	N.
			2	68	30	0	N.
			1	63	36	0	N.
			3	59	38	0	N.
	30.45						

Table No. - 13 BH-6

Figure 13



Location: 385-440m

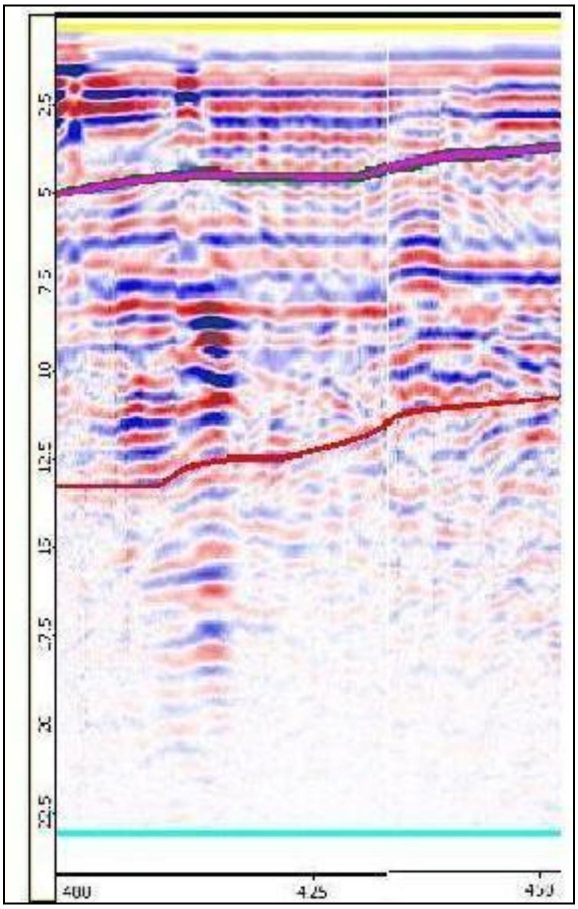


Location: 440-495m

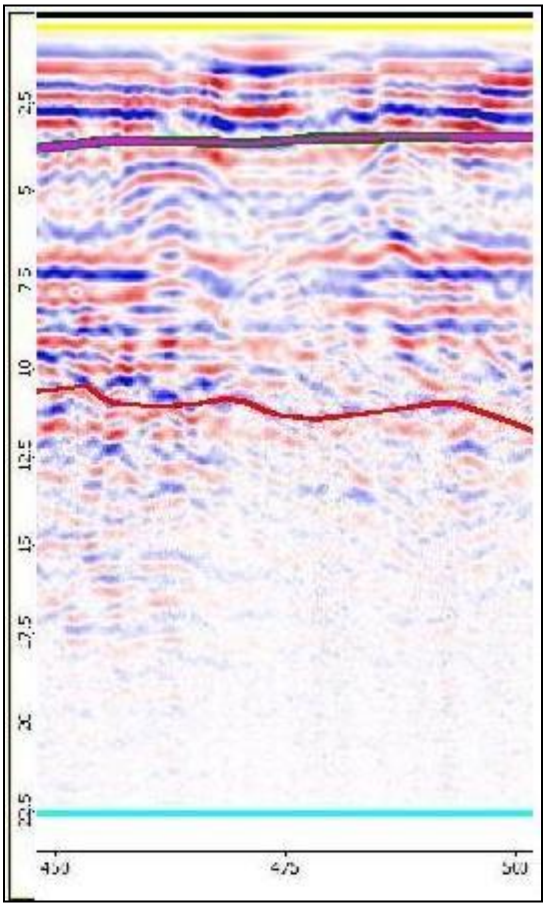
Filled up Soil	0		19	66	15	0	-
SM: Medium Yellowish Silty Sand	1.50		5	81	14	0	N
			4	60	32	4	N
			6	61	33	0	N
			7	61	30	2	N
SM: Dense to Very Dense Yellowish Silty Sand	6.00		2	78	20	0	N
			2	72	26	0	N
			0	83	17	0	N
			1	56	40	3	N
			2	58	37	3	N
	15.00						

Table No. - 18 BH-7A

Figure 14



Location: 495-550m

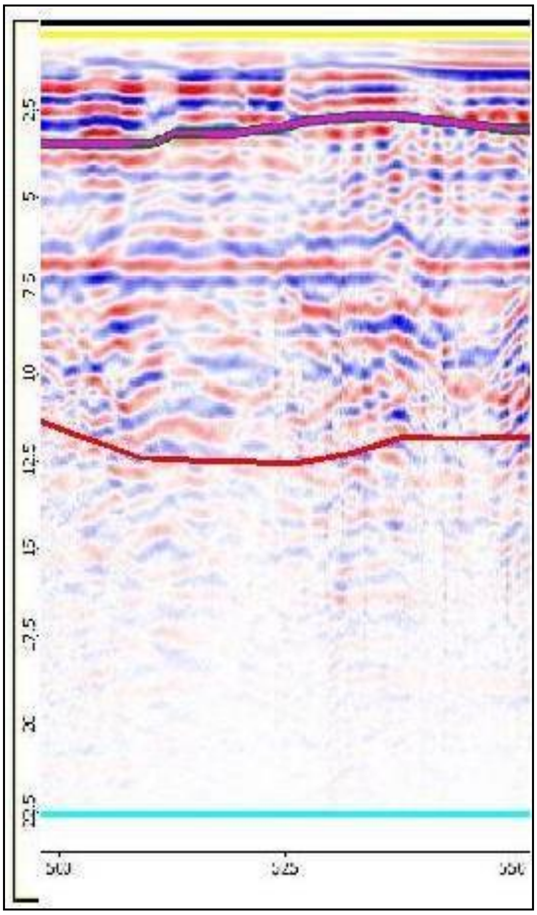


Location: 550-605m

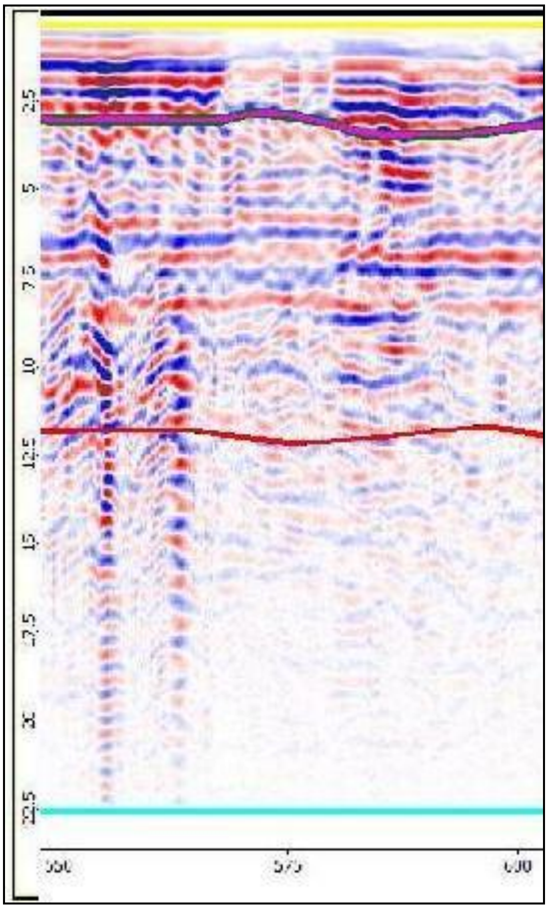
Filled up Soil	0	5	81	14	0	-
SM: Loose to Medium Yellowish Silty Sand	1.50	0	81	19	0	N.
		2	63	35	0	N.
		3	74	23	0	N.
SM: Medium to Dense Yellowish Silty Sand	7.50	2	78	20	0	N.
		0	83	17	0	N.
		7	77	16	0	N.
		4	76	20	0	N.
		0	83	17	0	N.
	15.00					

Table No. - 16 BH-7

Figure 15



Location: 605-660m

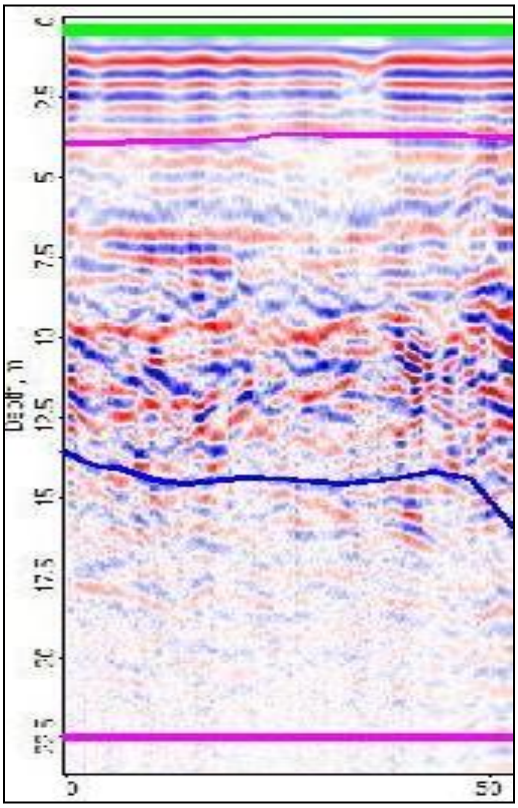


Location: 660-710m

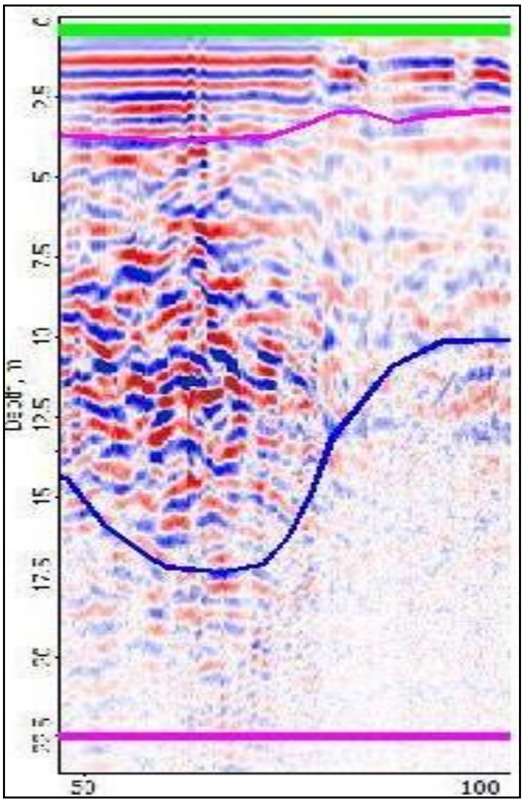
Filled up soil	0		50	36	14	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	1.00		0	78	22	0	N.	P.	-
			3	65	30	2	N.	P.	-
			5	67	27	1	N.	P.	-
			3	65	30	2	N.	P.	-
			0	81	19	0	N.	P.	-
SM: Dense to Very Dense Yellowish Silty Sand	9.00		0	75	25	0	N.	P.	-
			0	67	33	0	N.	P.	-
			0	62	38	0	N.	P.	-
	15.00								

Table No. - 20 BH-7B

Figure 16



Location: 710-765m

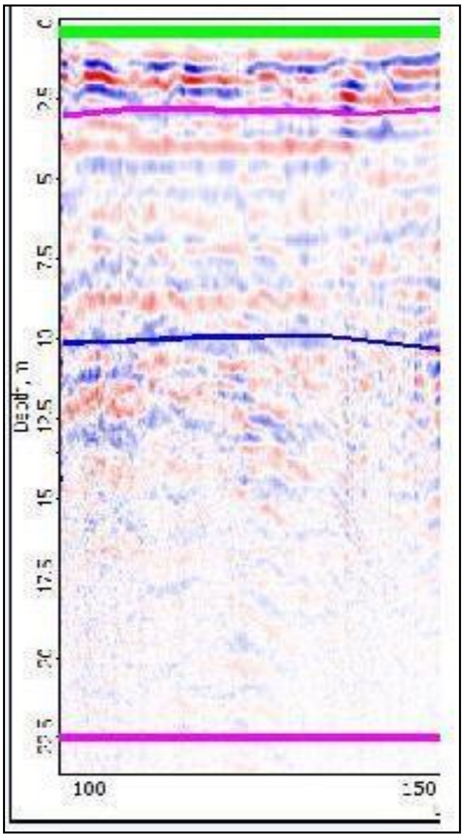


Location: 765-820m

Filled up Soil	0		23	65	12	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	1.50		7	75	18	0	N.	P.	-
			5	81	14	0	N.	P.	-
			3	79	18	0	N.	P.	-
			0	77	23	0	N.	P.	-
			0	80	20	0	N.	P.	-
SM: Dense to Very Dense Yellowish Silty Sand	9.00		0	70	27	3	N.	P.	-
			2	65	33	0	N.	P.	-
			2	71	27	0	N.	P.	-
			0	85	15	0	N.	P.	-
	15.00								

Table No. - 22 BH-7C

Figure 17

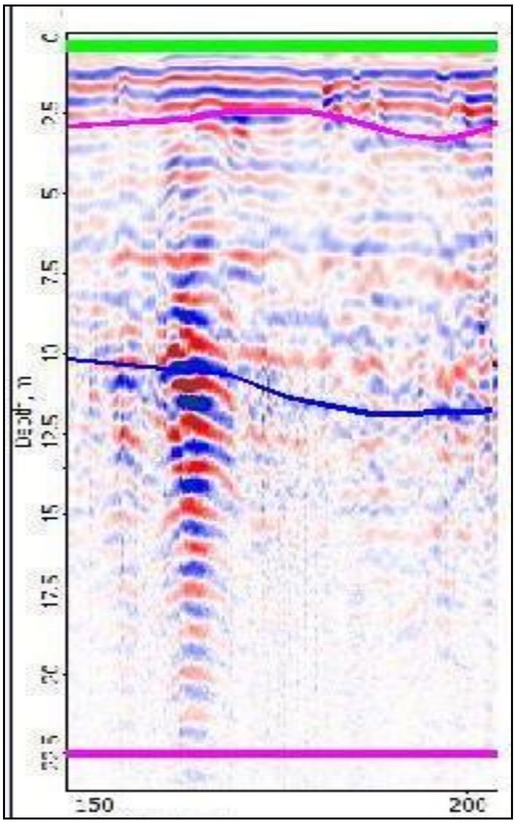


Filled up Soil	0		66	16	18	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	1.50		0	77	23	0	N.	P.	-
			0	82	18	0	N.	P.	-
			2	70	28	0	N.	P.	-
			3	67	30	0	N.	P.	-
SM: Dense Yellowish Silty Sand	8.00		3	63	34	0	N.	P.	-
			6	61	30	3	N.	P.	-
			0	86	14	0	N.	P.	-
			2	80	18	0	N.	P.	-
			0	80	20	0	N.	P.	-
	15.00								

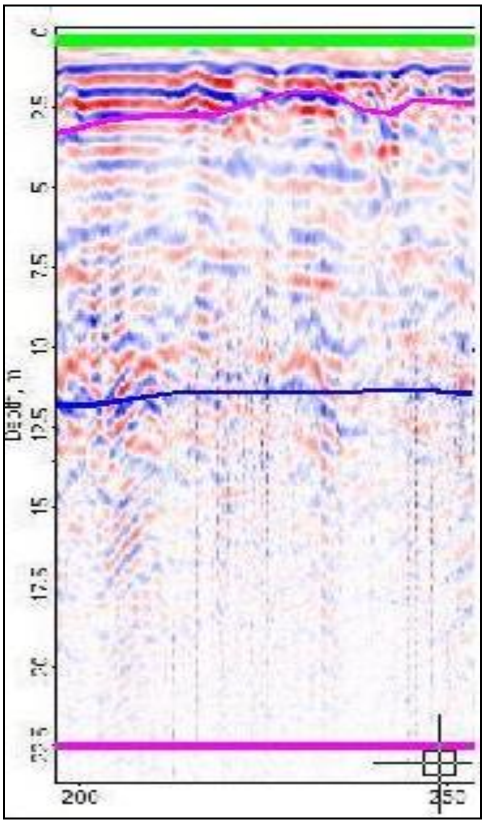
Location: 820-870m

Table No. - 24 BH-8

Figure 18



Location: 870-925m

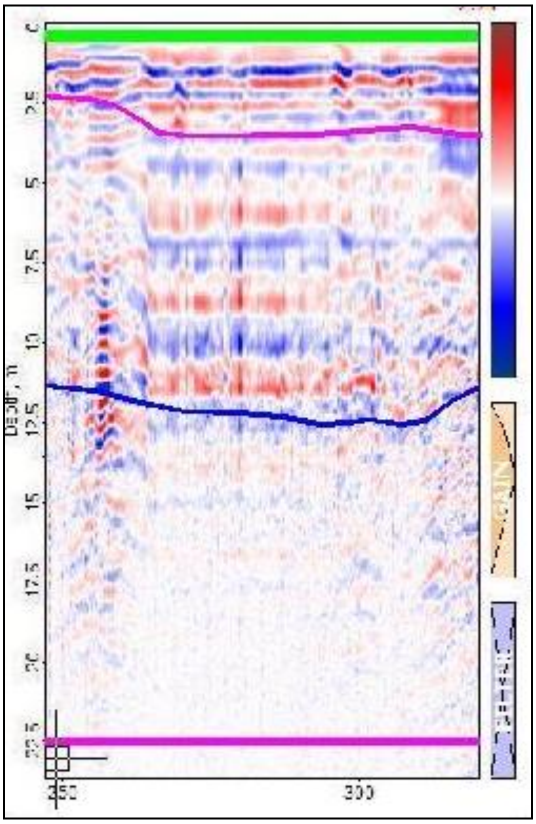


Location: 925-980m

Filled up Soil	0		8	79	13	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	1.50		2	82	16	0	N.	P.	-
			3	79	18	0	N.	P.	-
			2	68	30	0	N.	P.	-
SM: Medium to Dense Yellowish Silty Sand	6.00		2	60	35	3	N.	P.	-
			0	66	34	0	N.	P.	-
			0	70	30	0	N.	P.	-
SM-SC: Dense Yellowish Silty Sand	11.00		2	56	37	5	23	18	5
SM: Dense Yellowish Silty Sand	12.00		0	68	32	0	N.	P.	-
SP-SM: Dense to Very Dense Yellowish Silty Sand	14.00		0	91	9	0	N.	P.	-
	15.00								

Table No. - 30 BH-11

Figure 19

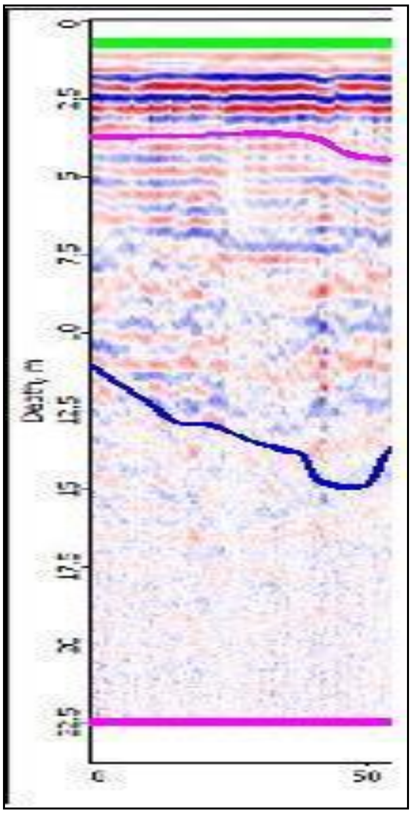


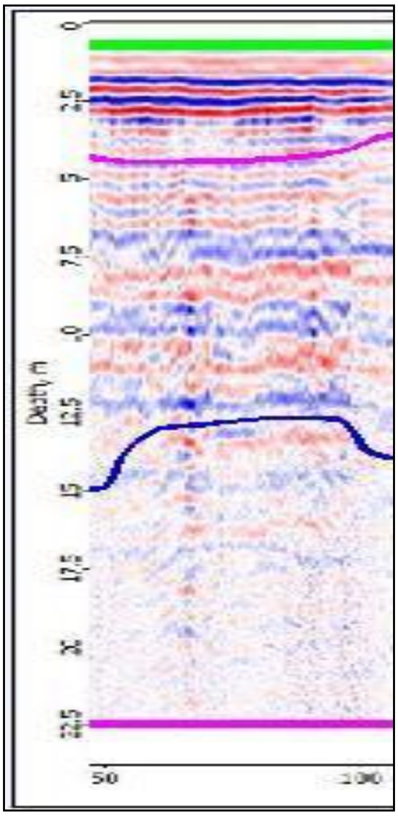
Filled up Soil	0		41	44	15	0	-	-	-	-
SM: Medium to Dense Yellowish Silty Sand	3.00		2	75	23	0	N.	P.	-	-
			2	70	28	0	N.	P.	-	-
			1	65	34	0	N.	P.	-	-
			2	70	28	0	N.	P.	-	-
			0	69	31	0	N.	P.	-	-
			0	78	22	0	N.	P.	-	-
			0	82	18	0	N.	P.	-	-
SP-SM: Dense to Very Dense Yellowish Silty Sand	11.00		0	91	9	0	N.	P.	-	-
			0	91	9	0	N.	P.	-	-
			0	92	8	0	N.	P.	-	-
	15.00									

Location: 980-1035m

Table No. - 36 BH-13B

Figure 20



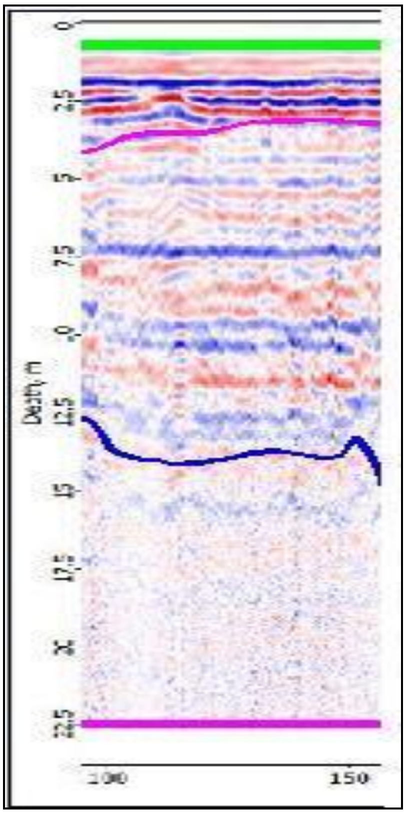


Location: 1035-1090m Location: 1090-1145m

Filled up Soil	0		41	42	17	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	1.50		0	83	17	0	N.	P.	-
			0	72	28	0	N.	P.	-
			2	59	37	2	N.	P.	-
			2	82	16	0	N.	P.	-
			2	62	32	4	N.	P.	-
SM: Dense to Very Dense Yellowish Silty Sand	7.50		3	77	20	0	N.	P.	-
			2	83	15	0	N.	P.	-
			2	80	18	0	N.	P.	-
			1	85	14	0	N.	P.	-
			6	74	20	0	N.	P.	-
			14	64	22	0	N.	P.	-
	15.00								

Table No. - 34 BH-13A

Figure 21

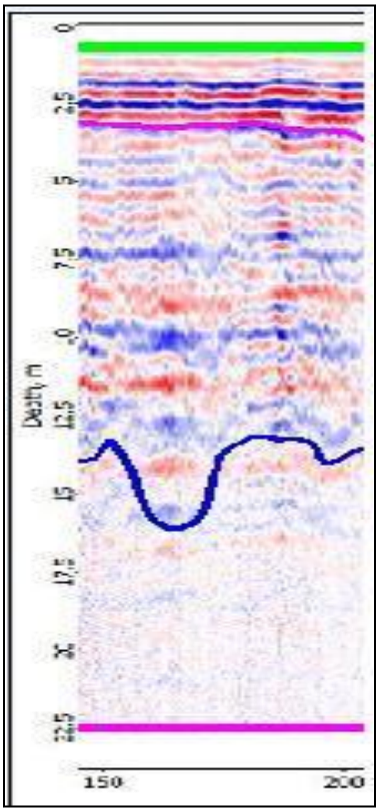


Filled up Soil	0		41	42	17	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	1.50		0	83	17	0	N.	P.	-
			0	72	28	0	N.	P.	-
			2	59	37	2	N.	P.	-
			2	82	16	0	N.	P.	-
			2	62	32	4	N.	P.	-
SM: Dense to Very Dense Yellowish Silty Sand	7.50		3	77	20	0	N.	P.	-
			2	83	15	0	N.	P.	-
			2	80	18	0	N.	P.	-
			1	85	14	0	N.	P.	-
			6	74	20	0	N.	P.	-
			14	64	22	0	N.	P.	-
	15.00								

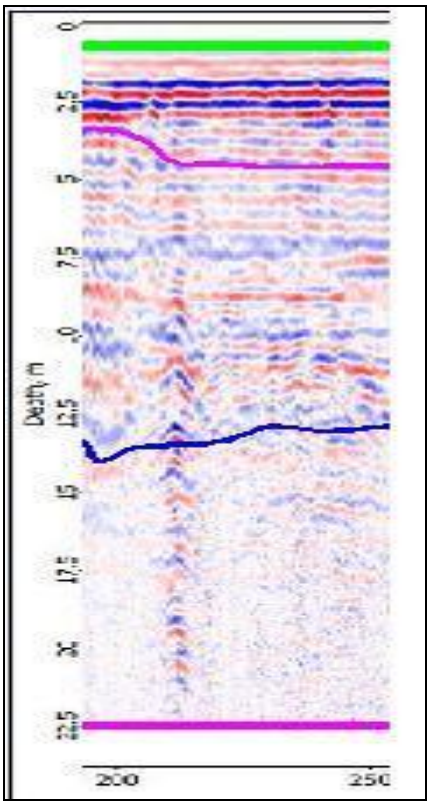
Location: 1145-11200m

Table No. - 34 BH-13A

Figure 22



Location: 1200-1255m

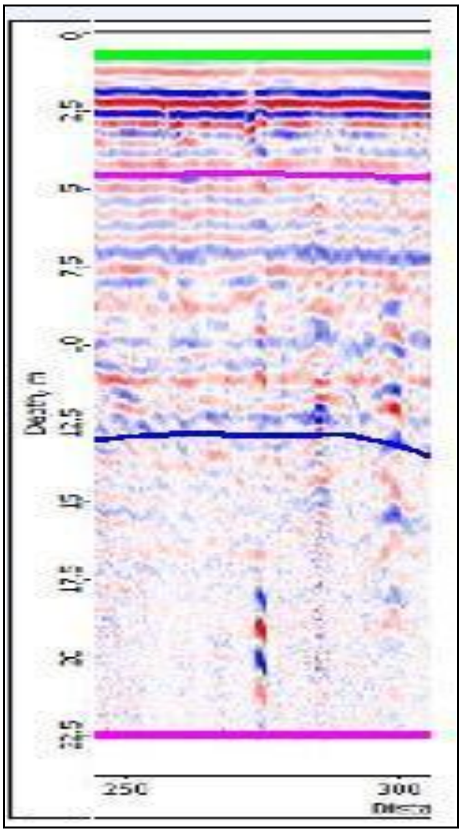


Location: 1255-1310m

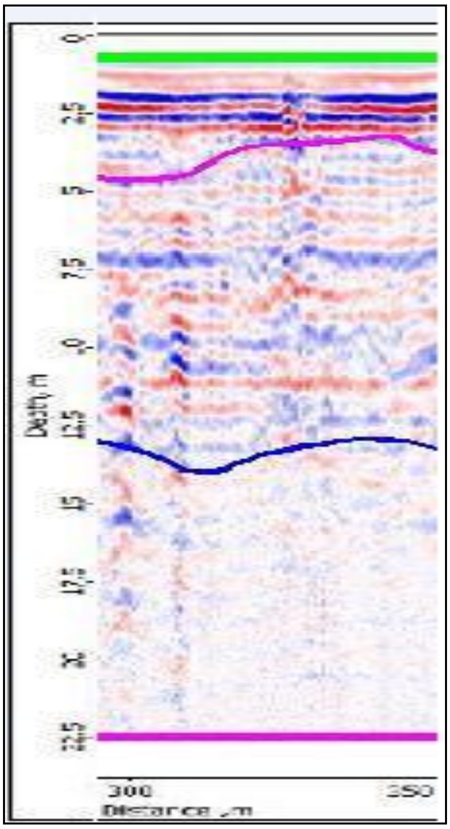
Filled up Soil	0		62	27	11	0	-	-	-
SP-SM: Medium Yellowish Silty Sand	1.50		4	85	11	0	N.	P.	-
			3	85	12	0	N.	P.	-
			2	88	10	0	N.	P.	-
			3	87	10	0	N.	P.	-
SP-SM: Dense to Very Dense Yellowish Silty Sand	6.00								
			4	88	8	0	N.	P.	-
			2	88	10	0	N.	P.	-
			1	91	8	0	N.	P.	-
			1	93	6	0	N.	P.	-
			0	88	12	0	N.	P.	-
			0	89	11	0	N.	P.	-
	15.00								

Table No. - 38 BH-13C

Figure 23



Location: 1310-1365m

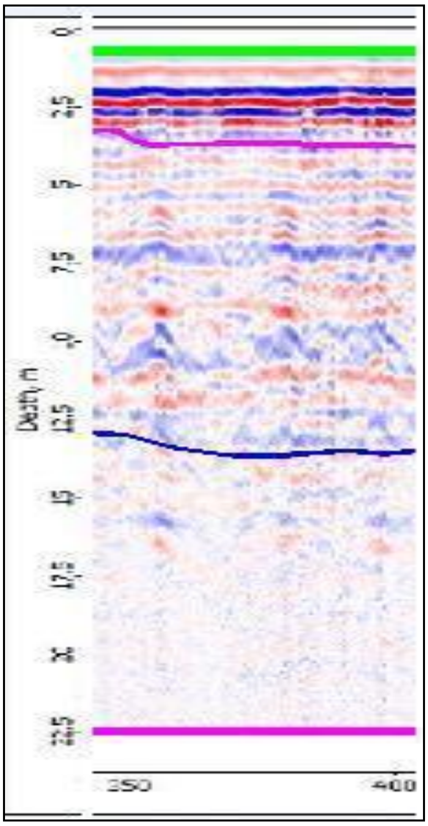


Location: 1365-1415m

Filled up Soil	0		62	27	11	0	-	-	-
SP-SM: Medium Yellowish Silty Sand	1.50		4	85	11	0	N.	P.	-
			3	85	12	0	N.	P.	-
			2	88	10	0	N.	P.	-
			3	87	10	0	N.	P.	-
SP-SM: Dense to Very Dense Yellowish Silty Sand	6.00		4	88	8	0	N.	P.	-
			2	88	10	0	N.	P.	-
			1	91	8	0	N.	P.	-
			1	93	6	0	N.	P.	-
			0	88	12	0	N.	P.	-
			0	89	11	0	N.	P.	-
	15.00								

Table No. - 38 BH-13C

Figure 24

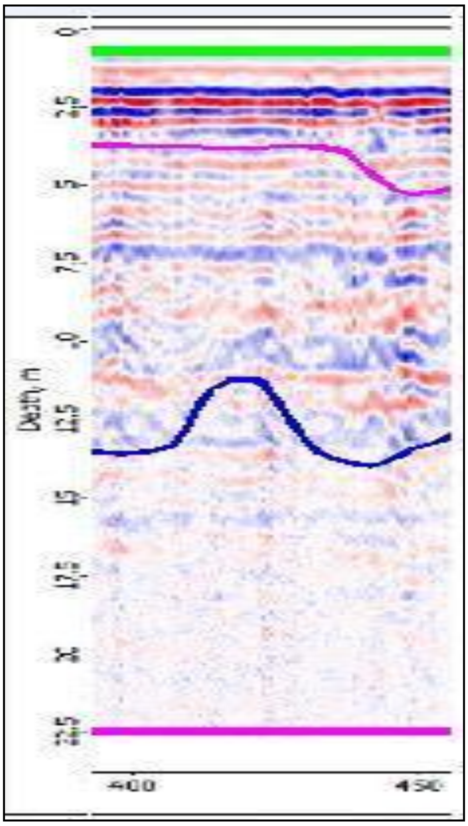


Filled up Soil	0		61	32	7	0	-	-	-
SM-SC: Medium to Dense Yellowish Silty Sand	3.50		2	50	42	6	23	18	5
			2	53	41	4	22	18	4
			4	50	40	6	23	18	5
ML-CL: Hard Yellowish Sandy Silt of Low Plasticity	8.00		2	44	49	5	23	18	5
			2	46	47	5	23	18	5
SP-SM: Dense to Very Dense Yellowish Silty Sand	11.00		0	91	9	0	N.	P.	-
			0	89	11	0	N.	P.	-
SM: Very Dense Yellowish Silty Sand	14.00		2	57	37	4	N.	P.	-
	15.00								

DST : Direct Shear Test
Consolidated Drained Triaxial Shear Test UCT :

Location: 1415-1470m Table No. - 40 BH-13D

Figure 25

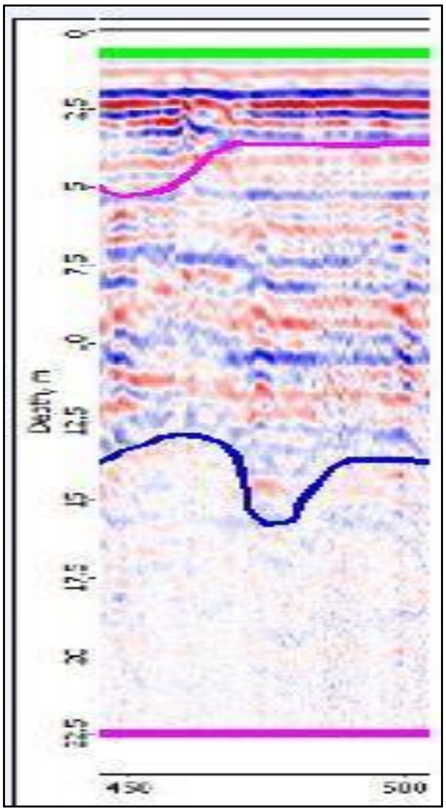


Filled up Soil	0		60	15	5	0	-	-	-
SM: Loose to Medium Yellowish Silty Sand	2.00		1	70	29	0	N.	P.	-
			2	76	22	0	N.	P.	-
GM: Very Dense Yellowish Sandy Gravel	4.50		58	24	18	0	N.	P.	-
			51	34	15	0	N.	P.	-
SM: Very Dense Yellowish Silty Sand	8.00		0	74	26	0	N.	P.	-
			16	47	34	3	N.	P.	-
			6	50	40	2	N.	P.	-
			3	54	40	3	N.	P.	-
SP-SM: Very Dense Yellowish Silty Sand	14.00		3	86	11	0	N.	P.	-
	15.00								

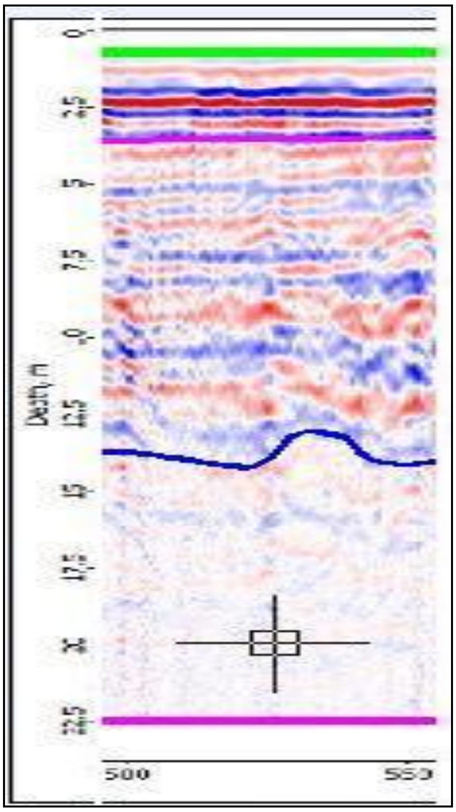
Location: 1470-1525m

Table No. - 42 BH-14A

Figure 26



Location: 1525-1575m

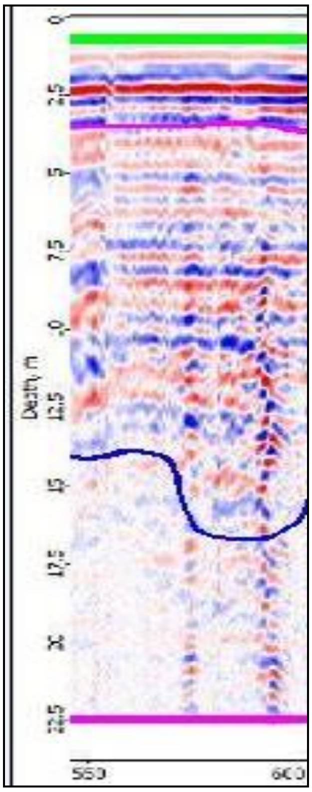


Location: 1575-1625m

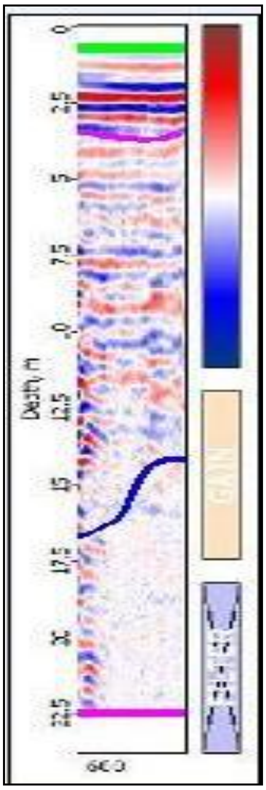
Filled up Soil	0		78	19	3	0	-	-	-
SP-SM: Medium Yellowish Silty Sand	2.00		0	93	7	0	N.	P.	-
			0	91	9	0	N.	P.	-
			0	88	12	0	N.	P.	-
SM: Medium to Dense Yellowish Silty Sand	6.60		8	75	17	0	N.	P.	-
			3	78	19	0	N.	P.	-
ML-CL: Hard Yellowish Sandy Silt of Low Plasticity	9.60		2	36	57	5	24	18	6
			2	32	62	4	23	18	5
			8	41	48	3	22	18	4
	15.00								

Table No. - 44 BH-16

Figure 27



Location: 1625-1675m



Location: 1675-1690m

ML-CL: Hard Yellowish Sandy Silt of Low Plasticity	15.00		2	34	59	5	24	18	6
			4	39	51	6	23	18	5
			2	35	59	4	22	18	4
			5	33	57	5	24	18	6
			3	40	53	4	22	18	4
SM: Very Dense Yellowish Silty Sand	23.00		2	54	41	3	N.	P.	-
	25.45		3	50	44	3	N.	P.	-

Table No. - 47 BH-17

Figure 28

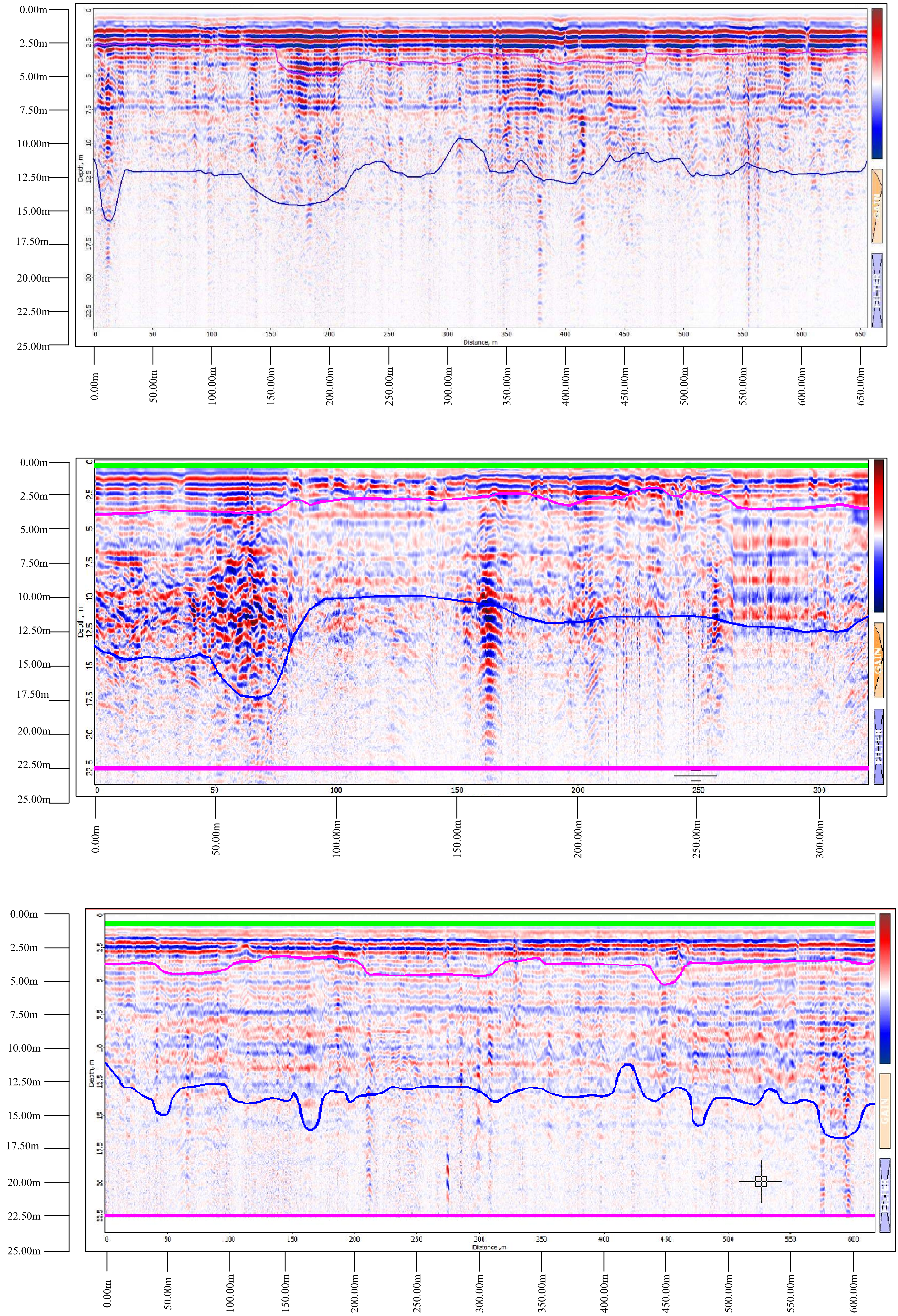
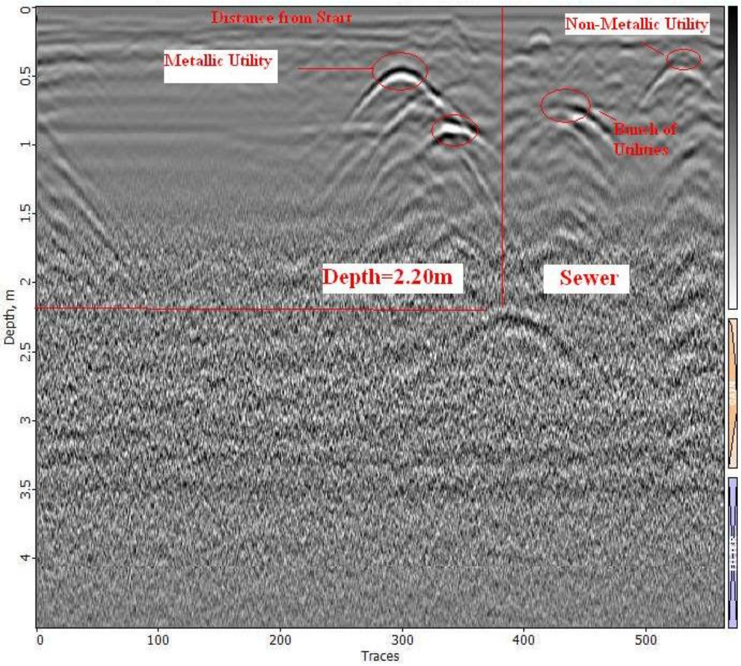


Figure 29: GPR Section Chandpole to Badi Chaupar



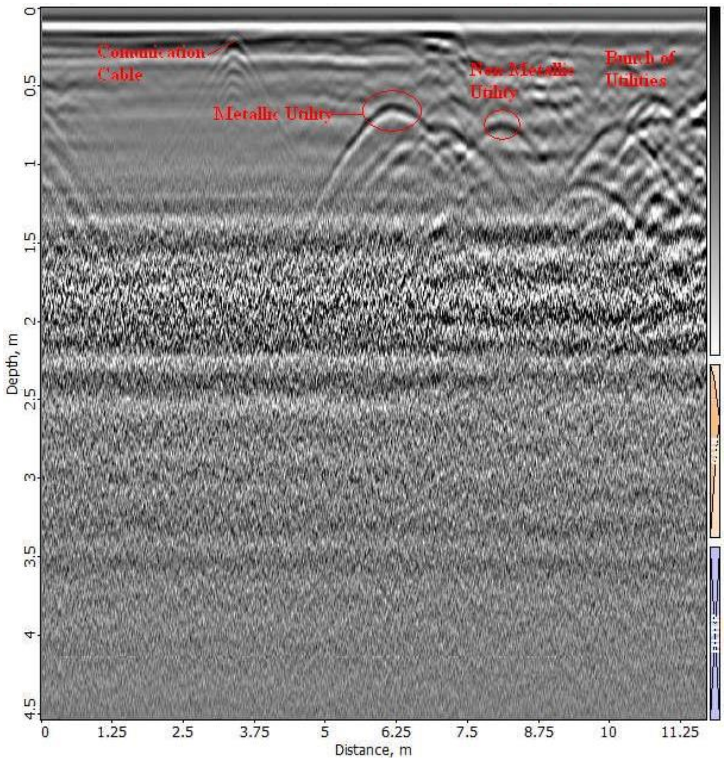


Figure 30: Utilities as identified on scanning using 400 MHz antenna