DEPARTMENT OF FOREIGN AFFAIRS AND INTERNATIONAL TRADE OF CANADA

Building Condition Report:
Geotechnical investigation on Chancery
Bridgetown, Bishop Court Hill, Barbados

Final Report

Presented by :

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Final Report

Building Condition Report : Geotechnical investigation on Chancery
Bridgetown, Bishop Court Hill, Barbados

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RECORD OF REVISIONS AND ISSUES		
REVISION NO.	DATE	DESCRIPTION OF THE MODIFICATION AND/OR OF THE ISSUE
00	2008-04-21	Final report

1 INTRODUCTION

1.1 Mandate

The Department of Foreign Affairs and International Trade Canada (DFAIT) awarded a mandate to Dessau Inc., as an engineering consulting group, to produce a Building Condition Report related to the evaluation of the condition of the Chancery building in Bridgetown, Barbados. Having concerns about the ground stability, DFAIT has extended our mandate to carry out a geotechnical investigation at the site of the Chancery building. The purpose of this investigation is to assess the presence or absence of voids (dissolution openings and/or caves) underneath and at the perimeter of the Chancery building, and, if present , their impact on the structural integrity of the Chancery building.

1.2 Investigations

The investigation to assess the presence of karstic formations (underground dissolution openings, voids or caves) was carried into two phases. Initially, a ground penetrating radar (GPR) survey was carried out order to identify possible ground heterogeneity caused by karstic formations. This geophysical survey has produced data for the entire building surface and perimeter. The resulting data was then used to identify the most suitable location for sampled boreholes. Consequently, four (4) boreholes were put down at the selected locations. The boreholes have permitted the identification and validation of physical and mechanical characteristics of the ground materials as well as the presence of karstic openings identified by the ground penetrating radar survey.

The ground penetrating radar survey and the boreholes drilling program were performed between the 17th of February and the 4th of March 2008. The coral rock core samples collected during the borehole drilling were sent to our Gatineau office in Québec. The rock samples were received a week later.. The rock core samples have been characterized and laboratory analysis have been performed on them. *Please note that these rock core samples will be disposed of according to the Canadian Food Inspection Agency specifications one month following the delivery of this report if no further notice is given by DFAIT.*

2 SITE DESCRIPTION

2.1 Topographic location

The Chancery building is located in the Parish of St. Michael on the Barbados Island. More precisely, it is located almost at the summit of a hill on Bishop Court Hill Rd. The approximate elevation of the property is 35 m (115 feet) AMSL (above mean sea level). The property land is relatively flat around the Chancery building. Around the property, steep slopes are present on the West side (slope of approximately 35% over a length of 40 m) whereas on the East side, the slopes are inclined with a slight slope of approximately 5%. The North and South land limits are relatively flat. The general topography of the area is oriented in the South-East to North-West axis, the South-East part being at higher elevations.

The building consists of a concrete structure with two (2) storeys including a ground floor an a partial basement located in the northern half of the building. Part of the building also has a crawl space. During the construction of the building, karstic openings were observed in the coral rock Formation in the basement area. The information regarding the building construction are available in a Dessau Inc. Report entitled “Building Condition Report for Chancery”, Ref # 034-P015952-0100-ME-0001-00, January 2008.

2.2 Geological and Hydrological Context

The bedrock present in the area consists of the Coral Rock formation of the Middle Reef Terraces. The coral rock is essentially a limestone with fossiliferous deposits. According to available geological and topographic maps, the Coral Rock Formation is approximately 70 m. Out of the 70 m thickness, 35 m are located below mean sea level.

The Bajan community relies in major part on the underground water sources for their potable water supplies. A coastal desalination plant is also located in the Parish of St. Michael providing approximately one fourth of all potable water on the Island. The underground aquifers are recharged through rainfall events. The rainfall water percolates into the ground and seeps into bedrock to reach the aquifer’s levels. During this process of percolation and seepage, rainfall water which contains carbon dioxide dissolves the bedrock limestone. The porous nature of the bedrock and presence of

openings and cavities allow the water to circulate almost everywhere underground causing the dissolution process difficult to predict.

Though, in areas of water accumulation such as existing caves or karstic formations, the dissolution process tends to be accelerated due to the higher water discharges.

Through different discussions with geologists and government officials and a brief literature review, we can conclude that most of the Island is characterized by the Coral Limestone Formation of the Lower, Middle and Upper Reef Terraces Complex which is very prone to the formation of karsts.

These karstic formations can have different sizes and can be found at any depth in the ground. Hence, a network of underground caves and karstic formations, connected or not, is probably spread out over most of the Island. At the time being, no mapping of this network or individual caves seems to have been carried out, except for Harrison's Cave which is a tourist attraction.

2.3 Observed karstic formations in the neighbouring area

During our stay in Barbados, our technician visited neighbouring properties to find if karstic formations could be present. This was not a thorough survey and the objective was to learn about different actual characteristics of karstic formations. As shown on plan Nos. 034-P015952-0160-000-SC-0002-00 and 034-P015952-0160-000-SC-0003-00 in appendix 5, three (3) sites with recorded karstic formations have been identified, they are :

- the school and neighbouring property just North of the Chancery (approximately 90 m away);
- Britton Hill (approximately 500 m away);
- Harrison's Cave (approximately 10 km away)

The karst on the property located just North of the Chancery (school and neighbouring property) has been partially visited. The bottom of the karst opening lies at depths of 7.5 to 9 m below ground surface. Its height reaches 3 to 5.5 m over a total length of approximately 85 m.

The karst formation at Britton Hill was, according to Dr. Hans Machel of the University of Calgary and a reporter, approximately 30 m deep[1] and the crown of the arch seems to have been located less than a meter below the foundations of a building. This karst has unfortunately collapsed last summer along with the building above and its occupants.

Harrison's Cave is almost to 2.3 kilometres long and its largest cavern is about 15 m high. The cave holds a massive water stream.

[1] Barbados Free Press, *Brittons Hill Barbados - Apartment Building Collapse Into Known Cave - Family Of 5 Trapped - US Miami Dade Rescue Team Goes To Work,* in [http://barbadosfreepress.wordpress.com/2007/08/26/brittons-hill-barbados-building-collapse/]

3 DESCRIPTION AND RESULTS OF THE GROUND PENETRATING RADAR (GPR) SURVEY

3.1 Required information

The work schedule with Ground penetrating radar (GPR) consists of verifying the presence of karstic zones near the installations of The Canadian High Commission in Bridgetown, Barbados. The GPR survey relies on both the resolution and the entire coverage of the target area. The survey itself involves setting up a grid on the ground covering the entire footprint of the building and adjacent area. A radar emitter is pulled on the ground grid lines and changes in ground densities are recorded. The areas where anomalies are observed are noted in order to locate sampled boreholes in a second stage.

3.2 Ground Penetrating Radar Survey (GPR)

The GPR is a non-destructive method tested for the internal imaging of several types of geological materials like the soils and rocks as well as artificial building materials such as concrete, asphalt or wood. The GPR can be used to locate metallic or non-metallic objects such as cables, pipes, sewers, foundations, reinforcement, anchorages, and several other buried structures. In geology and geotechnic, it can be used to study the layout and thickness of the different layers of ground prior to different types of work. This method was chosen because it is the most suitable to obtain relevant information from the subsoil.

The GPR is a geophysical method which, by itself or combined with other methods, (refraction experiment, electrical resistivity, VLF, EM), enables to clarify the geometry of the subsoil with the use of audio-frequency antennas that allow investigation depths of several meters. There are many possible uses. For example, the location of a rocky top, the stratigraphy, the visualization of ground water, the study of lacustrine bottoms or river profiles, the study of contaminated sites, the search for voids, faults or vughs.

3.3 Ground Penetrating Radar Principle

The GPR sends electromagnetic pulses in the studied structure and records the electrical echoes caused by the difference in dielectric characteristics between the different materials. When the radar is moved at the surface by the operator, an image is created in the same way as an ultrasound.

The echoes can be caused by natural phenomena like the stratification of the subsoil or artificial like pipes, cisterns, voids, etc. This tool can precisely detect a great variety of targets.

The GPR operates on the analysis principle of signals emitted then reflected by some heterogeneities of the studied environment. It takes into account the return upole time of the electromagnetic impulsion as well as its amplitude, like an echo sounder. The emitted signal has a large frequency band included between 10 MHz and 2 GHz, the use of different antennas allowing to scan the entire spectrum according to the desired investigation depth and the size of the objects we are searching for. Indeed, the investigation depth is high at low frequency but the resolution is lower. On the other hand, for antennas of 1-GHz and more, the opposite is obtained and allows the visualisation of fine details in the concrete.

The GPR is made up of several elements that can be handled by only one person. The transmitting/receiving antenna is moved above the studied surface and its size is inversely proportional to its central frequency. It is linked to an electronic part of the signal monitoring (RAMAC/X3M control unit) and transferred to an analysis monitor on which the operator sees in real time a vertical soil/structure profile generated by the multiple reflections of the wave fronts.

The following instruments are used to carry out the GPR survey:

- 2 shielded antennas: 100 and 250 MHz;
- RAMAC/X3M control unit;
- GPR RAMAC analysis monitor.

3.4 Methodology and Realization

Following the visit of the Chancery building, the GPR survey in the crawl space could not be carried out due to the limited space for the antennas. Moreover, the size of HVAC equipment in the building limits the access to carry out a full GPR survey..

However, a significant portion of the ground floor was free from equipment and thus allowed the realization of the GPR survey through the floor slab.

A total of 45 lines of measure were carried out on the site of the chancery as follows :

- Lines Nos. 1 to 5 in the basement with a 250 MHz antenna (5 lines);
- Lines Nos. 6 to 10 on the ground floor with a 250 MHz antenna (5 lines);
- Lines Nos. 11 to 23 outside with a 250 MHz antenna (13 lines);
- Lines Nos 1 to 23 with a 100 MHz antenna except lines Nos L1, L-4 and L-7 (20 lines);
- Lines Nos. L-24 and L-25 outside with a 250 MHz antenna (2 lines)

The plan presented in Appendix No. 2 shows the location of the GPR survey gridlines. The azimuth of the survey lines are oriented N095 and N355 over lengths of 1.3 to 68.9 m (lines with a 250 MHz antenna) and 1.7 to 72.6 m (lines with a 100 MHz antenna).

3.5 Data Analysis

The data of the GPR survey is processed and interpreted with the RadExplorer 1.4 (MALÅ Geoscience, 2005) software. Each datum undergoes the radar signal processing in order to obtain a clearer report on the various structures encountered at ground level. There are several types of processing operations such as the correction of time linked to the movement of the antennas, the deletion of the low-frequency component, the amplitudes compensation, the deconvolution, the analysis of speed and dynamic corrections, altimetry corrections, etc. The profiles of the different GPR lines are presented in appendix 3.

3.6 Results

In general, the information obtained from the surveys carried out with the 250-MHz antenna appear to provide better results than the ones carried out with the 100-MHz antenna. The signal seems to be highly softened by soils that are electrically very conductive like clays or high-salts content soils. Thus, the average investigation depth is approximately 11,0 m.

The most important anomalies obtained from the GPR survey are presented on the plan presented in appendix 2. Following the acquisition, processing and interpretation of the GPR survey data, four (4) potential karstic zones were identified as follows :

- Zone 1 : area located west of the building between Stations 21.0 and 23.7 m in line L-20;
- Zone 2 : area located north of the building between Stations 13.0 and 16.2 m of line L-17;

- Zone 3 : area located south of the building between Stations 30.0 and 39.0 m of line L-19 and between Stations 26.0 to 34.0 m of line L-23.
- Zone 4 : area located east of the building between Stations 29.0 and 38.0 m of line L-18, between Stations 23.0 and 30.0 m of line L-22 and between Stations 29.0 and 36.0 m of line L-24.

Inside these zones, the probability of intercepting karstic formations during the execution of the drilling is stronger. In all, four (4) potential drilling targets are identified around the Chancery building. The targets are located on the lines L-20, L-17 and L-19, at respective distances of 21.5 m, 12.5 m and 36.5 m, calculated from the beginning of each line. The fourth target is located mid-way between two anomalies identified on adjacent lines L-18 and L-22 at respective distances of 34.0 m and 27.0 m, calculated from the beginning of each line.

The most significant anomalies are located South and East of the building. The South anomaly was observed on lines L-23 and L-19; the extension of the anomaly to the North ends between lines L-11 and L-19, under the terrace. Indeed, the profiles of the lines L-11 and L-12 do not reveal any anomaly suggesting that a karstic zone continues under the Chancery. At the East portion of the building, a possible karstic formation was identified on lines L-18 and L-22 with the 250-MHz antenna and another one on line L-24 with the 100-MHz antenna.

The GPR profiles of lines L-11 and L-14 do not show any significant sign that could reveal the presence of a karstic formation; the extension of the anomaly to the West continues and ends between lines L-14 and L-18, under the terrace.

4 DESCRIPTION AND RESULTS OBTAINED FROM BOREHOLE DRILLING

4.1 Location and Depth of Boreholes

A total of four (4) boreholes were drilled at each of the four locations defined by the GPR survey. The boreholes reached depths between 10.7m to 13.7m beneath present site grades as described in our work proposal (Ref. : 92033-07-130). The exact locations of the boreholes is presented on plan 034-P015952-0160-000-SC-0001-00 in appendix 5. Boreholes BH-01-08 and BH-02-08 could not be executed exactly over the possible karstic formation determined with the GPR because of site conditions. In fact, buried electrical wires were present at these locations and precluded drilling the borehole at these exact locations. The boreholes were carried out closest to their proposed location, where underground services were absent.

The services of a local Barbados drilling company, Hydrotech Carribean Inc. were retained to perform the drilling. Dessau's representative, Mr. David Noël, Senior Technician., carried out a full time supervision of the drilling operations to ensure work quality.

Special attention was carried by the drillers and by our site supervisor for any variation (sudden drop of the drill rods, etc.) during drilling that could indicate the presence of voids in the bedrock. Following the drilling operations, all boreholes were backfilled with coral rock crushed stone. The first 15 cm (6 in) from the surface was then sealed with a cement grout. This sealing will prevent water to flow directly from the surface through the boreholes and accelerate the erosion and dissolution process in the bedrock.

4.1.1 Soil and rock sampling

Soil sampling in the boreholes was performed using a standard split spoon sampler according to the method described in the ASTM D-1586 Standard. The standard penetration index "N" was measured at 1.5 m intervals in soils.

When bedrock was encountered the drilling was performed with a NQ size core barrel with pressurized air to clean the area of contact between bedrock and the core barrel.

Soil samples withdrawn were stored in plastic bags with hermetic closure in appropriate boxes immediately after sampling and sent out to our laboratory in Gatineau, Quebec. The preservation technique of the samples has ensured the safeguarding of the natural soil water content between the time of sampling and the time of laboratory testing and was executed in accordance to the Federal Law on soil imports managed by the Canadian Food Inspection Agency. The bedrock samples were also put in dedicated core boxes and were also sent to our Gatineau office.

4.2 Stratigraphy and Underground Water Table

The general stratigraphy of the surface soils observed in the four boreholes consist of an initial 7.5 to 15 cm (3'' to 6'') thick layer of earth and grass followed with backfill materials. The backfill materials consist of a 12.7 cm (5'') thick layer of fine to medium sand (BH-02-08) or a 10cm (4'') thick layer of coral crush stone of 10 mm in diameter (BH-03-08).

Bedrock was found outcropping at the location of borehole No. BH-02-08. It was observed at depths of 15 cm (6'') to 1 m (3'5'') below ground surface in the other boreholes. The general lithology of the observed bedrock consists of coral rock fragments of various sizes ranging from 0 to 10 cm or massive coral rock with the presence of closely spaced discontinuities and in some cases with voids created from dissolution process and/or well developed corals. Both types of coral rock (massive and fragmental) have also been observed in random order and in interbeds. In the fragmental state, the coral rock is a very porous material.

Structurally, the observed bedrock in all four boreholes is generally of very poor quality with a Rock Quality Designation (RQD) value most often of zero percent (0%). Though, some horizons are slightly of better quality with RQD values higher than twenty percent (20%).

Of all four bedrock samples selected for compressive strength testing, only three could be prepared to be tested. Due to the porous nature of the rock, the preparation of the samples could not be performed according the ASTM D2938 standard. Nevertheless, we find that the results can provide relevant information. All four samples were tested to verify their volumetric weight. No relationship can be established between the volumetric weight of the sample and its compressive strength. The following table describes the results obtained:

Table 1 : Laboratory analysis results			
Borehole-sample number	Depth (m)	Compressive strength (MPa)	Volumetric weight (kN/m^3)
BH-01-08-CR-8	8.70	-	12.66
BH-03-08-CR-1	0.76	18.2	22.05
BH-03-08-CR-6	8.43	18.5	14.78
BH-04-08-CR-2	2.25	10.1	22.11

During drilling, no underground water table was noted. We have been told by a representative of the Barbados Water Authority that the groundwater table level in the area of the Chancery is approximately at a depth of 34.5 m (113 feet) below ground surface. Historical data showed that groundwater table levels in wells in close proximity to the site had depths ranging from 30 to 35 m (98 ft to 115 ft).

All four borehole log reports are presented in appendix 4. Rock core samples have been characterized by our engineering geologist.

4.3 Observed karstic formations

The presence of two (2) karstic formations has been confirmed by drilling and coring in borehole Nos. BH-03-08 and BH-04-08. In borehole No. BH-03-08, a void of 30 cm (1 ft) in height was identified between depths of 7.3 to 7.6 m (24 to 25 ft). In borehole No. BH-04-08, a void of 1.4 m (4'6") height was identified between depths of 5.0 to 6.4 m (16'6" to 21'). The drilling confirms the results of the GPR survey which located the most important anomalies to the South and to the East of the Chancery building.

According to the GPR survey results, we can establish that the karst located on the East side of the building is in part located underneath the terrace and reaches up laterally to approximately 2 m from the closest foundation of the building. The karst also extends towards the East direction under the vacant field to an unknown distance.

The karst located on the South side of the building is in part located underneath the terrace and reaches up laterally to approximately 1.6 m from the building closest foundation. The karst extends towards the South direction under the botanical garden to an unknown distance (possibly underneath the driveway).

In borehole Nos. BH-01-08 and BH-02-08, no sign of karstic formation was observed from the drilling results. However, the drilling was not carried out at the exact anomaly location given by the GPR results due to the presence of underground conduits. The resulting information (GPR survey and drilling) has permitted to locate the extents of the possible karstic formations.

5 ANALYSIS OF POTENTIAL DANGER DUE TO EXISTING KARSTIC FORMATIONS

5.1 Previous Karstic Formations Detected during Building Construction

According to photographs provided by DFAIT, a karstic formation had been identified at the time of the Chancery building construction in 1983. The karstic formation was located in the East part of the basement of the Chancery. These photographs show that the karstic formation has been backfilled with granular materials and compacted.

According to the GPR survey results, no potential anomaly was detected in this area. Moreover, the photographs show that the existing karstic formation was backfilled with compacted granular materials. Consequently, no potential risk is considered in this area.

Photographs number SC-018 to SC-022 presented in appendix 1, show the karstic formation and backfilling operation at the time of the Chancery building construction.

5.2 Risk Analysis of Existing Karstic Formation

For the purpose of this study, the basement floor plan provided by DFAIT (Ref. BGN-C-005-1) was used to determine the building configuration and specification. This plan was the only available source of information. Dimensions were measured directly on this plan, which was presented as "to scale".

In the area of detected karsts, the widest footing is 1 meter wide. Since no plan was available to define the depth of the footings and there is no basement in these areas, the footings depth is estimated at approximately 1.5 m below ground surface.

As mentioned in Building Condition Report of January 2008[2] "the building foundations consist of cast-in-place concrete footings and concrete block walls which enclose the basement rooms and part of the crawl space. The surface finish is sometimes rough but there was no evidence of settlement or differential movement between building elements. This is an indication that loads being imposed are within the capacity of the underlying soils."

The risk analysis to building integrity was assessed in each detected karst zone as follows:

- East karst (borehole No. BH-04-08): The load distribution from the building foundations can be calculated by analytical methods. A load distribution modeling was carried out using the Settle3D program developed by RocScience, Toronto, Canada. This program uses the Boussinesq analytical method that employs the theory of elasticity to evaluate the distribution of loads in a semi-infinite homogeneous space. Figures 1, 2 and 3 show load distribution results in subsurface materials under a 500 kPa rectangular load pressure of 1 m wide resting at a 1.5 m depth. The actual building load is not known. Results show that at the depth of detected East karst, the load magnitude is less than 15 kPa (about 3 % of foundation surcharge). The load at this level is negligible for the considered configuration. Consequently, the karst detected on the East side of the building (borehole No. BH-04-08) is not problematic in regards of the building structural integrity because of its depth and its distance with respect to the closest foundation. At the time being, the building loads do not influence to a critical level the karst stability. However, this karst is subjected to overburden materials weight from terrace and lawn. Surcharge loads should therefore be avoided. Up to now, no sign of collapse or surface subsidence was reported in these areas.

[2] Dessau inc., Building Condition Report for Chancery, Ref # 034-P015952-0100-ME-0001-00, January 2008, p.6.

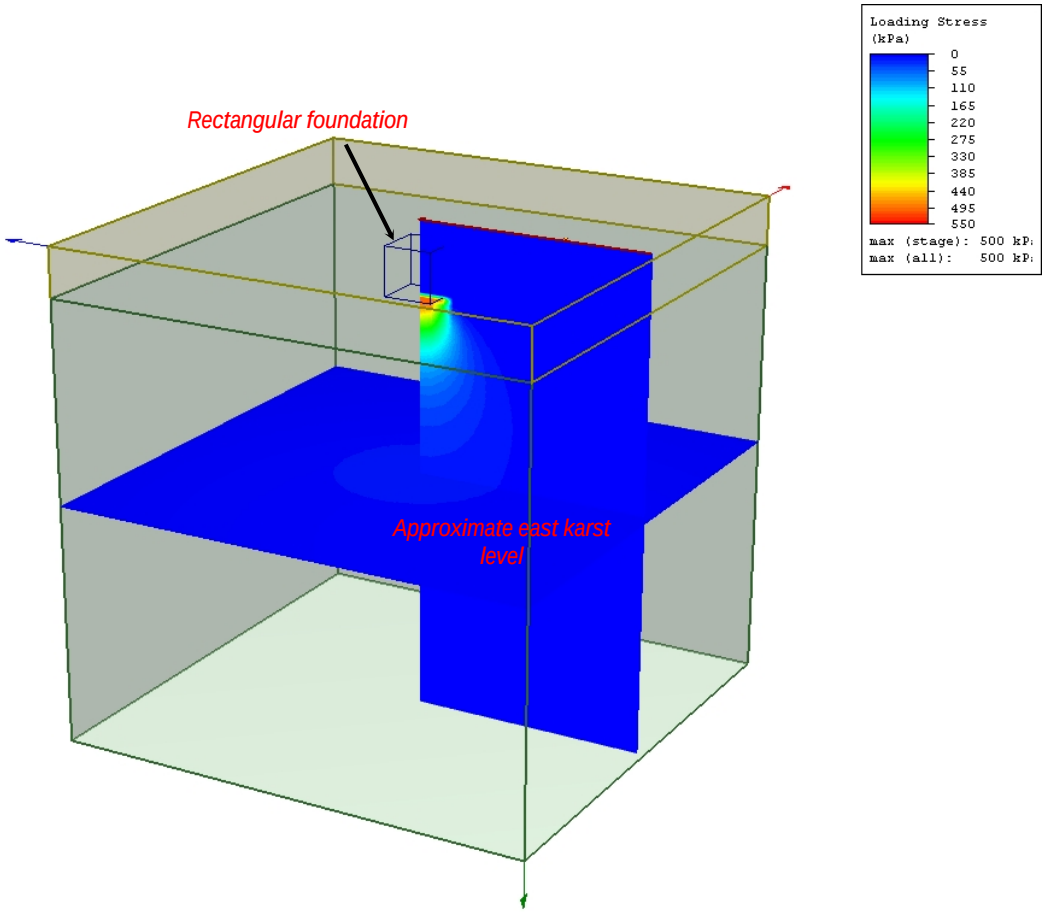


Figure 1 : Load distribution in subsurface materials under a 500 kPa rectangular load pressure of 1 m wide

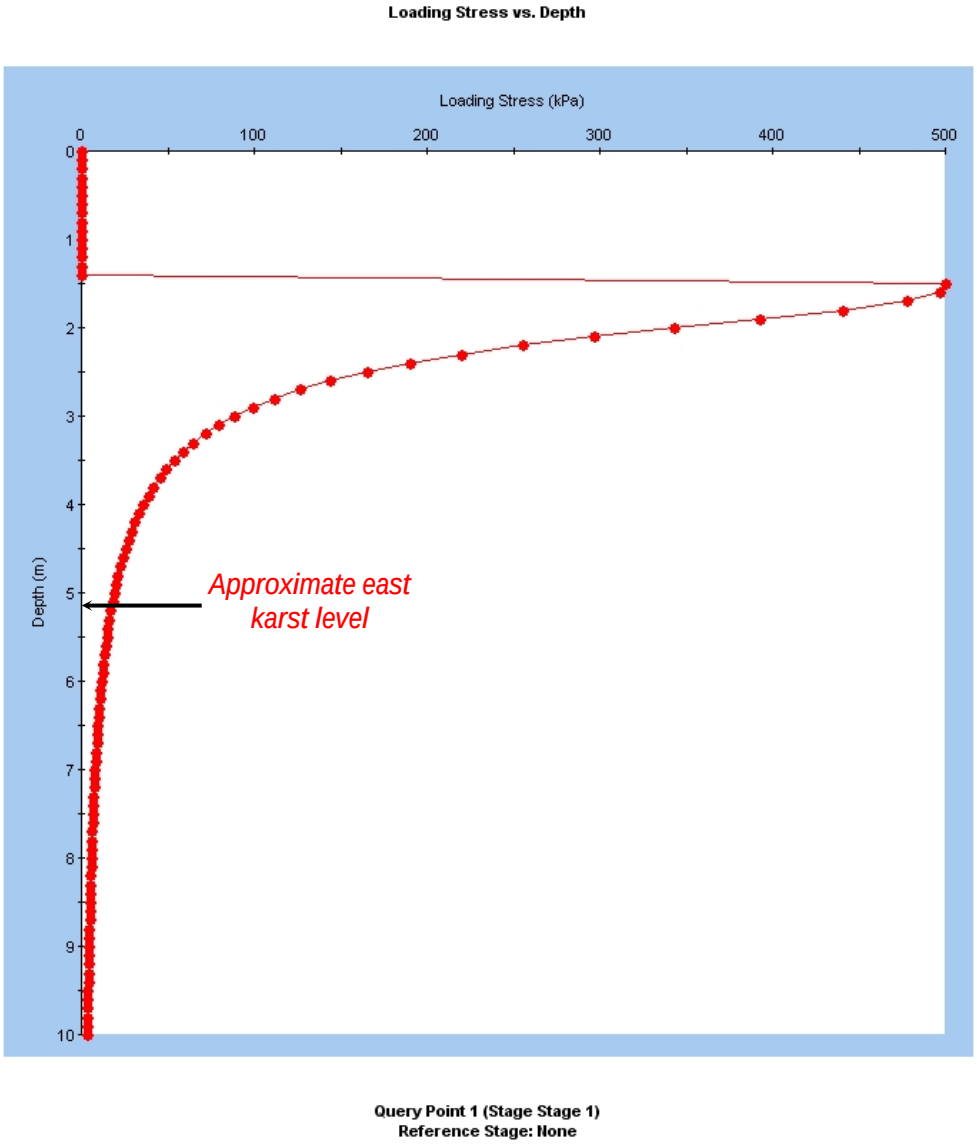


Figure 2 : Load distribution under the center of a 500 kPa and 1 m wide rectangular load pressure

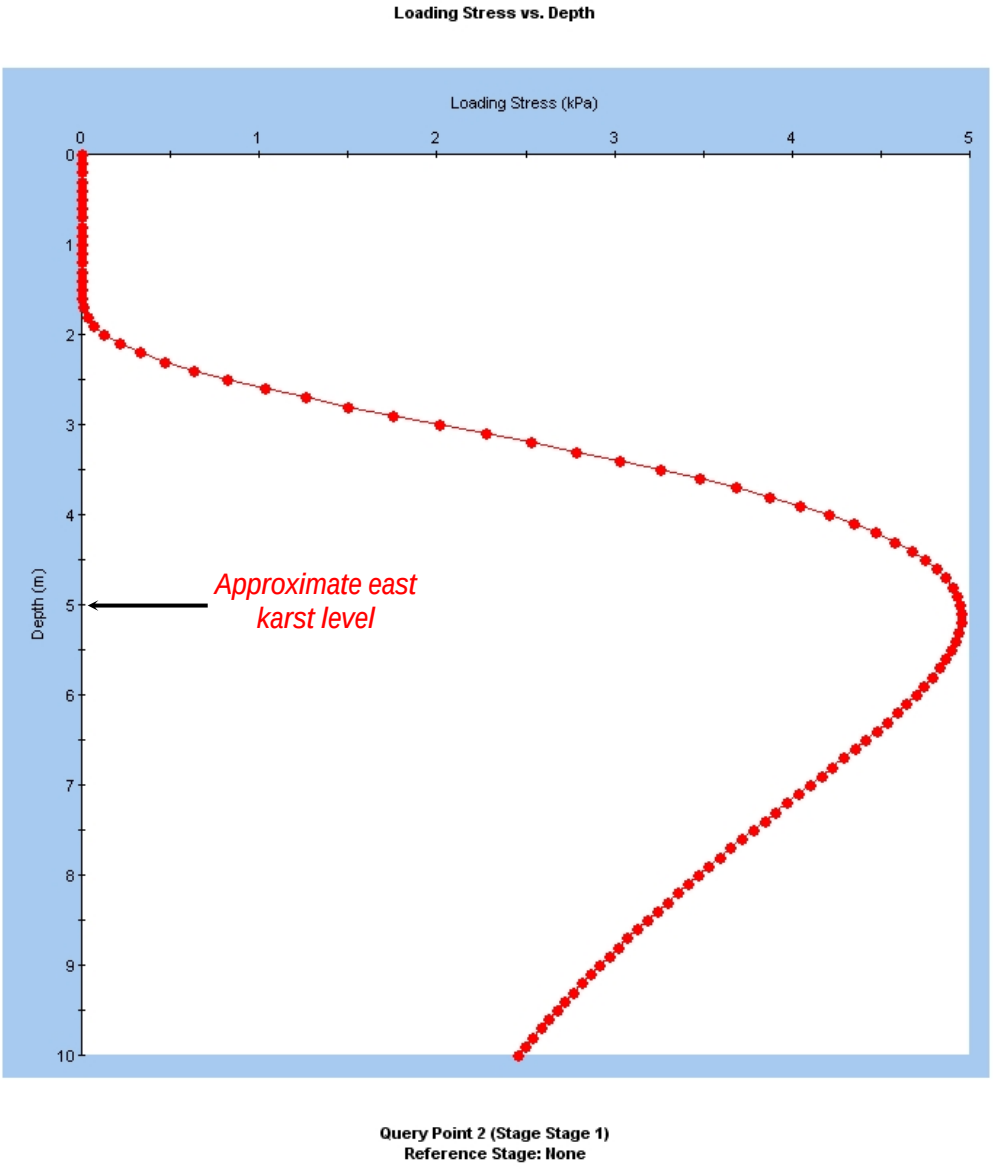


Figure 3 : Load distribution at a distance of 3m from center of the 500 kPa and 1 m wide rectangular load pressure

- South karst (borehole No. BH-03-08): In this case, the karst was identified at a deeper level (7.3 m deep). For the same reasons (explained earlier for the East karst), considering the location, the depth and height of this karst, no immediate risk is anticipated for the building structural integrity from this south detected karst. The weight of the building and of the terrace do not influence to a critical level the karst stability.

This karst is as well subjected to overburden materials weight from terrace, lawn, parking area and driveway. Surcharge loads should be avoided specially in parking area and driveway. Traffic of heavy duty vehicles shall not be authorized on the driveway. Until present, no sign of collapse or surface subsidence was reported in these areas.

- North and West karst (borehole Nos. BH-01-08 and BH-02-08): The North and West areas (where possible karstic formations were identified with the GPR survey) karsts were not encountered during drilling. Consequently, the presence of karsts could not be confirmed by drilling, since boreholes could not be located exactly over the identified areas in the GPR survey. Since these potential karsts are small and located relatively far form the building, they may not cause damages to the building. An eventual collapse in the West area would only affect the surrounding parking area and the lamp post. In the North area, an eventual collapse may probably affect the terrace and the chiller equipment. Since the depths, dimensions and stability of these potential karsts are unknown, the effects of a collapse are difficult to predict. However, the building structural integrity is not at risk by the presence of these two karstic formations.

6 CONCLUSIONS

This study pertained only to detect the presence of karstic formation that could affect the building structural integrity. Moreover, the GPR karst detection method was limited to about 11 m in depth. The use of the GPR was the most appropriate in this case, but unfortunately due to the nature of the bedrock, measurements could not be taken below depths of 11 m. Also, beneath this depth, the influence of the weight of the building is considered negligible over the stability of small karsts if any.

No karst formation was detected inside the perimeter of the building down to a depth of approximately 11 m. Four (4) potential karstic zones were identified outside of the building footprint by the GPR method.

The presence of two (2) karstic formations was confirmed by drilling in borehole Nos. BH-03-08 and BH-04-08. In boreholes Nos. BH-01-08 and BH-02-08, no sign of karstic formation was observed from the drilling results. However, the drilling was not carried out at the exact anomaly location given by the GPR method due to the presence of underground conduits. The extent of the karstic formations identified on site was not determined in directions away from the building.

There is no basement in the area of the detected karsts. The widest footing is 1 m wide and the footings depth is estimated to be at a maximum of 1.5 m below ground surface. No immediate risk is anticipated for the building structural integrity from these detected karsts. Up to now, no sign of collapse or surface subsidence was reported in these areas.

As mentioned in the introduction, the karstic formation process is to continue with time. More water seepage through this porous bedrock will inevitably lead to more erosion and dissolution of the coral bedrock towards karstic formations. Moreover, vibration and traffic loads may cause the expansion of detected karsts.

7 RECOMMENDATIONS

The following recommendations were made in order to minimize the impact of detected karsts on the building integrity and associated parking areas.

It is recommended that both karsts located on the East side and on the South side of the building be completely filled with an adequate concrete mix. The East karst should be completely filled with concrete from the building perimeter up to the East property limit. The South karst should be entirely filled with concrete since it could extend underneath the driveways. The quantity of concrete needed to fill these karsts will depend on their dimensional characteristics and orientations, which are only partly known at this time. Although the extent of the karsts in the West and North portion of the building were not confirmed with the boreholes, they should also be filled with adequate filling materials (grout and/or concrete).

Once the voids in the karsts are completely filled with concrete, we recommend that additional boreholes be carried out within the karst footprints to ensure that no voids remain in the coral rockmass.

Moreover, at all time and particularly during the building repair, we recommend that no additional surcharge be put upon the field and on the driveway. Traffic of heavy duty vehicles shall not be authorized on the driveway. These precautionary measures will apply over all identified karstic formations until they are totally filled up with concrete.

As this study pertains to actual site conditions, we recommend that a monitoring program be put in place for at least as long as the property is inhabited. A visual inspection of the structural integrity of the building should be conducted every five years, in order to identify the development of cracks in the foundations or any other relevant element showing signs of instability of the building.

Monitoring of the bedrock in order to determine the extents and the aggravation of karstic formations should also be performed every five years. The monitoring should consist of a GPR survey inside of the Chancery building. The GPR survey should also be extended outside to a larger area and most likely to the entire property to ensure the safety of the workers and of the infrastructures of the embassy. The GPR survey should be combined with the drilling of exploratory boreholes in the event that potential karstic formations are identified. At least one (1) borehole should be put down to a depth of at least 40 m, depth at which the ground water table was observed (see section 4.2). This will determine if a major karstic formation is located at great depths.

8 REFERENCES

Barbados Free Press, *Brittons Hill Barbados - Apartment Building Collapse Into Known Cave - Family Of 5 Trapped - US Miami Dade Rescue Team Goes To Work,* in [http://barbadosfreepress.wordpress.com/2007/08/26/brittons-hill-barbados-building-collapse/]

Dessau inc., *Building Condition Report for Chancery: Bridgetown, Bishop Court Hill, Barbados,* Ref # 034-P015952-0100-ME-0001-00, January 2008, 76 pages.

Geographic Map of Barbados (1: 10 000), Sheet: 8, Series: OSD 218/1, Edition 2-OSD 1988, Government of the United Kingdom (Ordnance Survey), © 1988 Government of Barbados.

Geology of Barbados (1: 50 000), Sheet: Geology of Barbados, Series: D.O.S 1229, Edition 1-D.O.S. 1983, Government of the United Kingdom (Ordnance Survey), © 1983 Barbados Government.

Harrison's cave, on line in [http://www.harrisonscave.com]

St Michael BWRO Desalination Plant, Barbados, on line in [http://www.water-technology.net/projects/barbados/]

T*opographic Map of Bridgetown – Barbados* (1: 1 250), Sheet 8011, Series D.O.S. 0018, Edition 1-D.O.S 1974, British Government's Ministry of Overseas Development (Directorate of Overseas Survey), © 1974 Barbados Government.

Appendix 1 Photographs (20 pages)

BOREHOLES 2008

Photo ID	Description
SC-001	Location of borehole BH-01-08, West side of the Chancery building

Photo ID	Description
SC-002	Location of borehole BH-02-08, North side of the Chancery building

Photo ID	Description
SC-003	Location of borehole BH-03-08, South side of the Chancery building

Photo ID	Description
SC-004	Location of borehole BH-04-08, East side of the Chancery building

SOIL AND ROCK CORES SAMPLES

Photo ID	Description
SC-005	Soil and rock core samples : BH-01-08; depth: 0 to 6.91 m (0 ft - 20 ft), dimensions in feet on picture

Photo ID	Description
SC-006	Soil and rock core samples : BH-01-08; depth: 6.91 to 9.15 m (20 ft - 30 ft), dimensions in feet on picture

Photo ID	Description
SC-007	Soil and rock core samples : BH-01-08; depth: 9.15 to 10.67 m (30 ft - 35 ft), dimensions in feet on picture

Photo ID	Description
SC-008	Soil and rock core samples : BH-01-08; depth:10.67 to 12.2 m (35 ft - 40 ft), dimensions in feet on picture

Photo ID	Description
SC-009	Soil and rock core samples : BH-02-08; depth: 0 to 7.62 m (0 ft - 25 ft), dimensions in feet on picture

Photo ID	Description
SC-010	Soil and rock core samples : BH-02-08; depth: 7.62 to 10.67 m (30 ft - 35 ft), dimensions in feet on picture

Photo ID	Description
SC-011	Soil and rock core samples : BH-03-08; depth: 0 to 3.05 m (0 ft - 10 ft), dimensions in feet on picture

Photo ID	Description
SC-012	Soil and rock core samples : BH-03-08; depth: 3.05 to 6. 1 m (10 ft - 20 ft), dimensions in feet on picture

Photo ID	Description
SC-013	Soil and rock core samples : BH-03-08; depth: 6.1 to 9.15 m (20 ft - 30 ft), dimensions in feet on picture

Photo ID	Description
SC-014	Soil and rock core samples : BH-01-08; depth: 9.15 to 13.72 m (30 ft - 45 ft), dimensions in feet on picture

Photo ID	Description
SC-015	Soil and rock core samples : BH-01-08; depth: 0 to 6.91 m (0 ft - 20 ft), dimensions in feet on picture

Photo ID	Description
SC-016	Soil and rock core samples : BH-01-08; depth: 0 to 6.91 m (0 ft - 20 ft), dimensions in feet on picture

Photo ID	Description
SC-017	Soil and rock core samples : BH-01-08; depth: 0 to 6.91 m (0 ft - 20 ft), dimensions in feet on picture

DURING CONSTRUCTION IN 1983

Photo ID	Description
SC-018	Karstic formation found during construction (1983). Center North section of basement.

Photo ID	Description
SC-019	Close-up view of identified karstic formation (1983)

Photo ID	Description
SC-020	Backfilling of identified karstic formation (1983).

Photo ID	Description
SC-021	Compaction on backfill in karstic formation (1983)

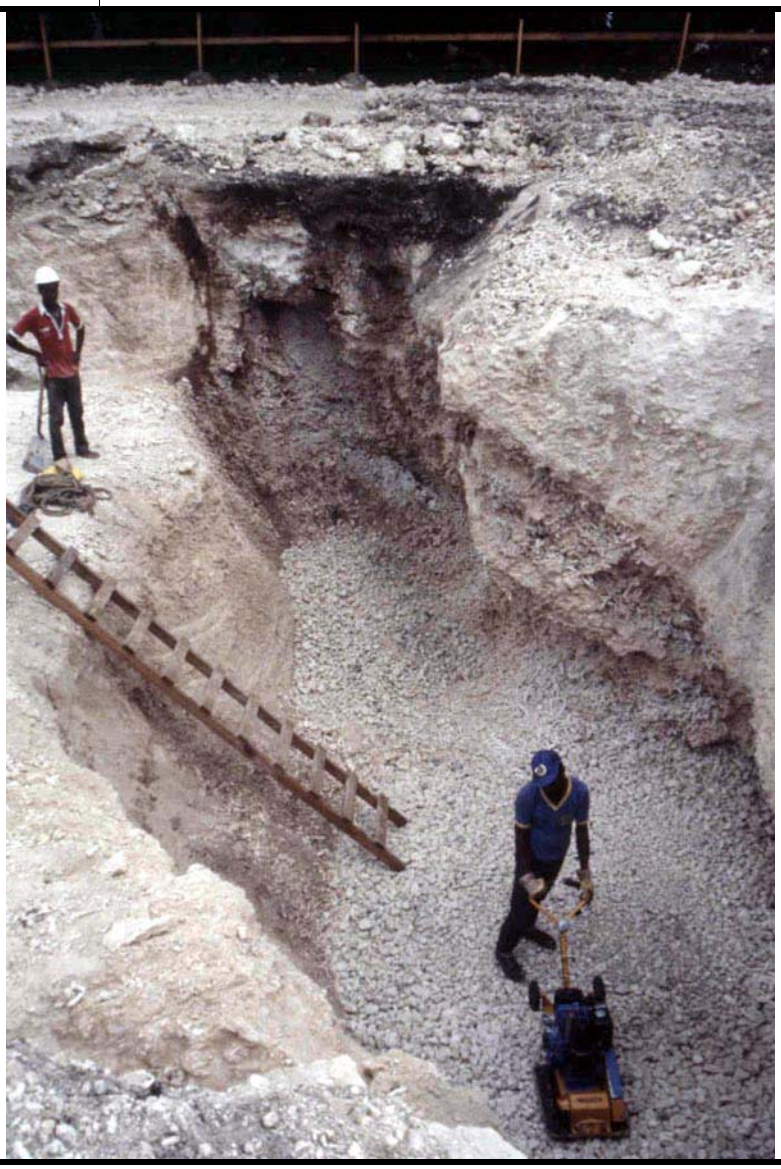
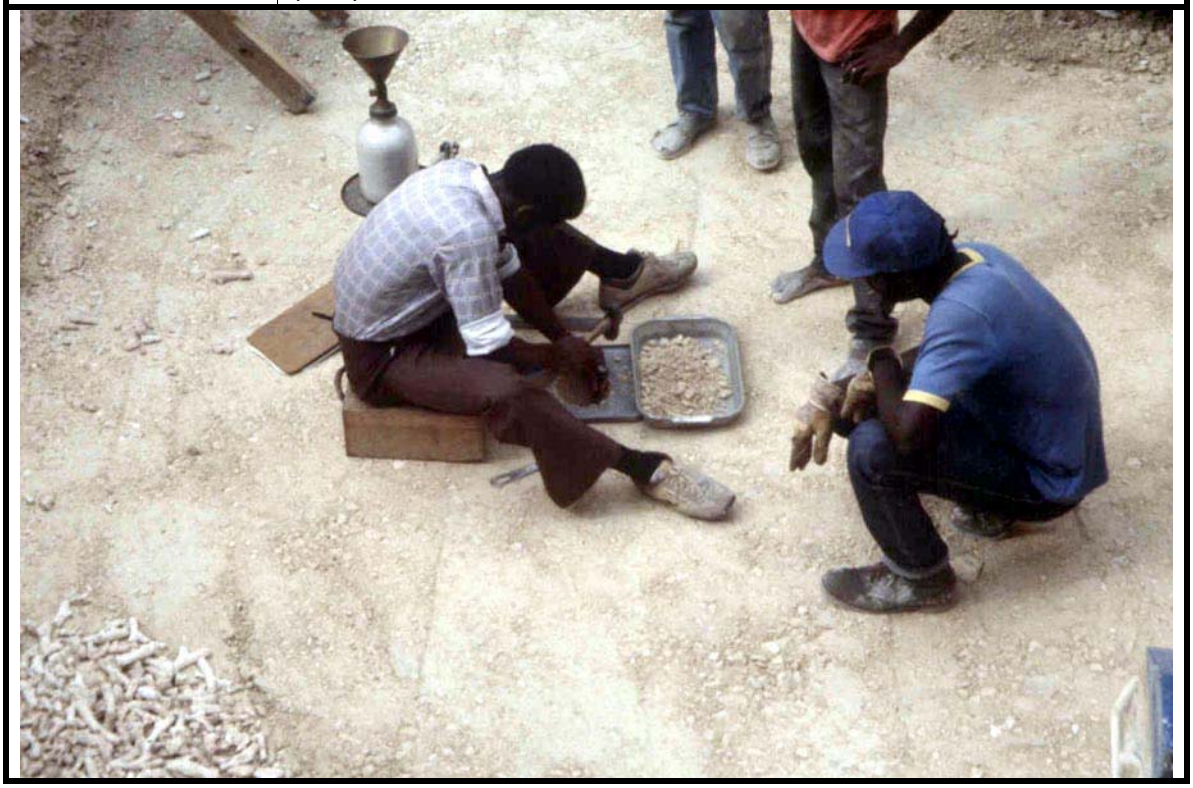
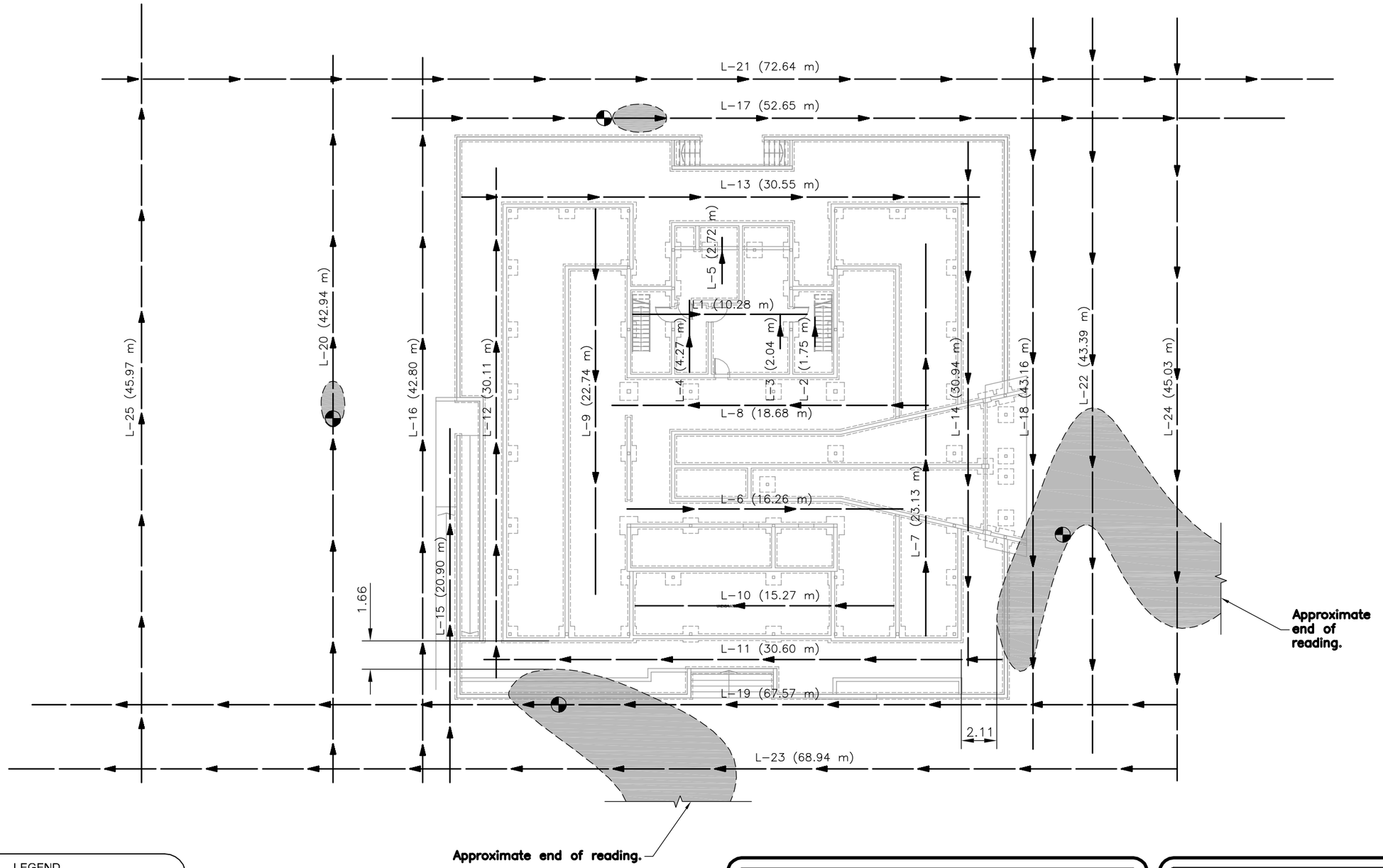


Photo ID	Description
SC-022	Verification of compaction of backfill in karstic formation by the Sand cone method (1983)



Appendix 2 Plan of Ground Penetrating Radar Survey (1 page)



LEGEND

- GEORADAR LINE
- POSSIBLE KARSTIC FORMATION
- POTENTIAL TARGET OF DRILLING

Project

CANADIAN HIGH COMMISSION CHANCERY

BRIDGETON BISHOPS COURT HILL - BARBADOS

Title

GEORADAR LINES LOCATION

HYDROGÉO-SOL
245, rue Riverin, bureau 101
Chicoutimi (Québec) G7H 4R6
Téléphone : 418.545.8256
Télécopieur : 418.545.8254

Prepared	A.G.	Discipline	GEOLOGICAL SCIENCES
Drawn	M.C.	Scale	1:250
Checked	A.G.	Date	2008-03-26

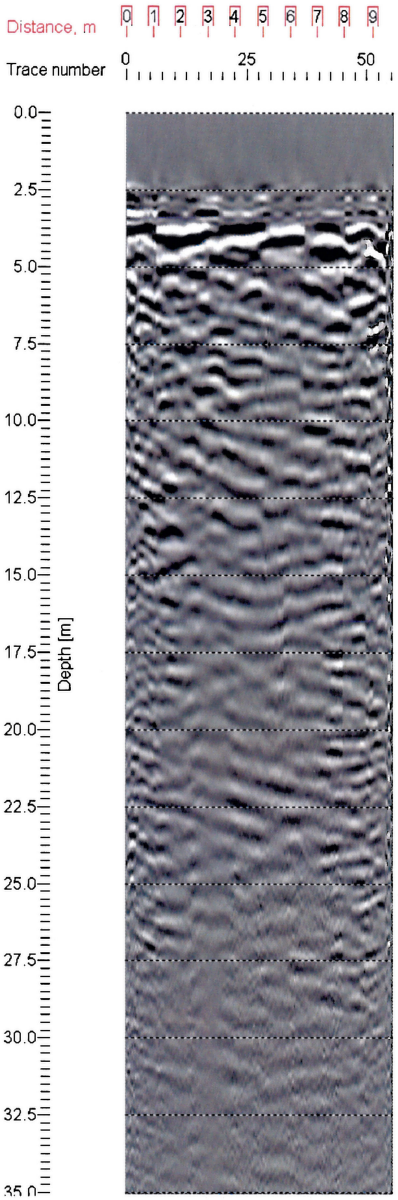
Project manager: **Andy Guyaz**
Extract from: Rev.: **00**

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
034	P015952	0170	000	SC	0001	00

Appendix 3 GPR Measurement Profiles (45 pages)

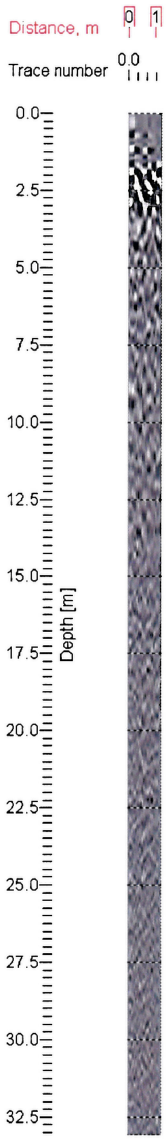
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-1
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



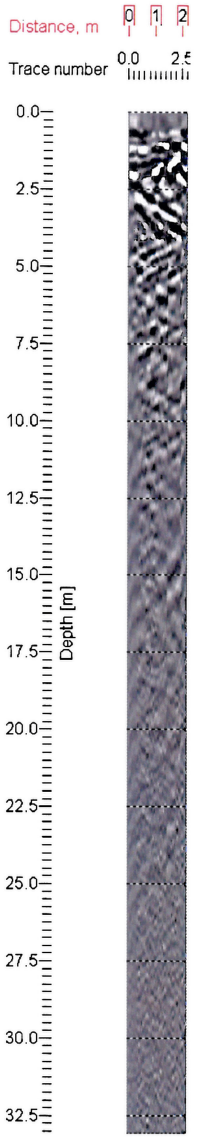
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-2
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



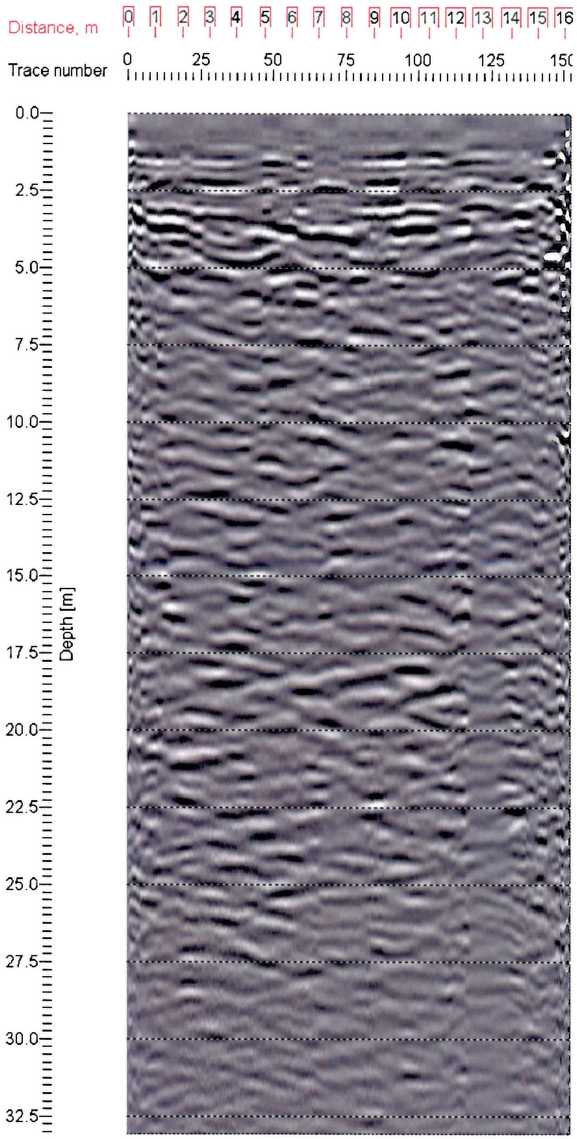
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-5
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



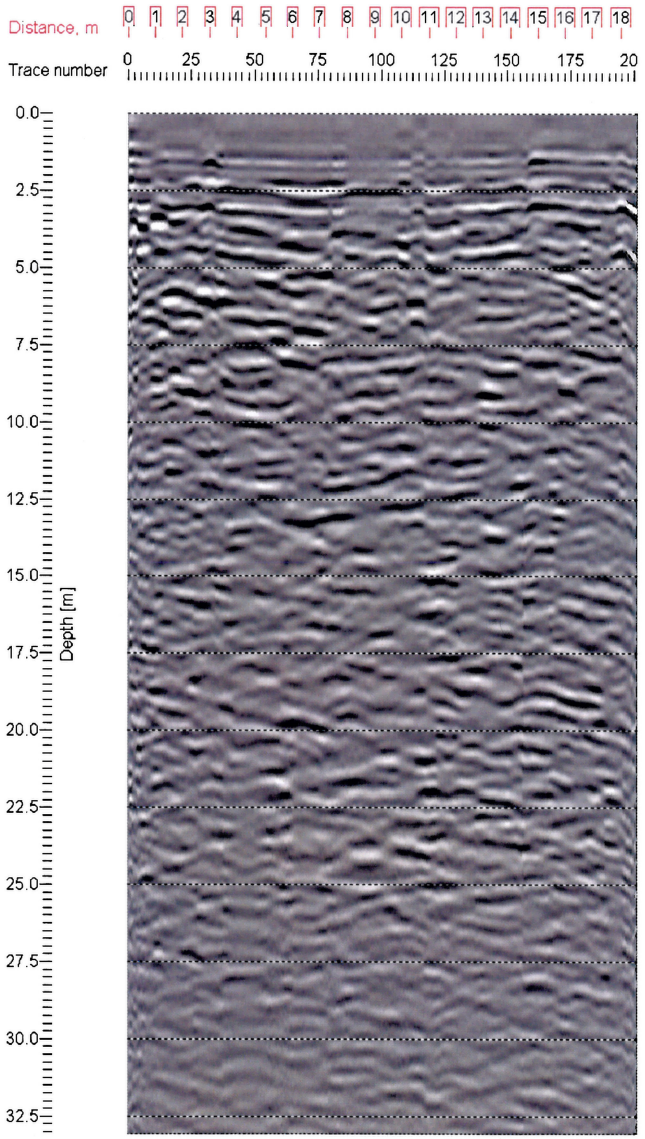
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-6
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



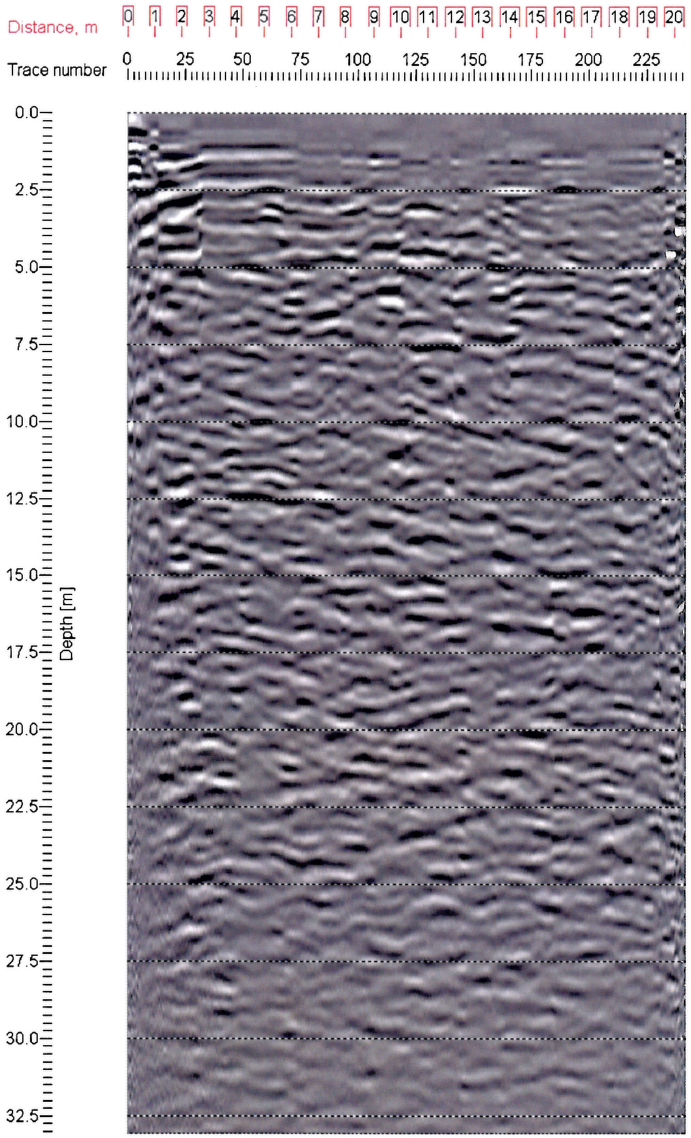
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-8
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



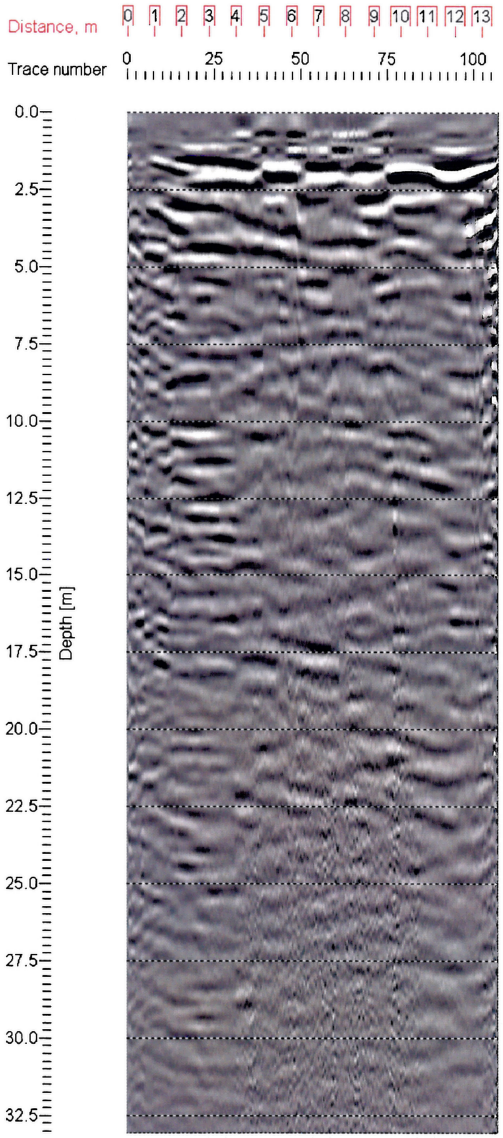
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-9
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



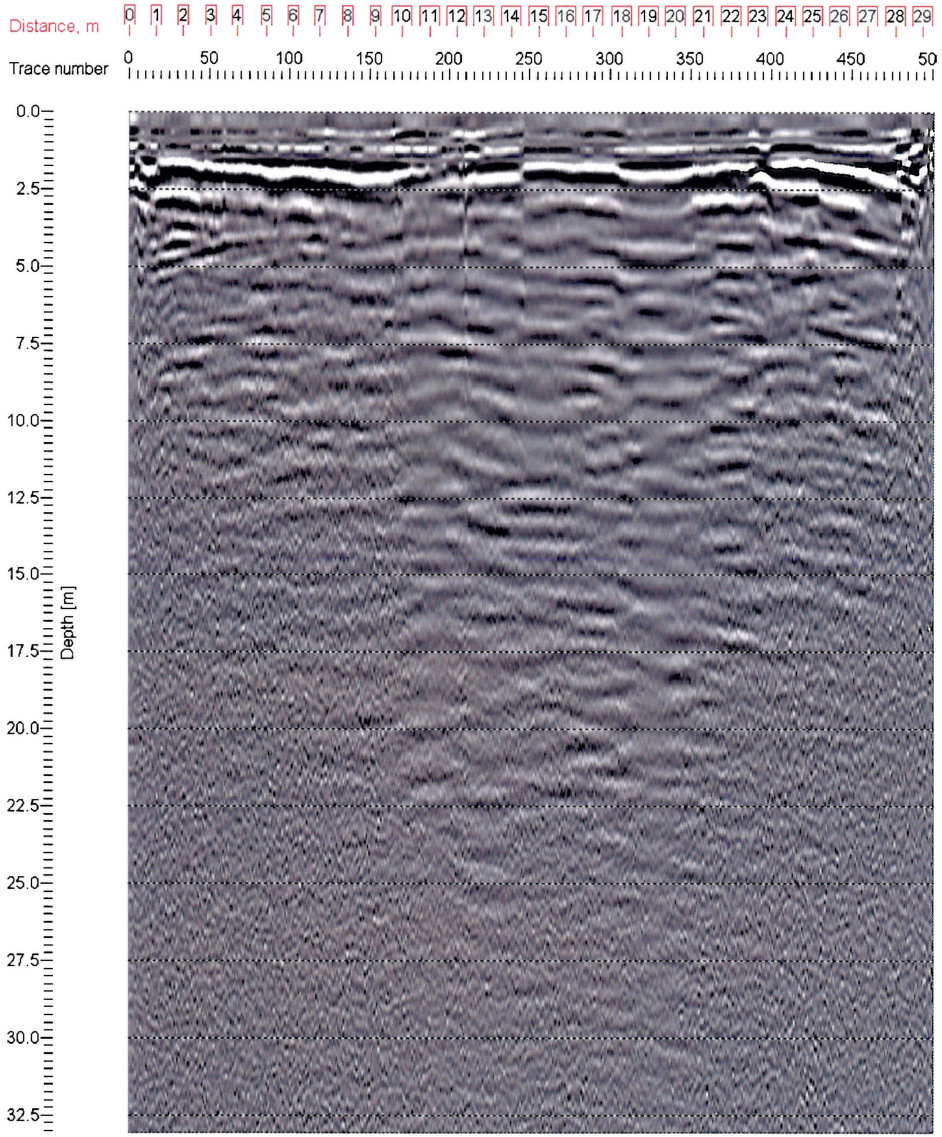
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-10
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	22 february 2008



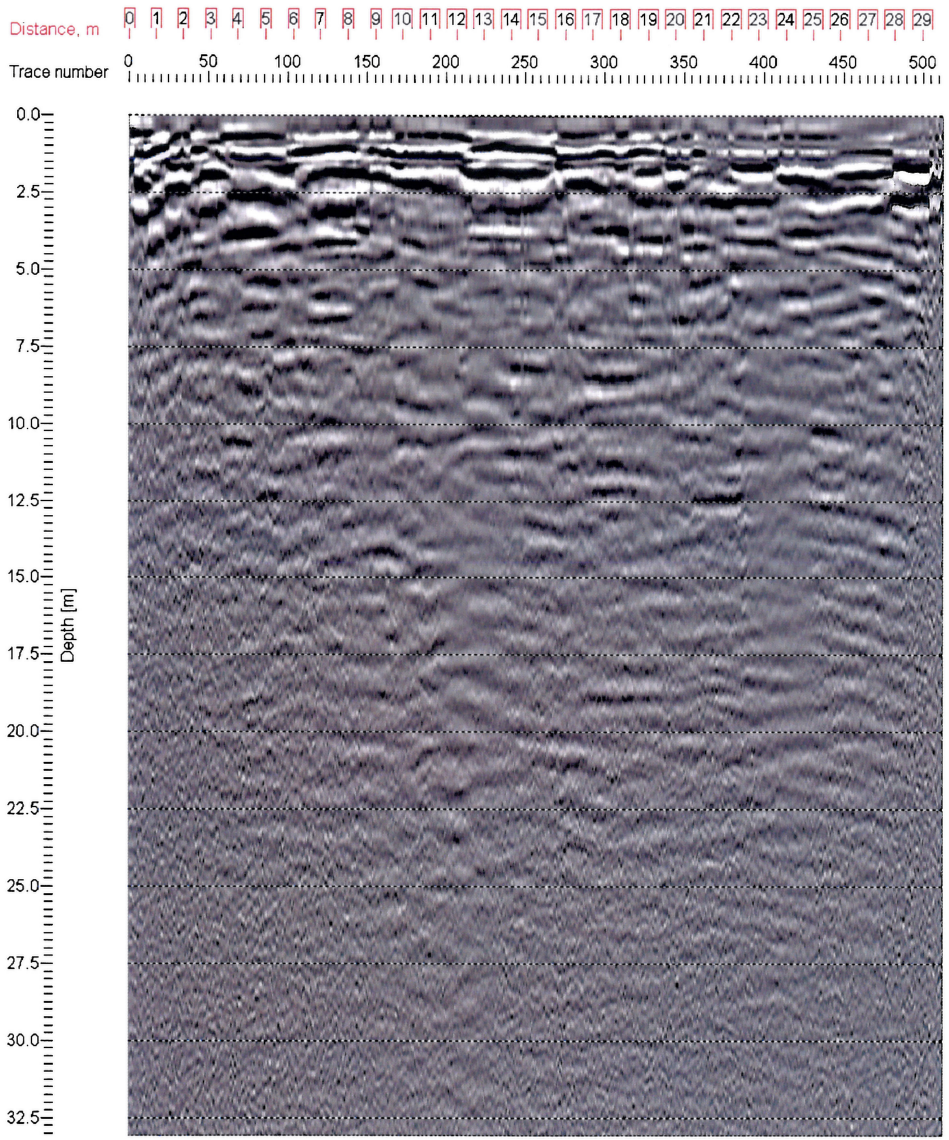
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-11
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



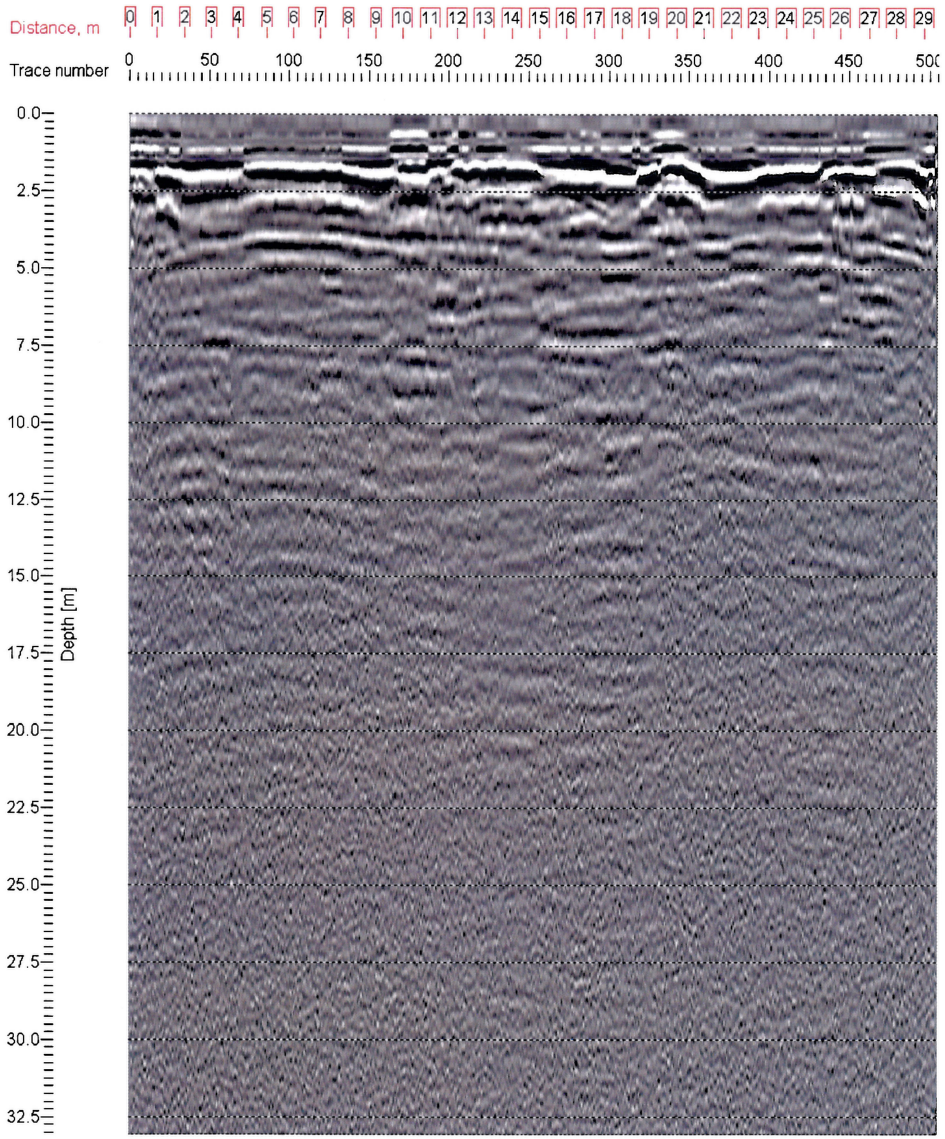
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-12
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



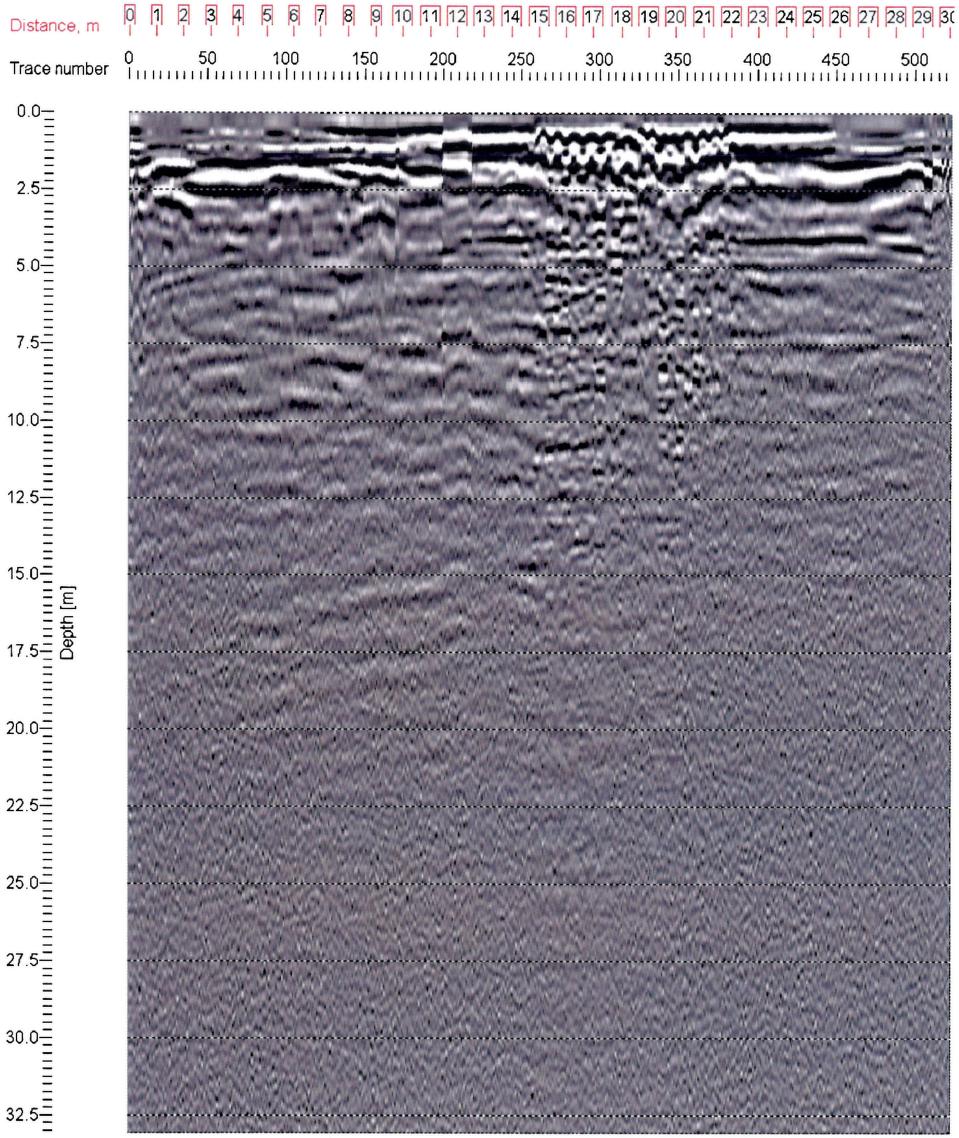
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-13
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



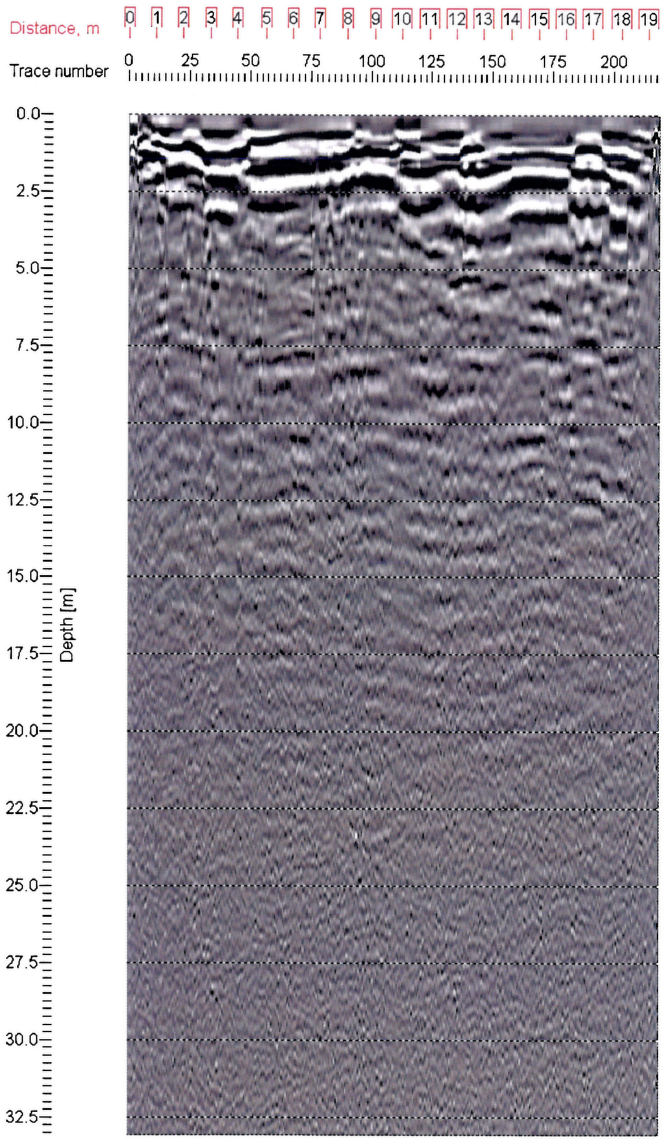
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-14
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



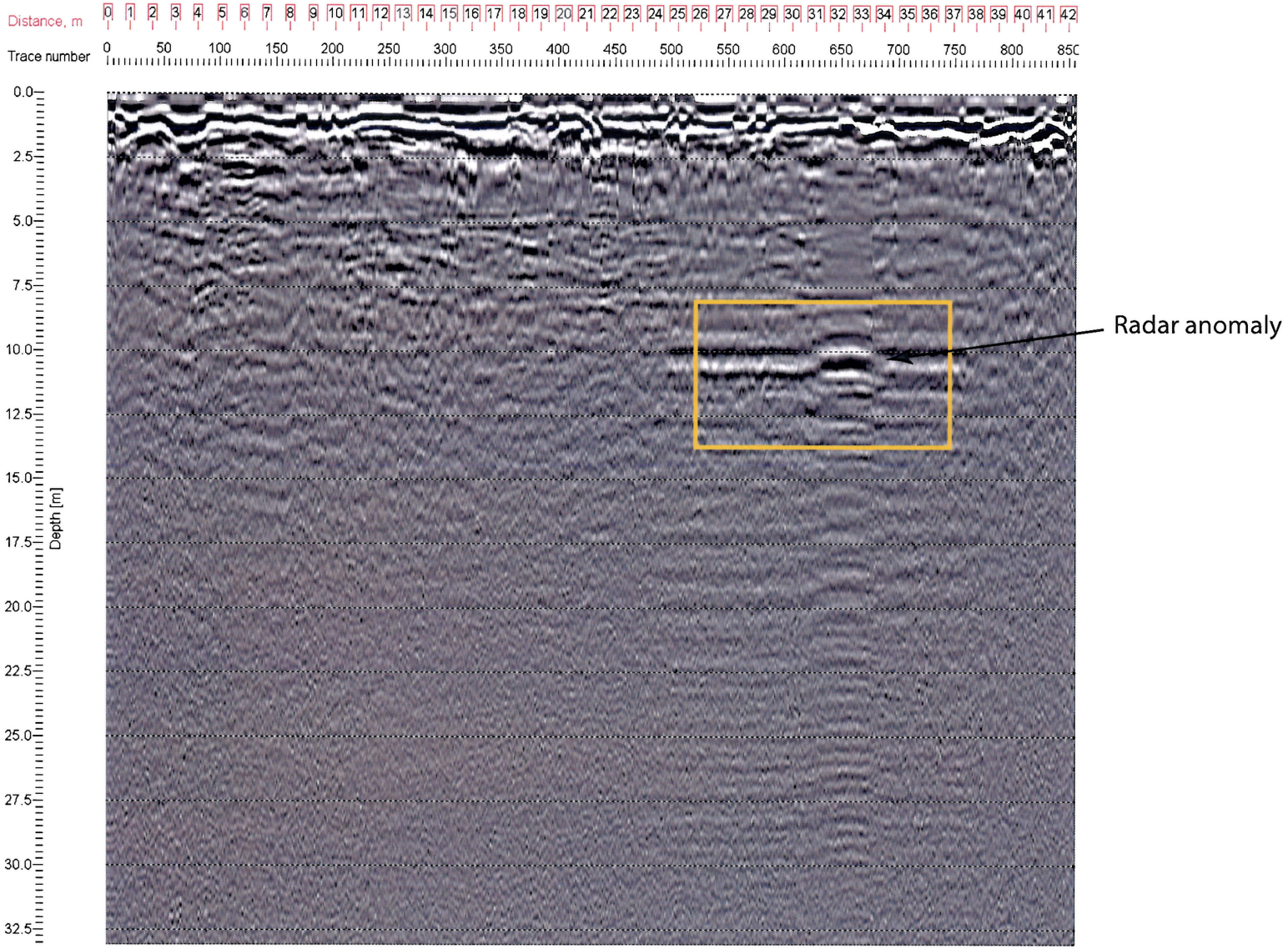
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-15
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



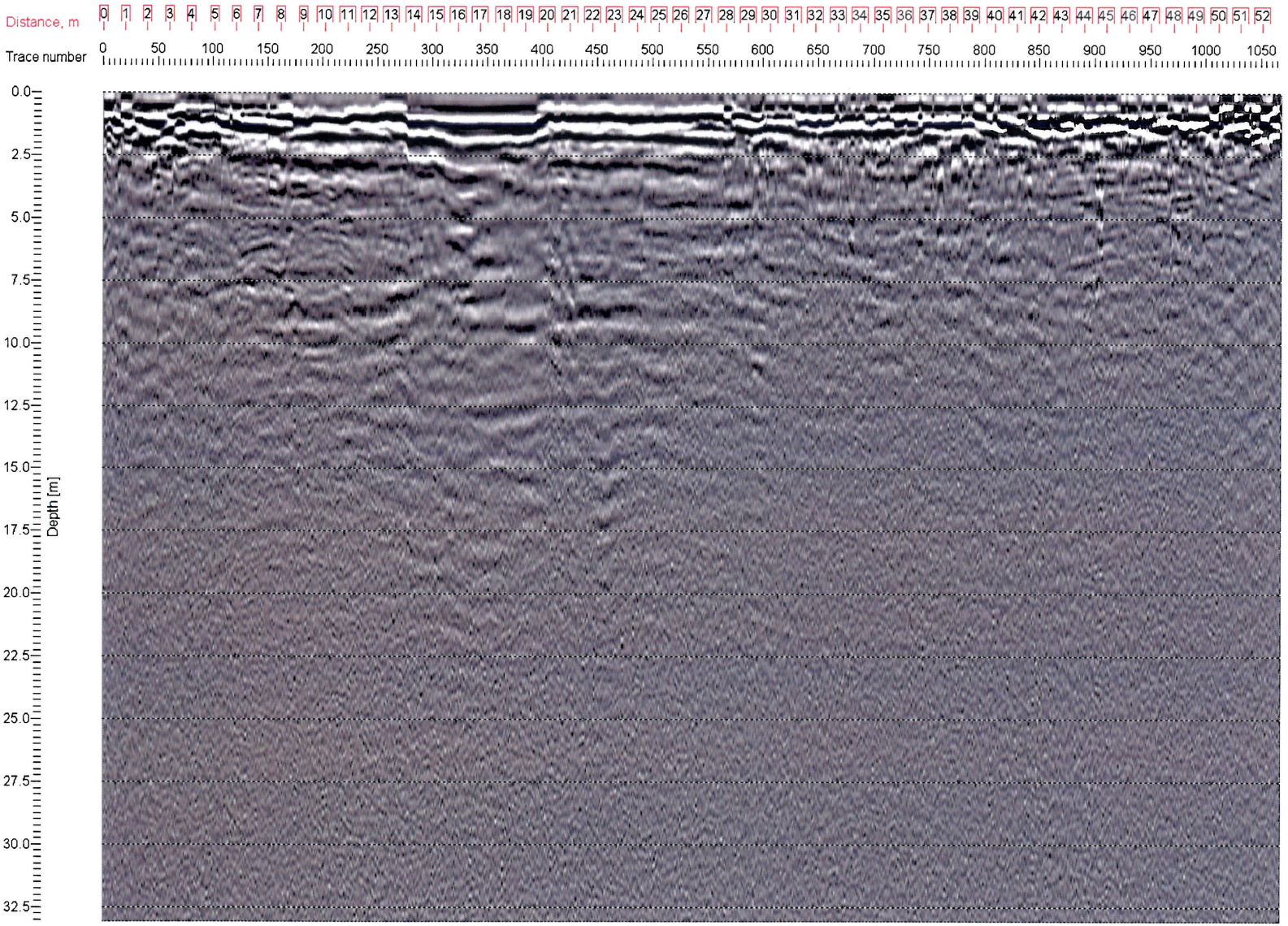
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-16
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



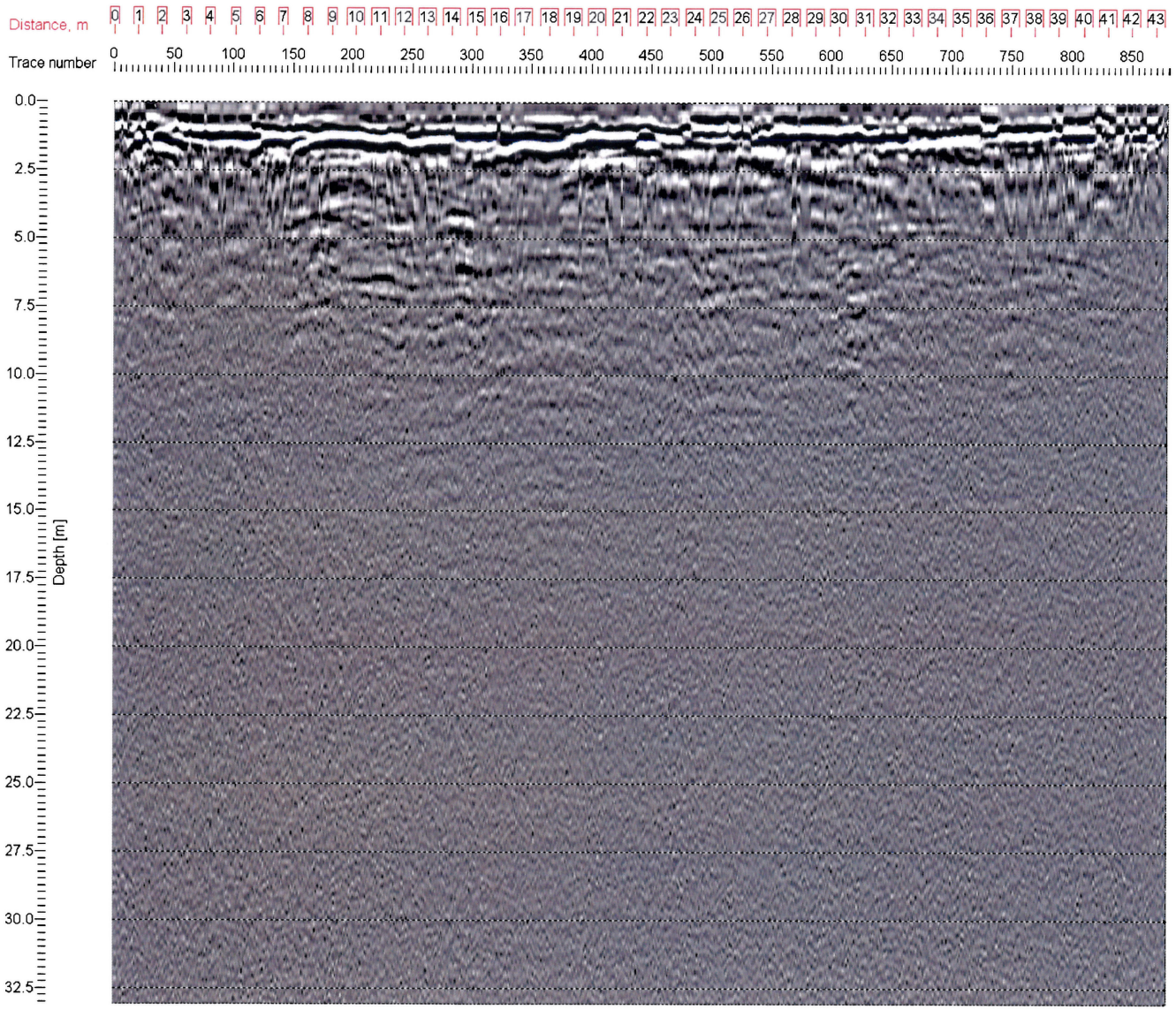
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-17
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



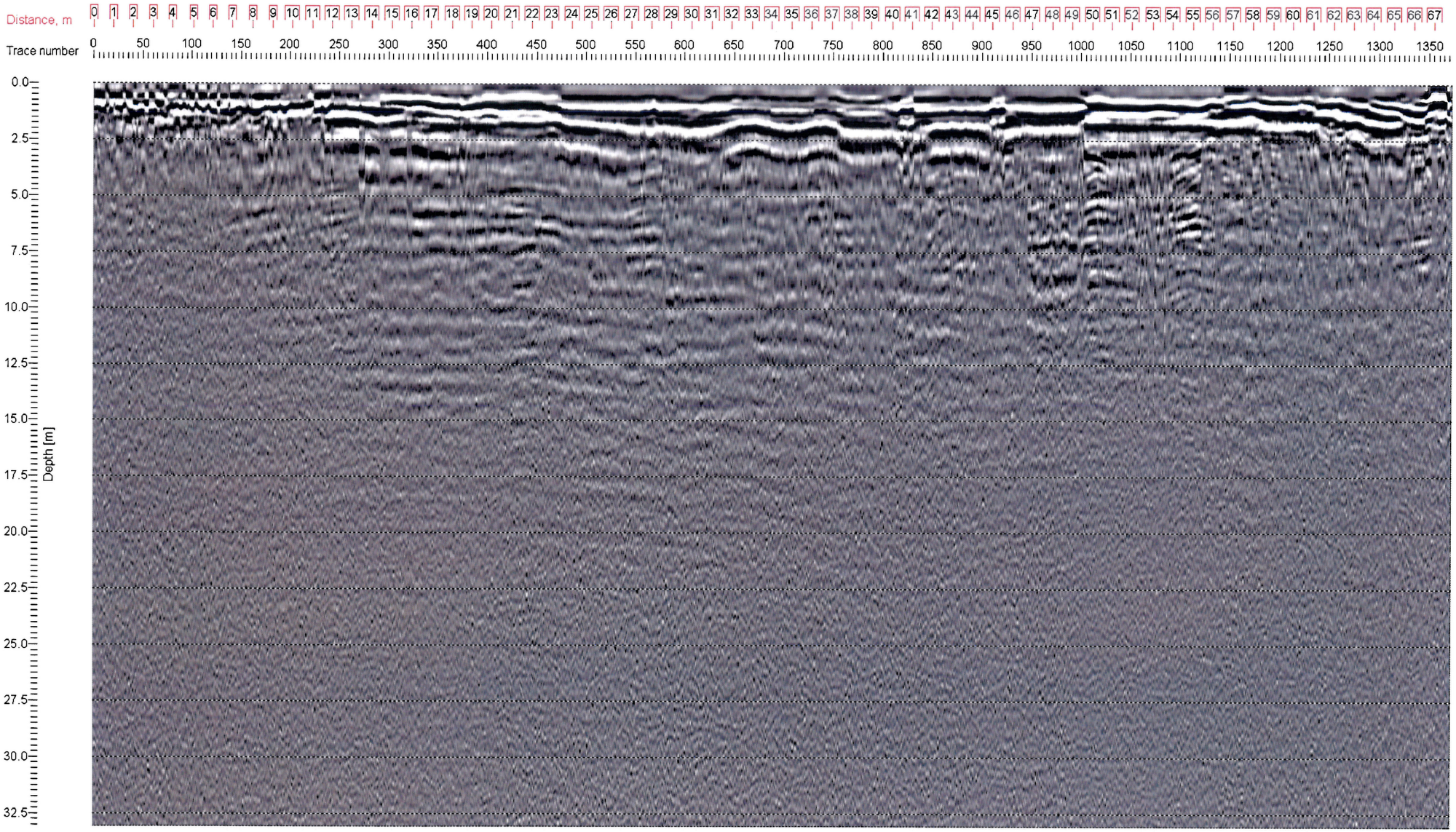
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-18
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



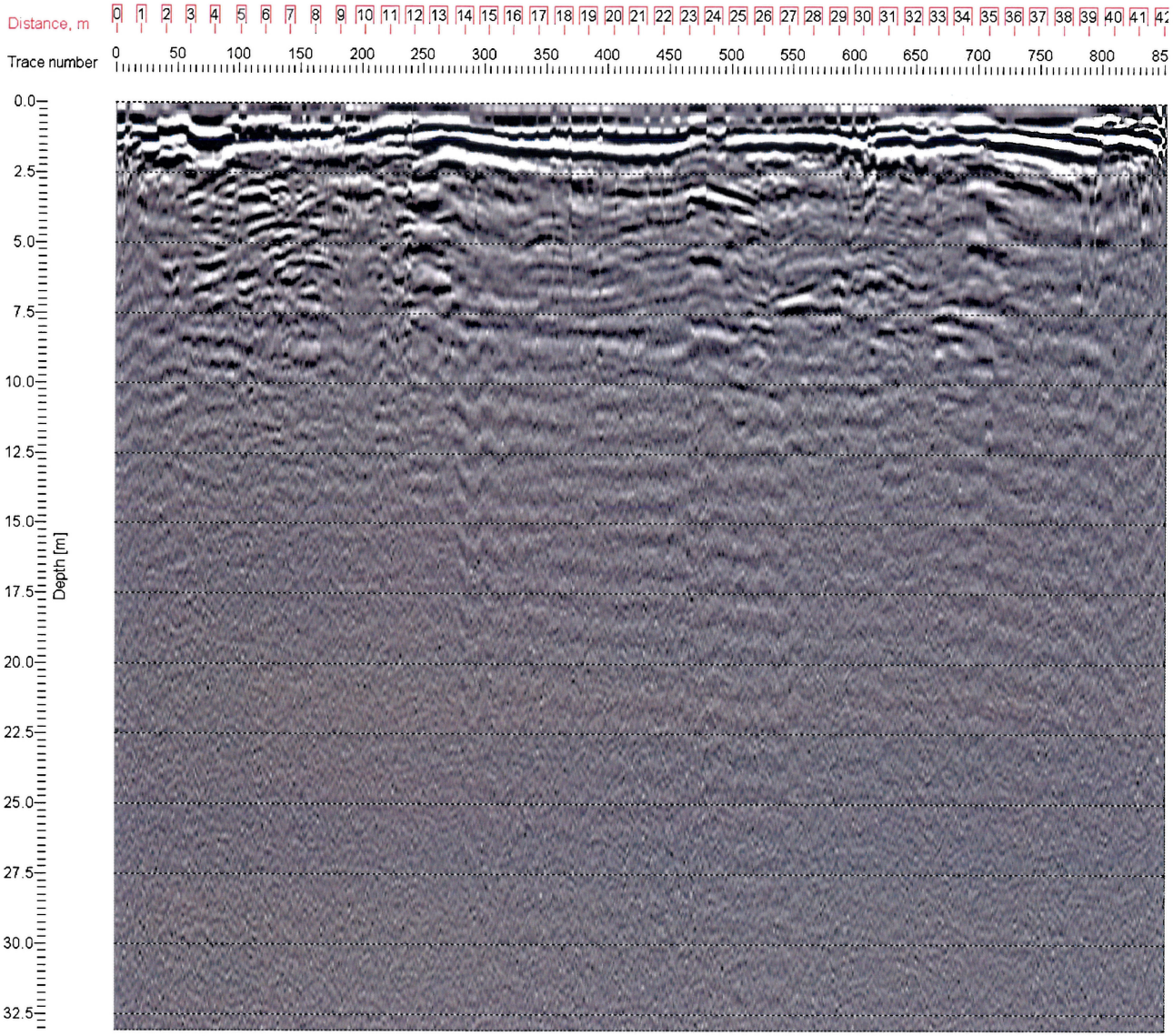
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-19
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



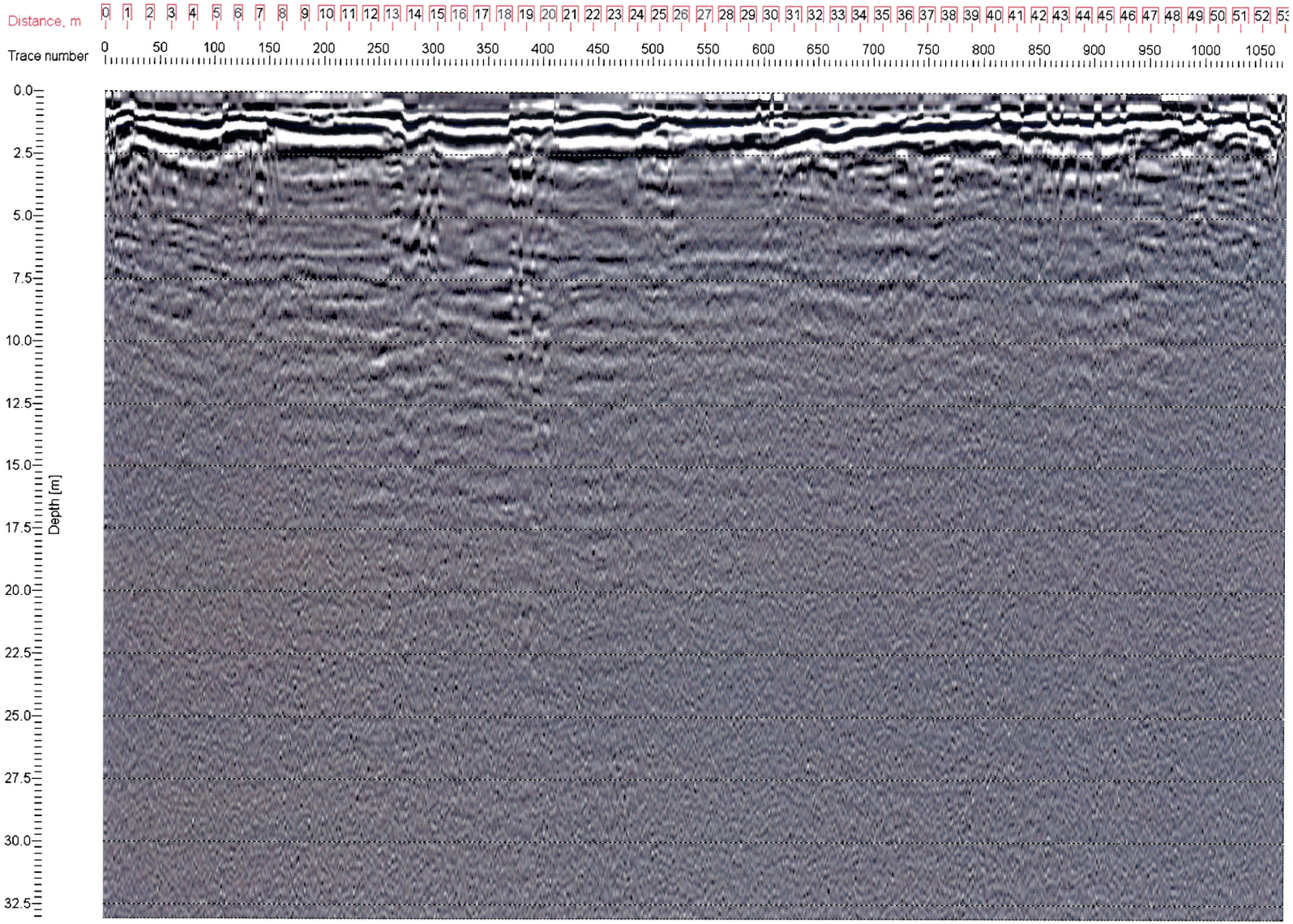
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-20
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



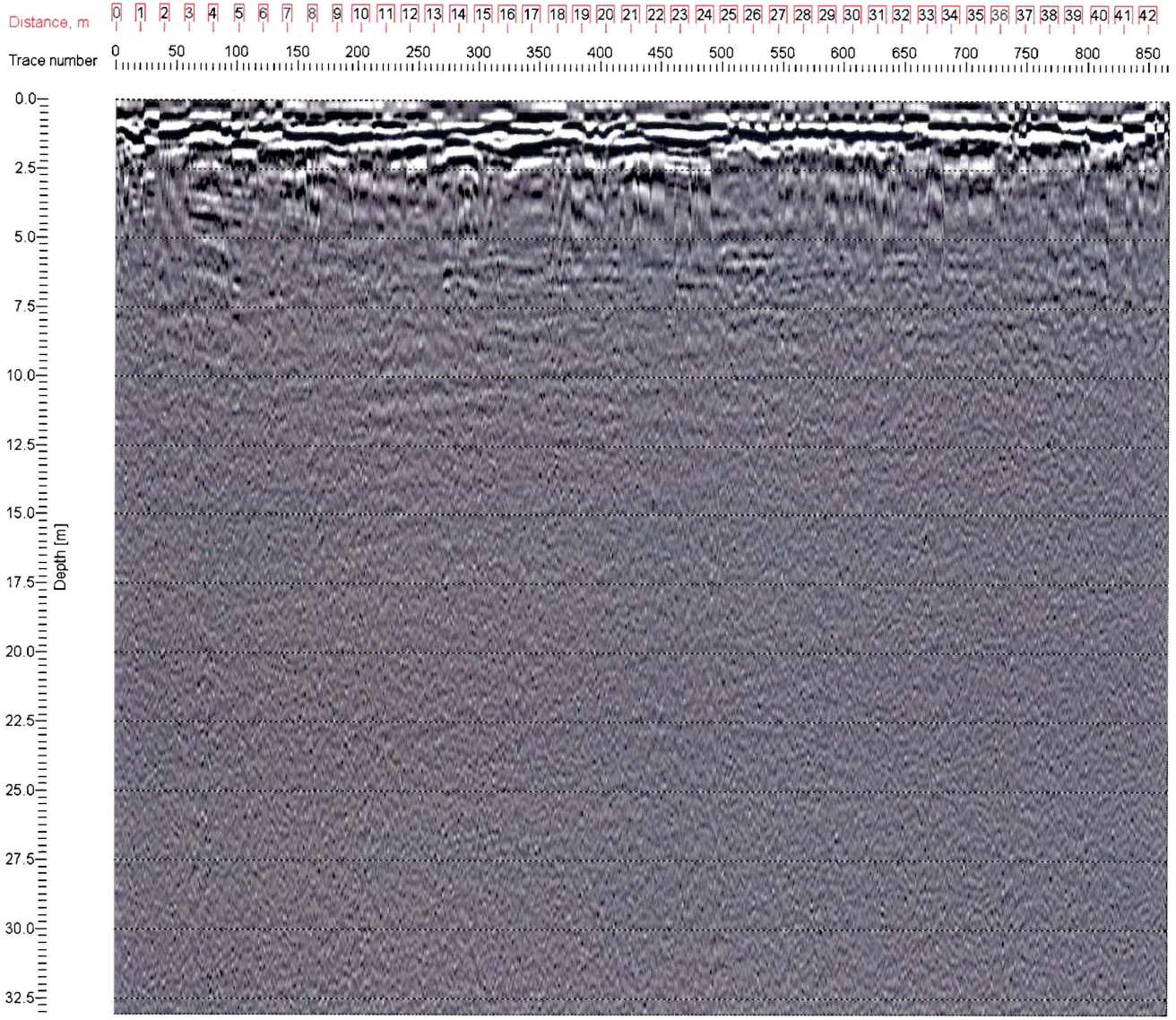
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-21
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



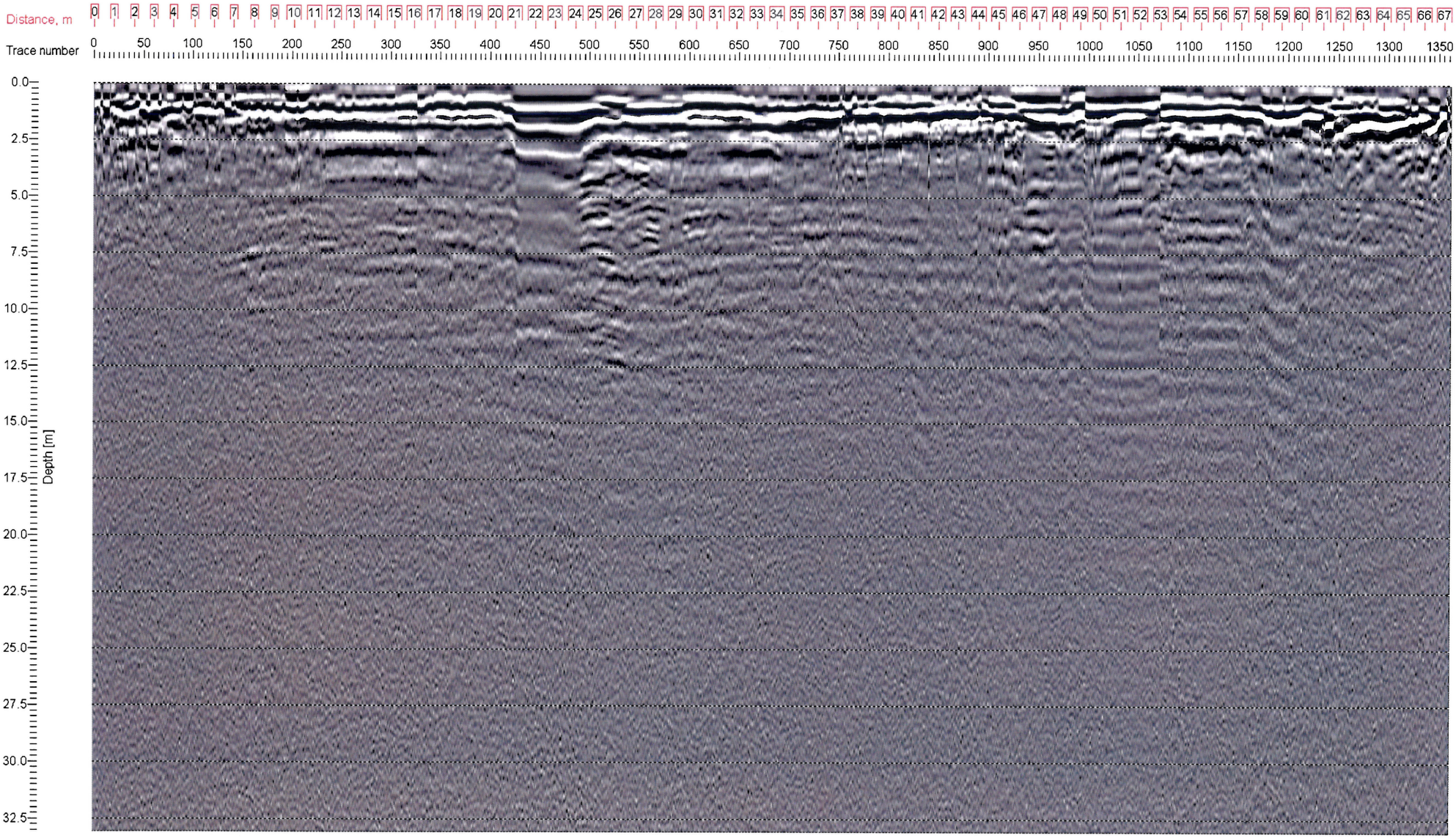
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-22
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



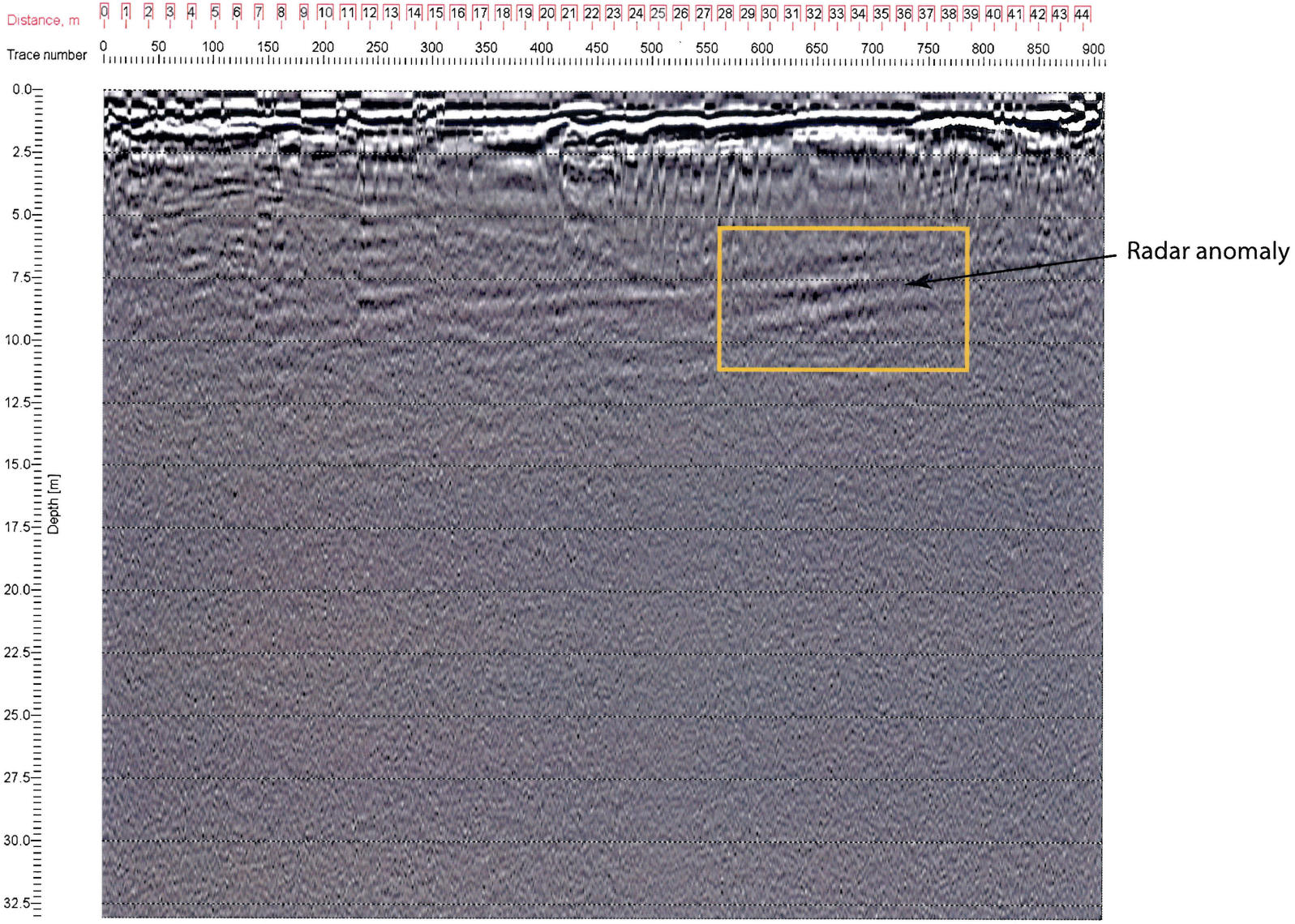
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-23
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



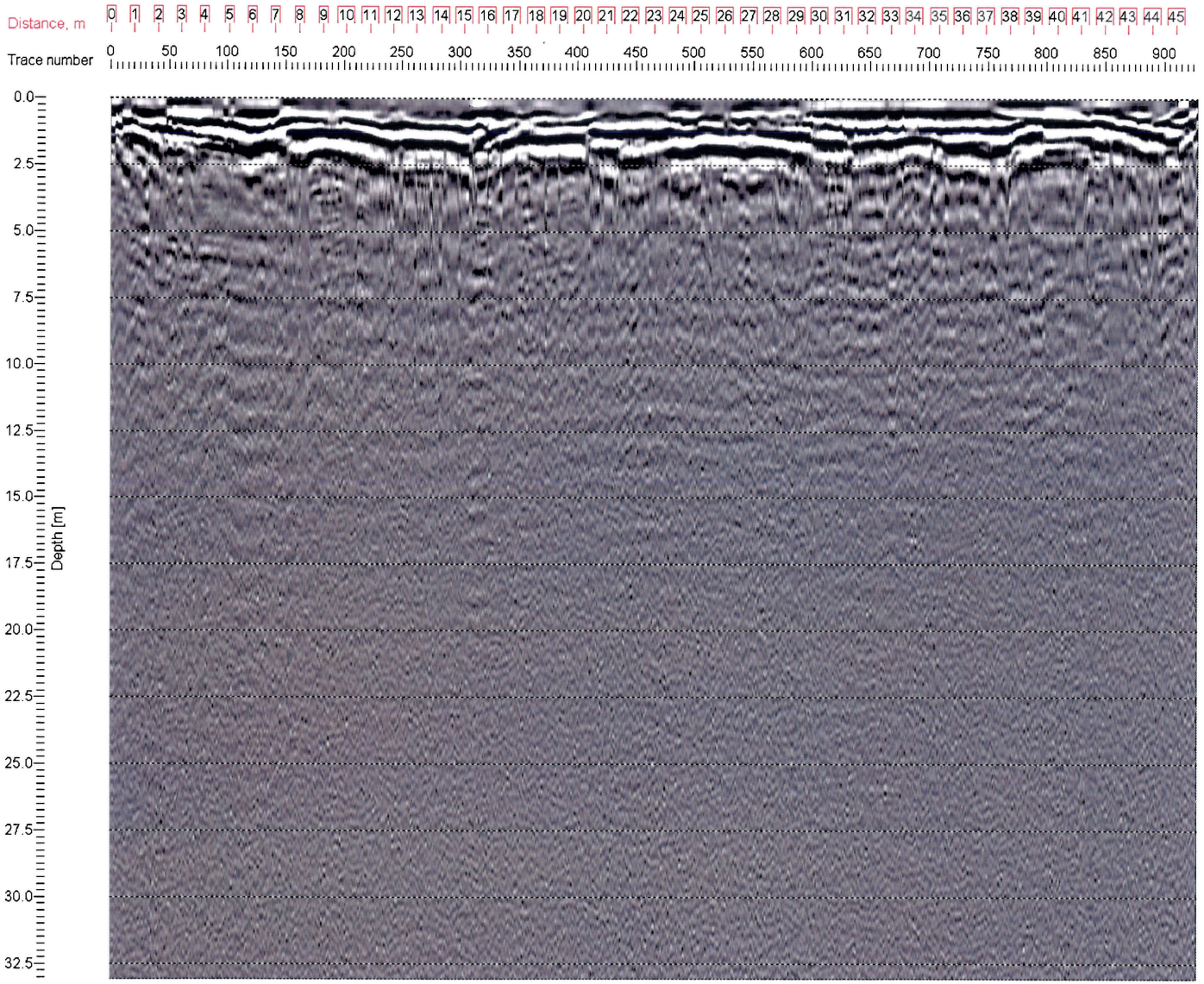
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-24
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



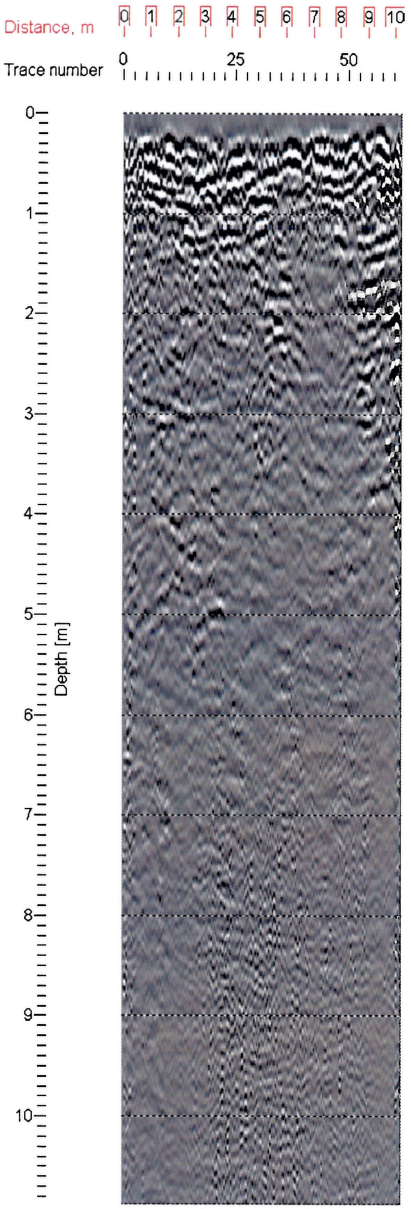
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-25
Antenna type:	100 MHz
Distance between antennas:	0,50 m
Date:	20 february 2008



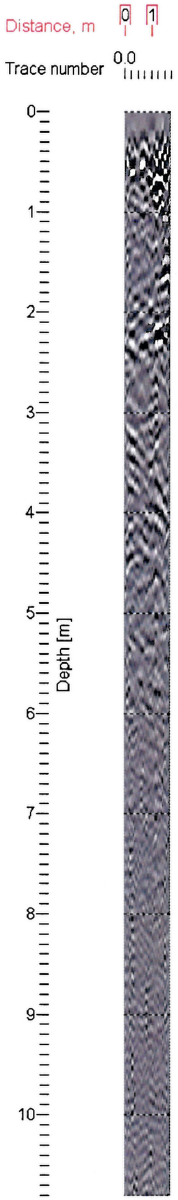
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-1
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



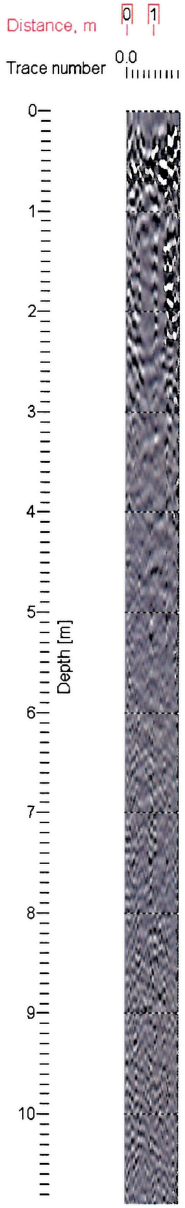
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-2
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



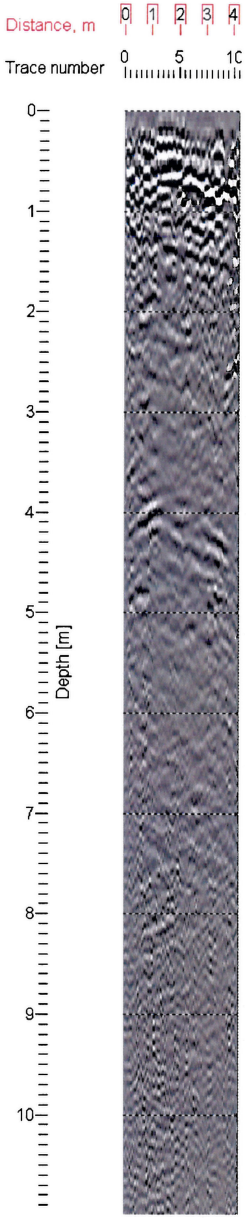
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-3
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



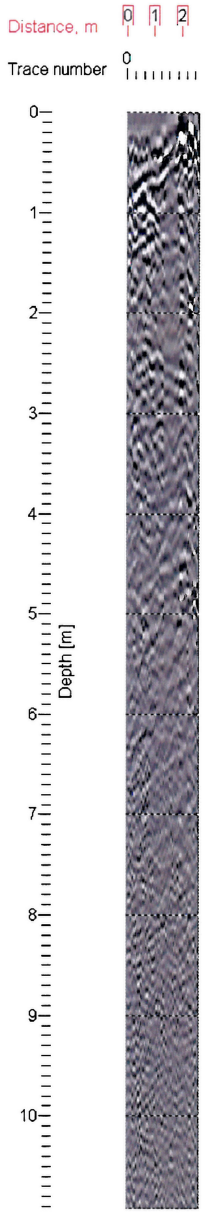
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-4
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



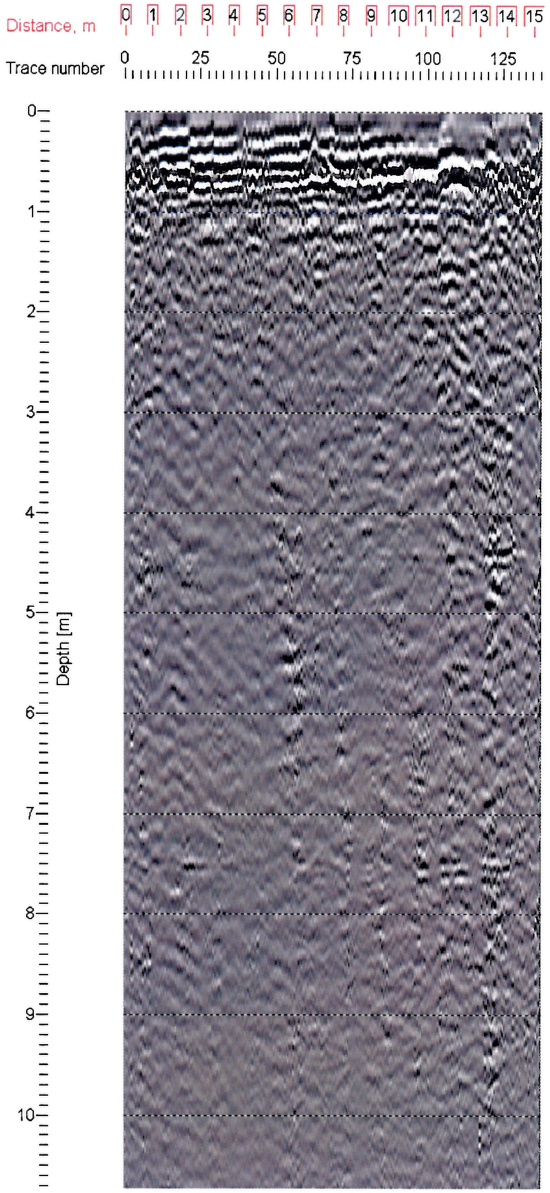
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-5
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



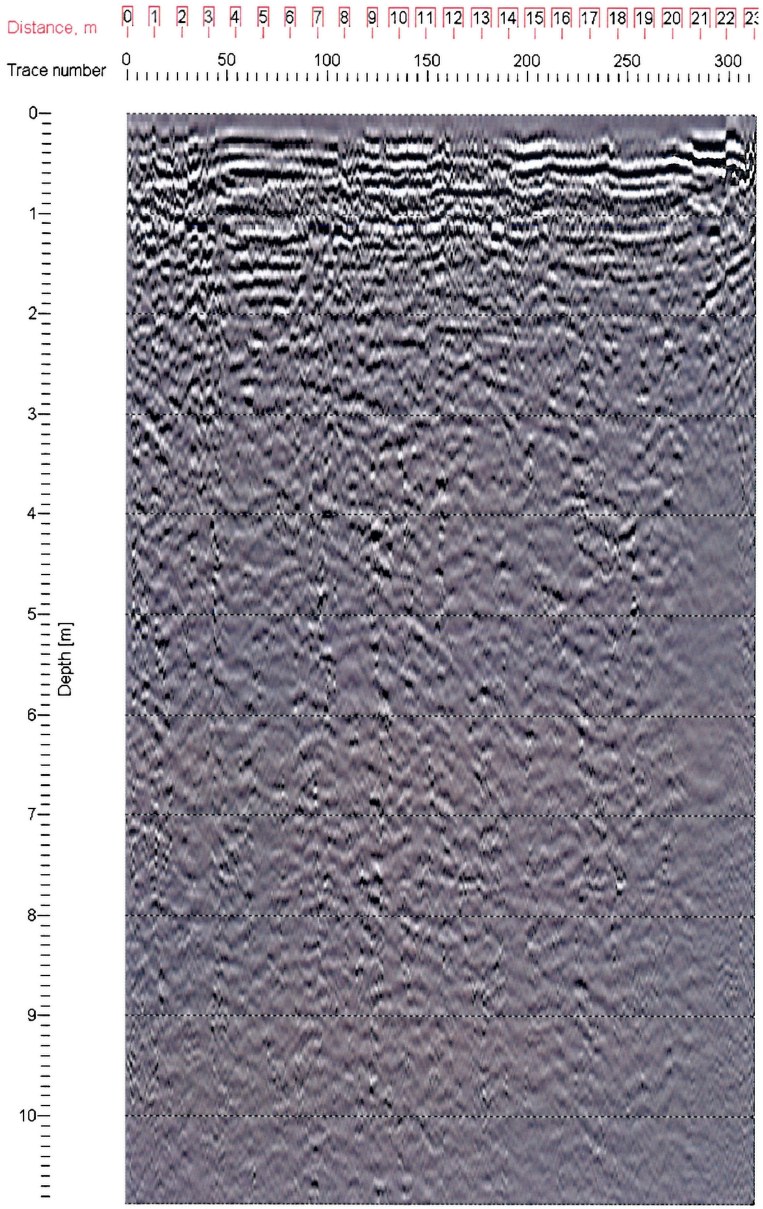
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-6
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



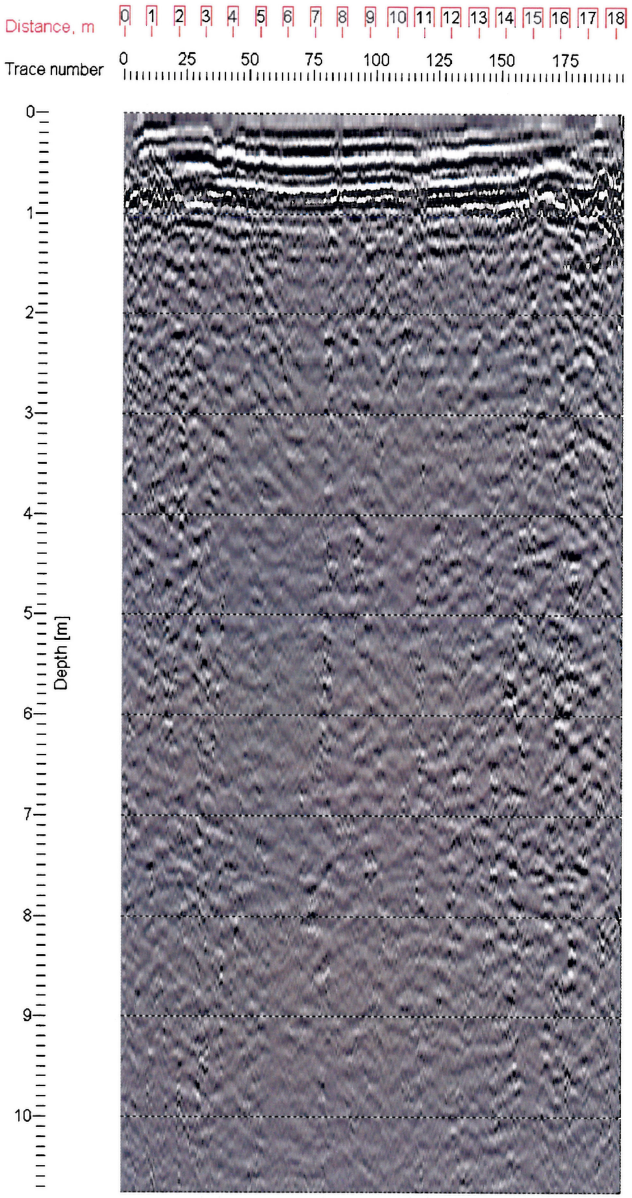
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-7
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



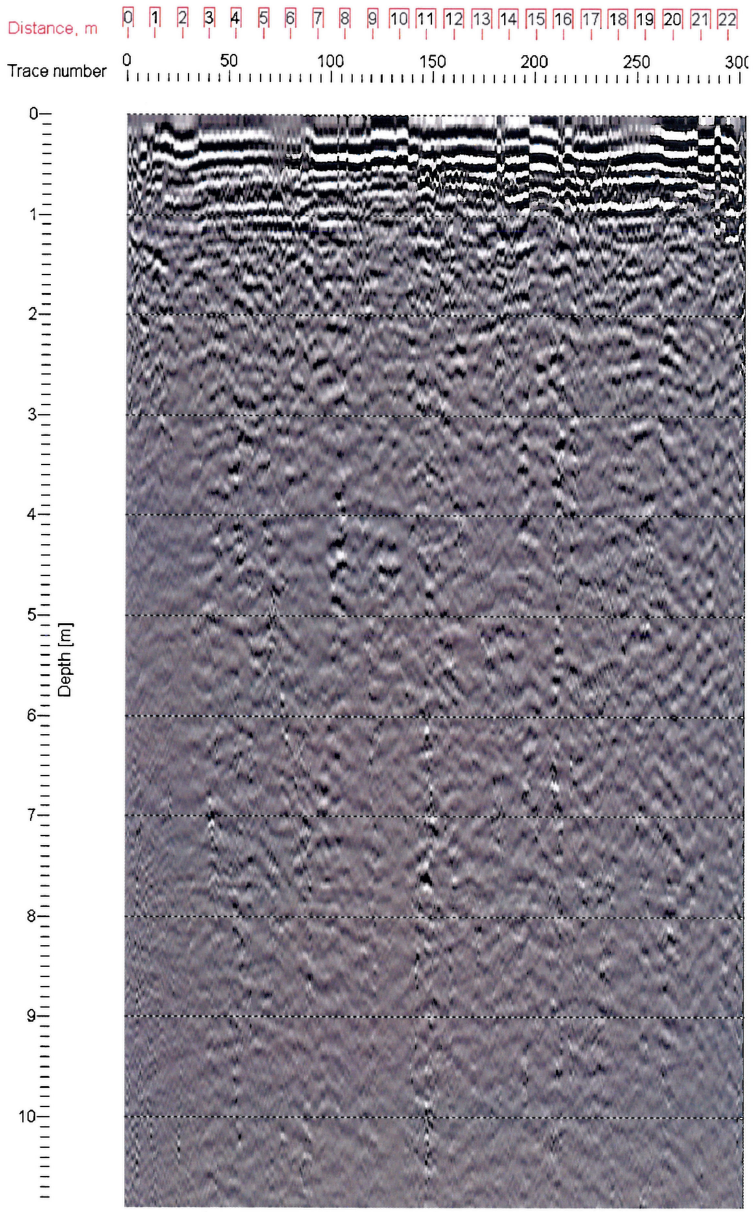
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-8
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



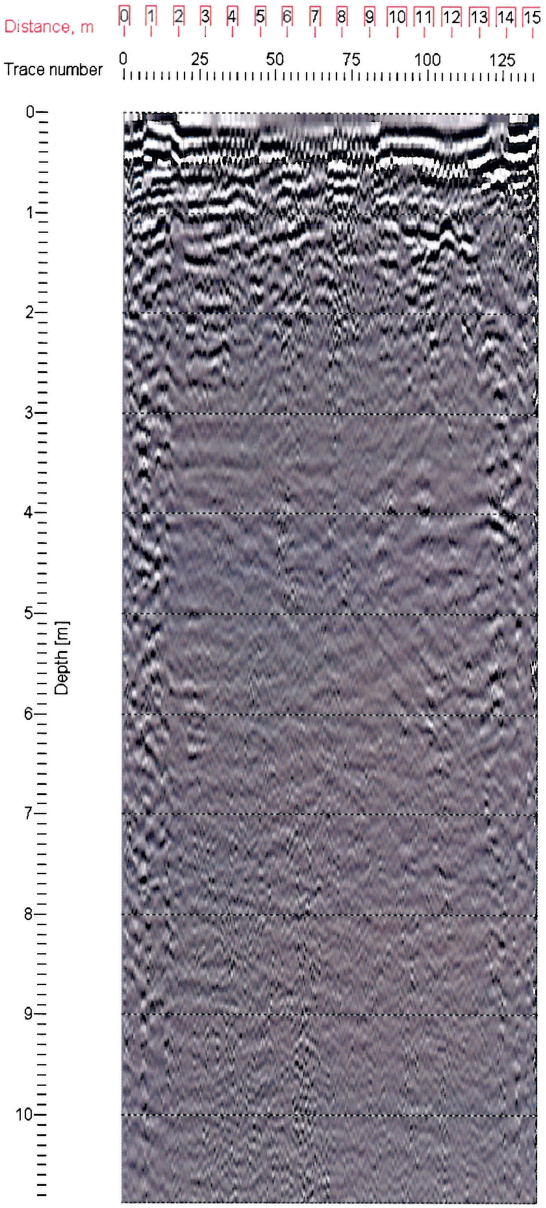
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-9
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



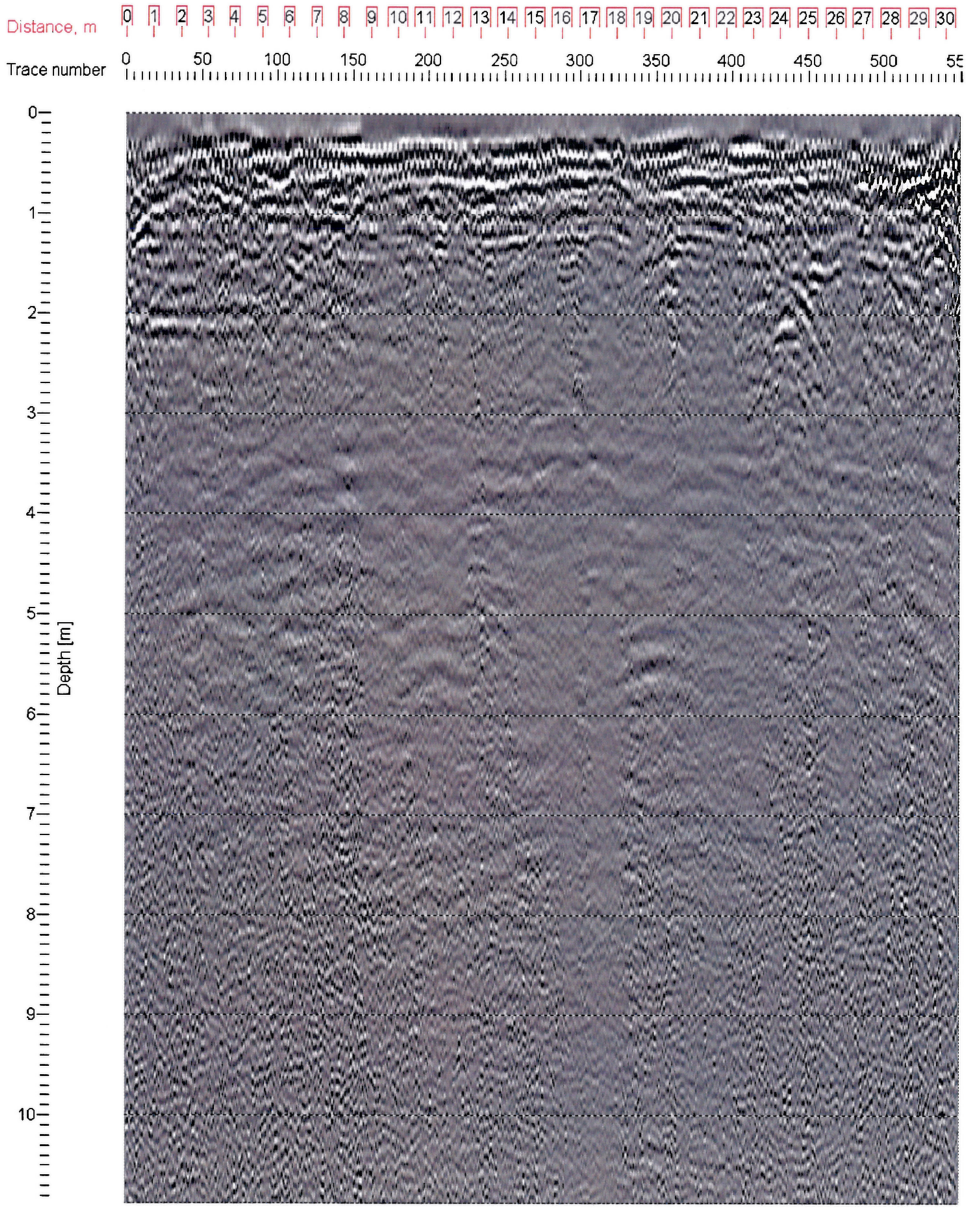
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-10
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



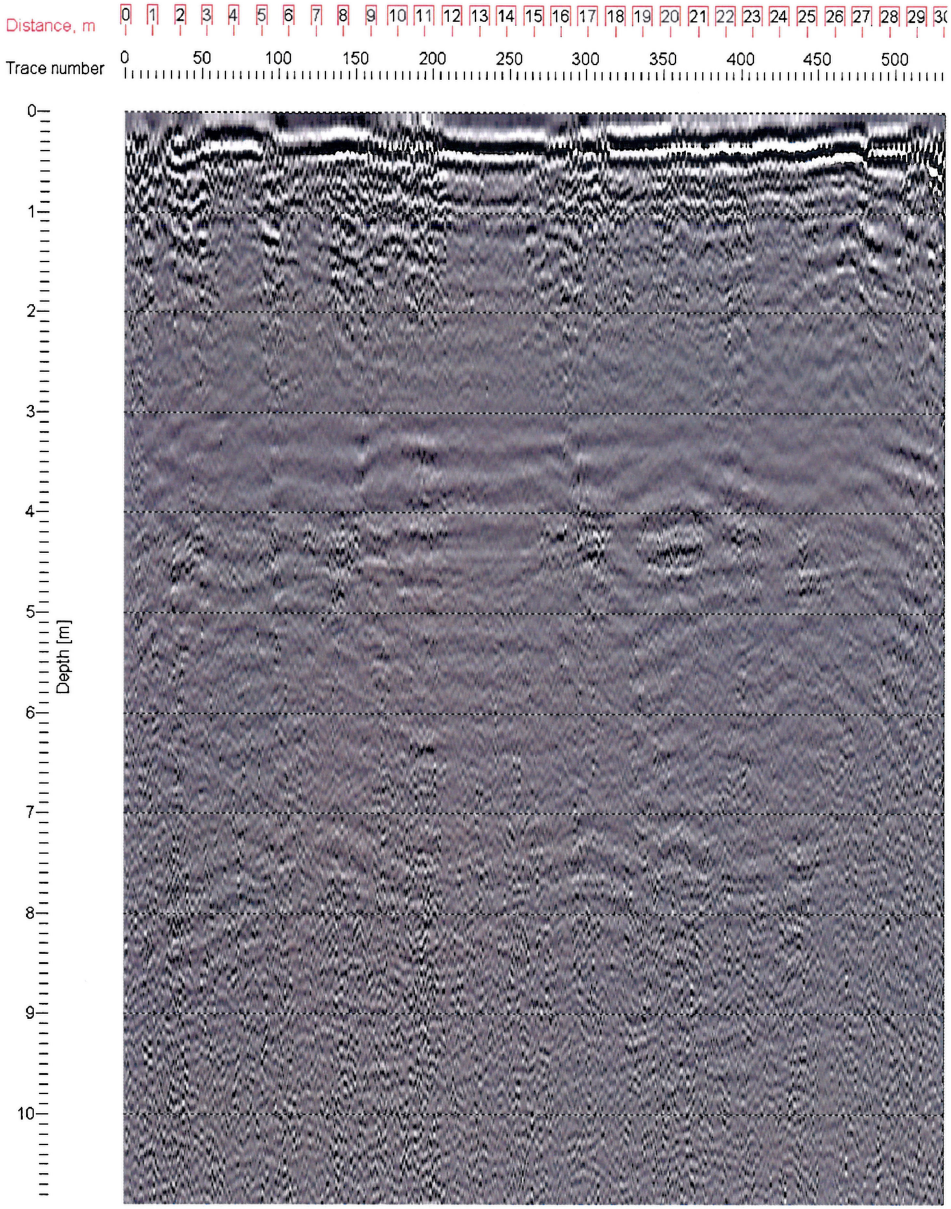
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-11
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	19 february 2008



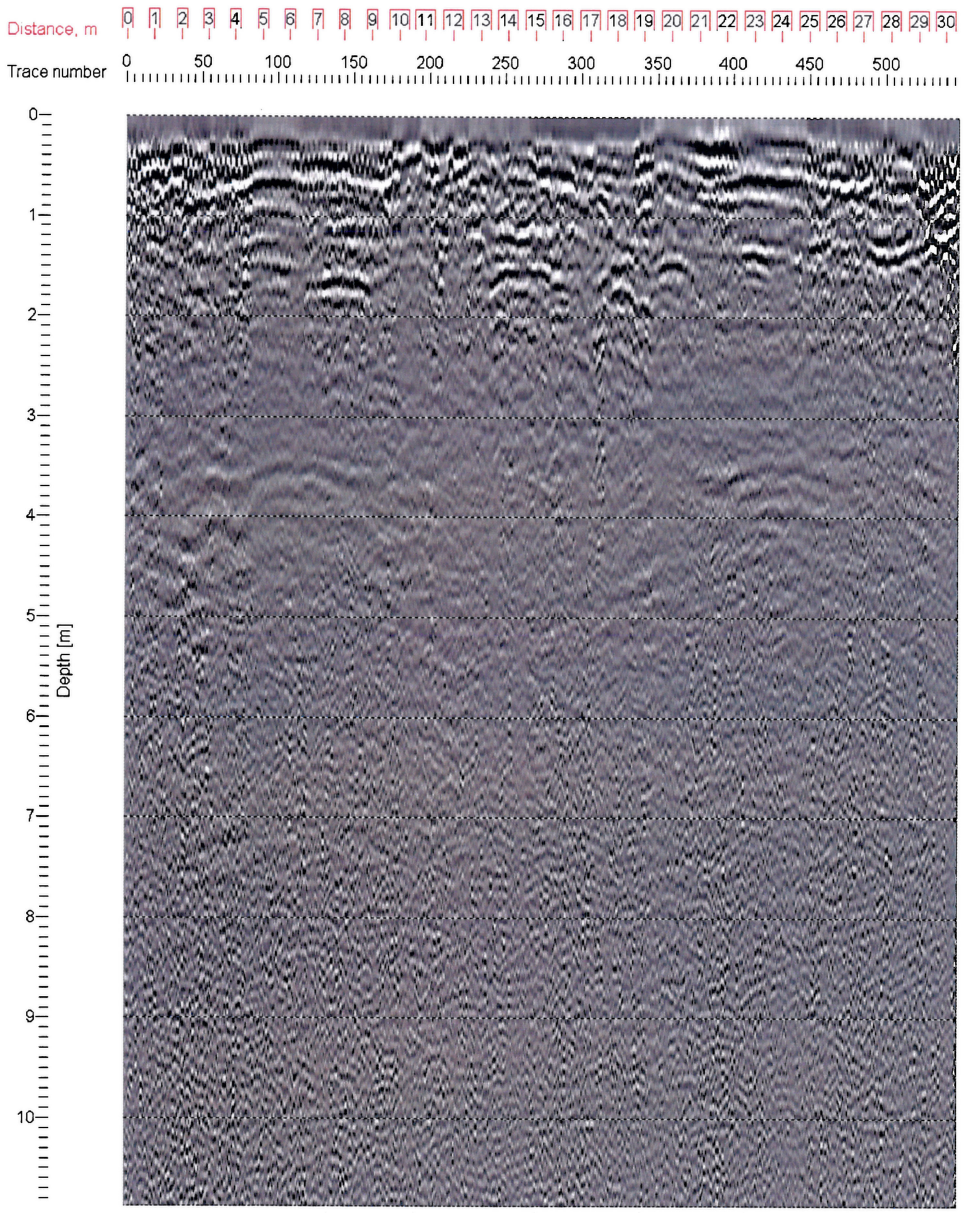
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-12
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



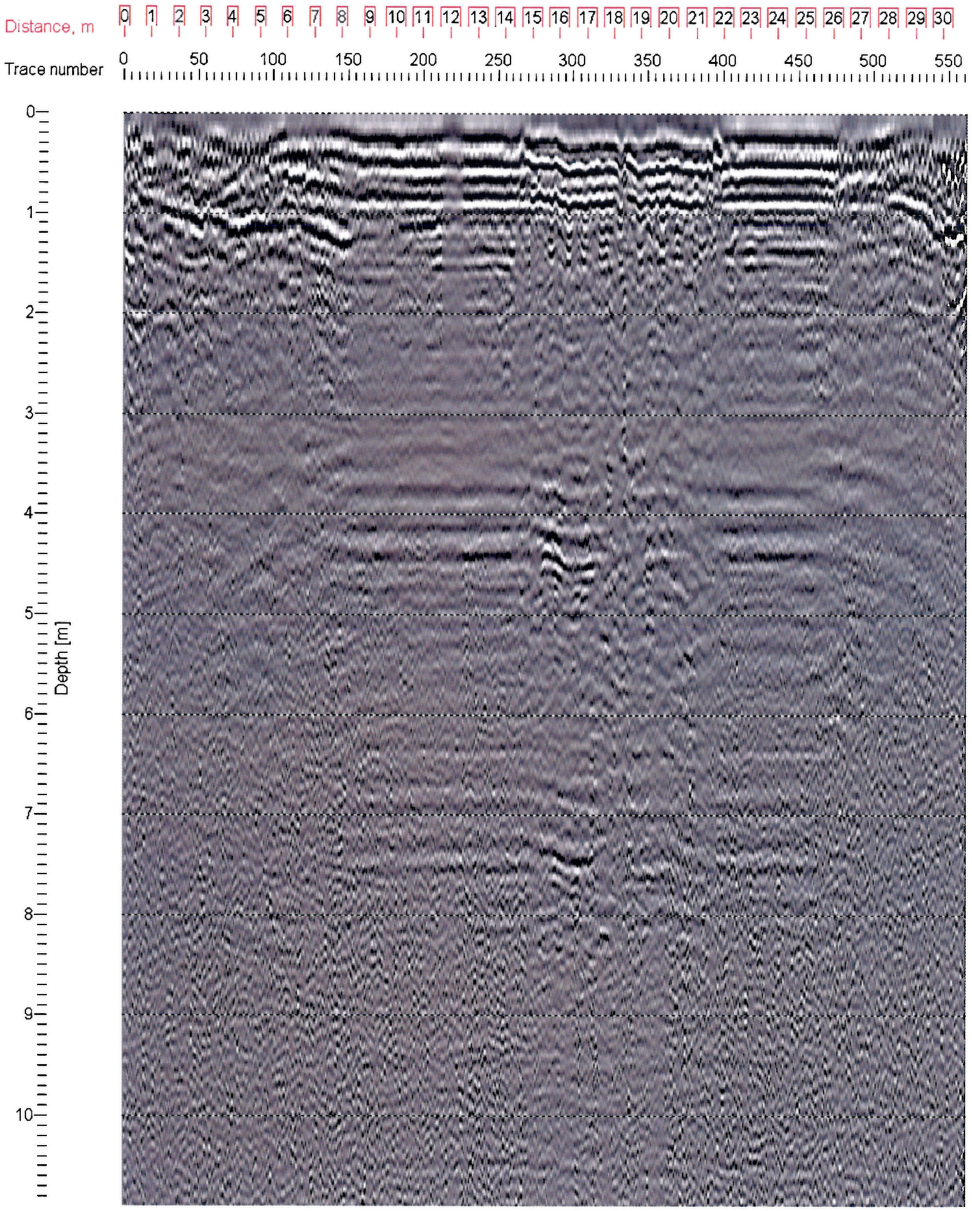
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-13
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



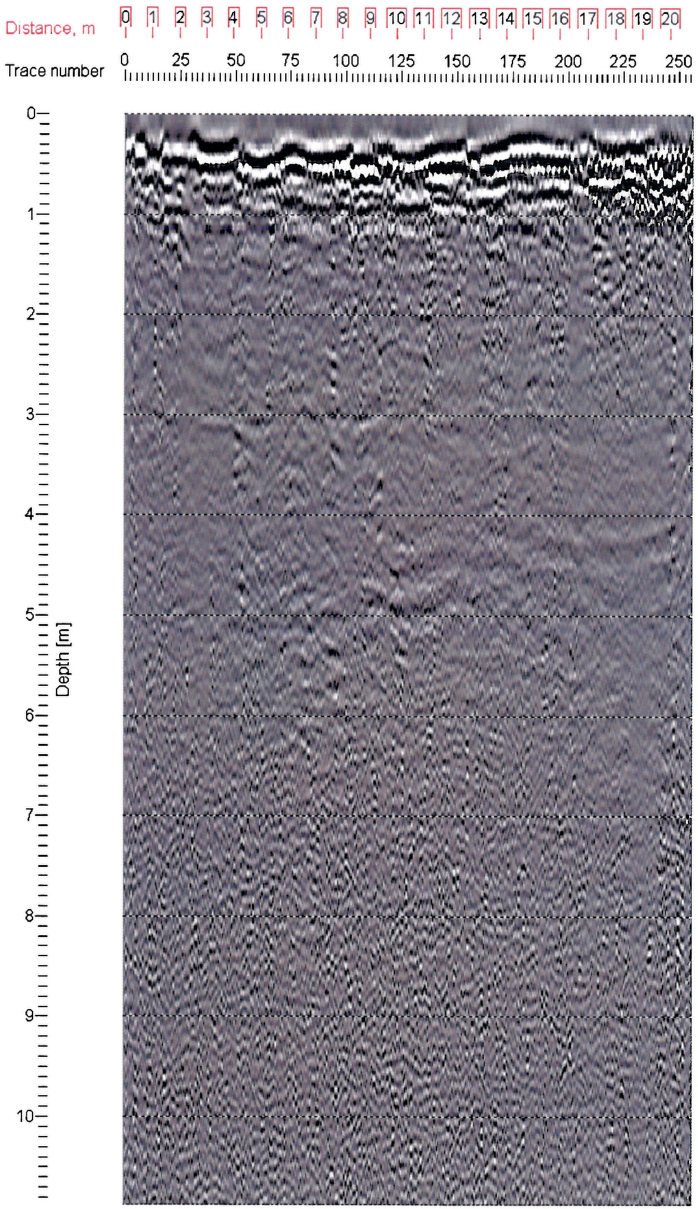
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-14
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



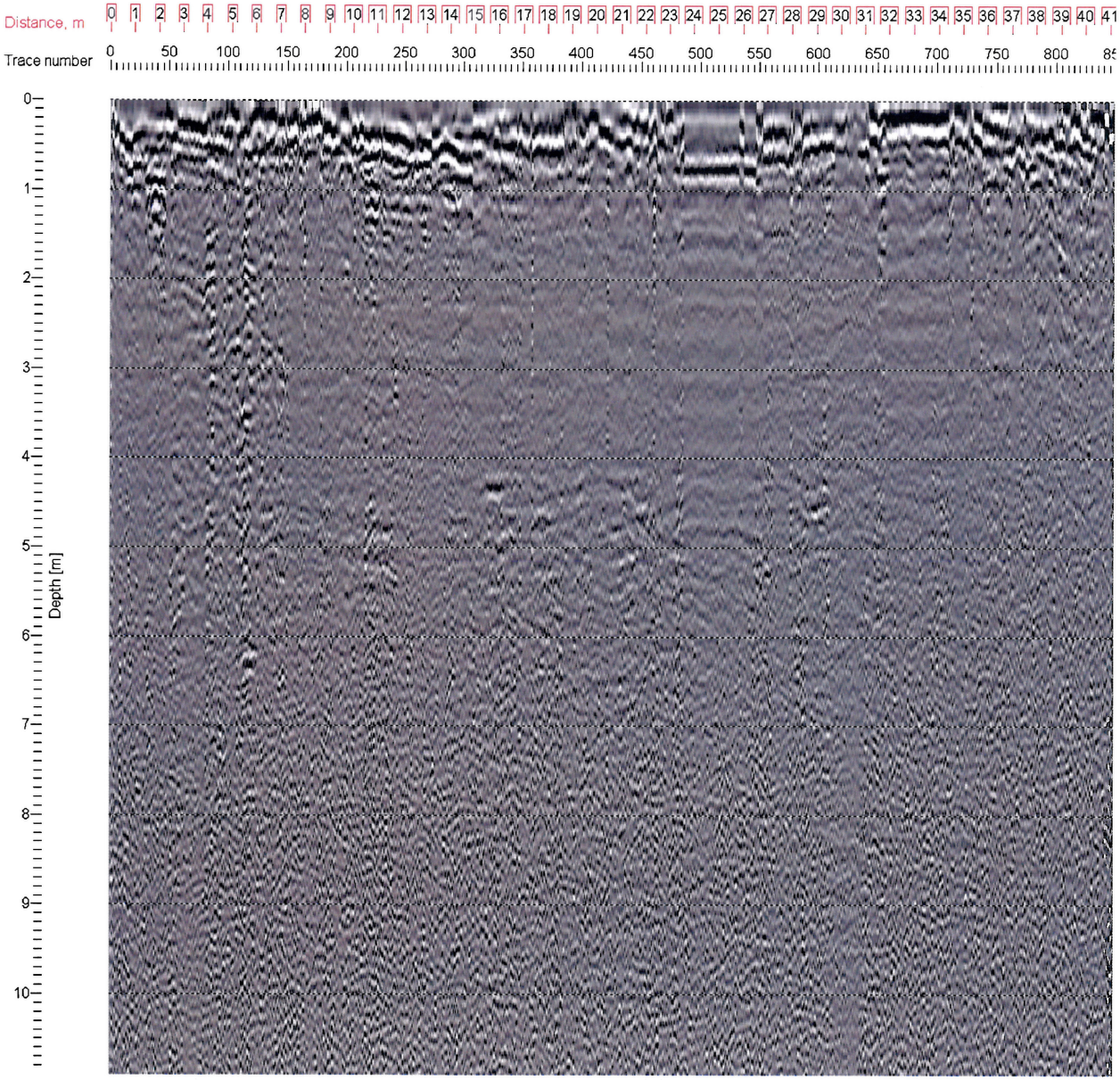
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-15
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



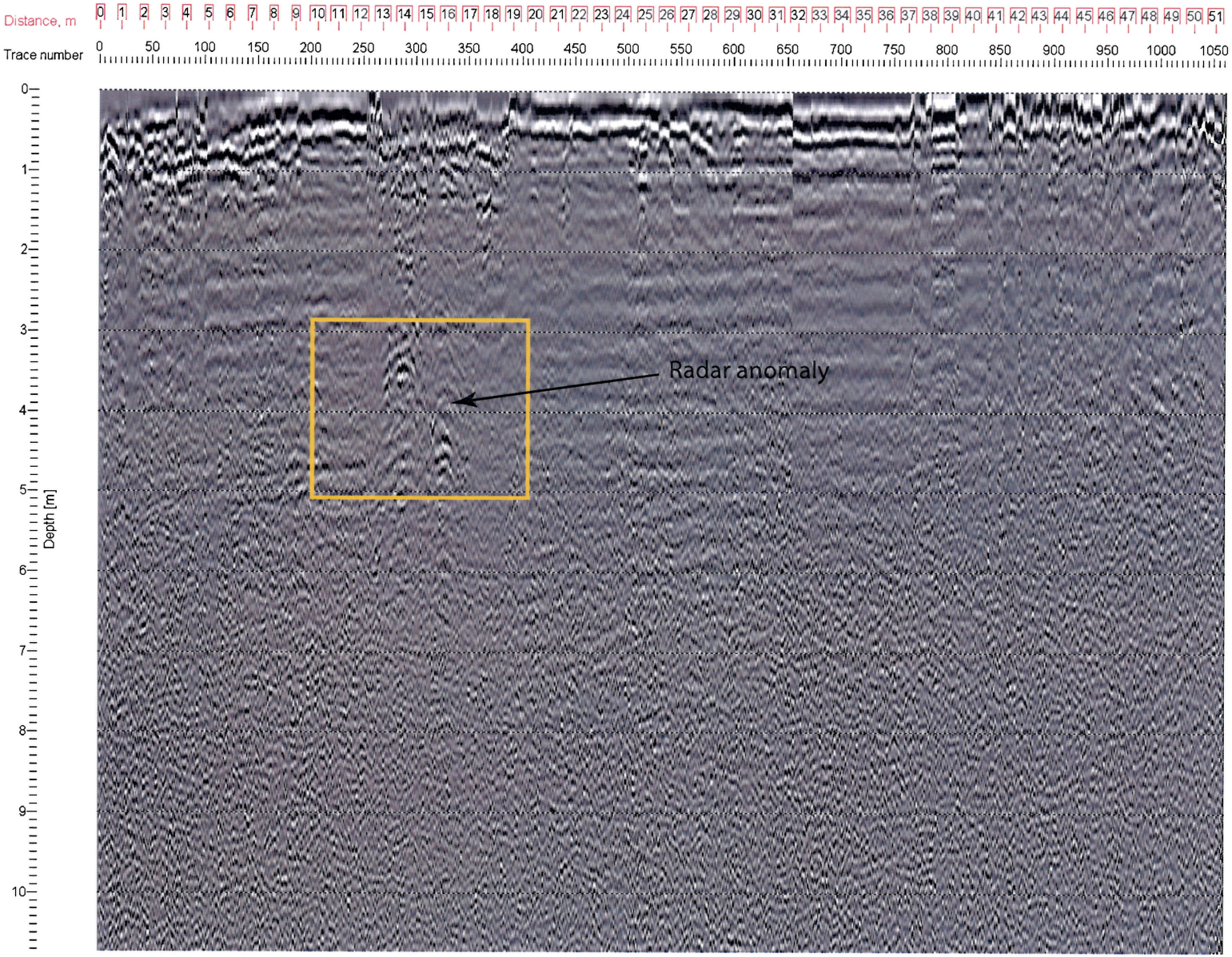
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-16
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



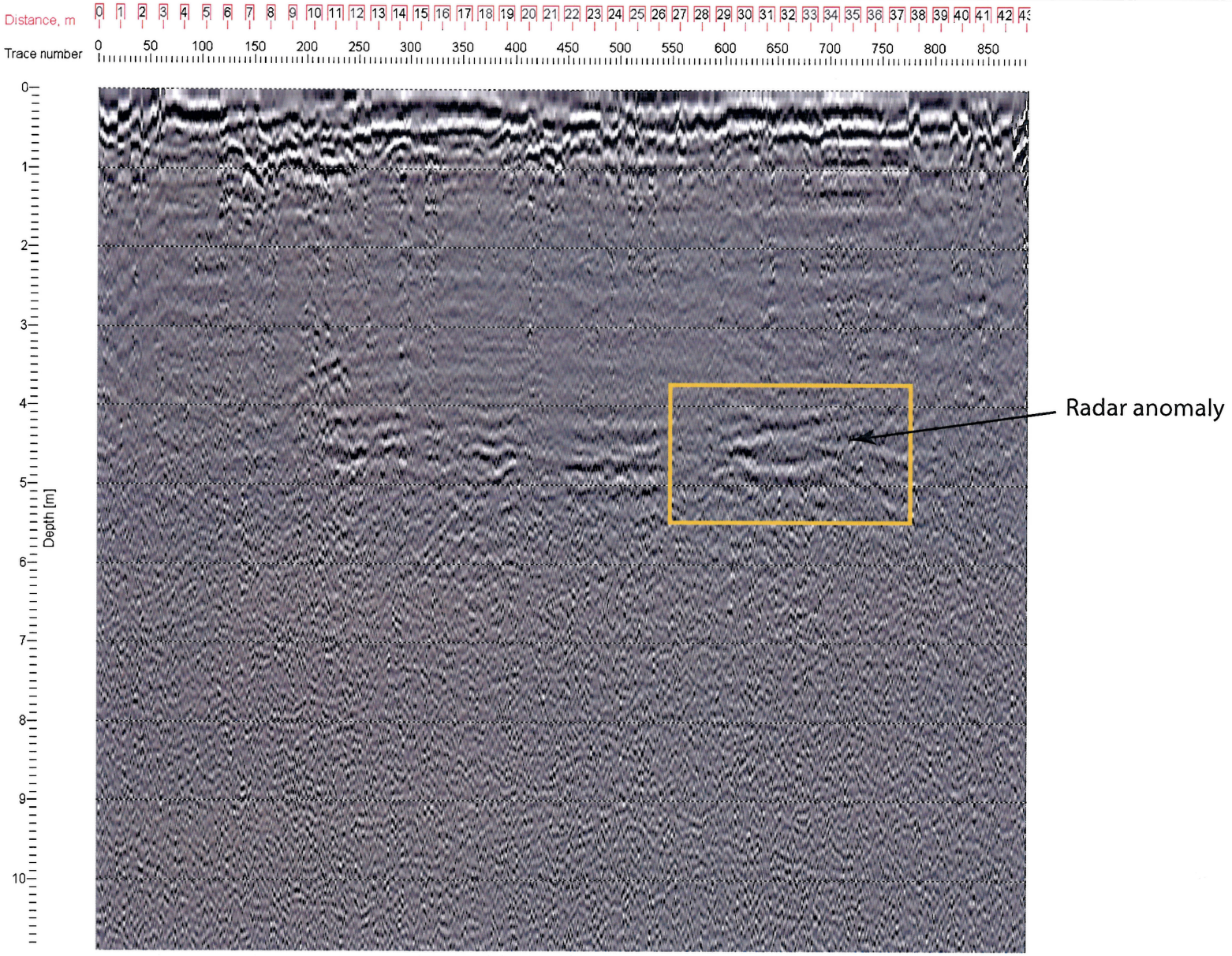
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-17
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



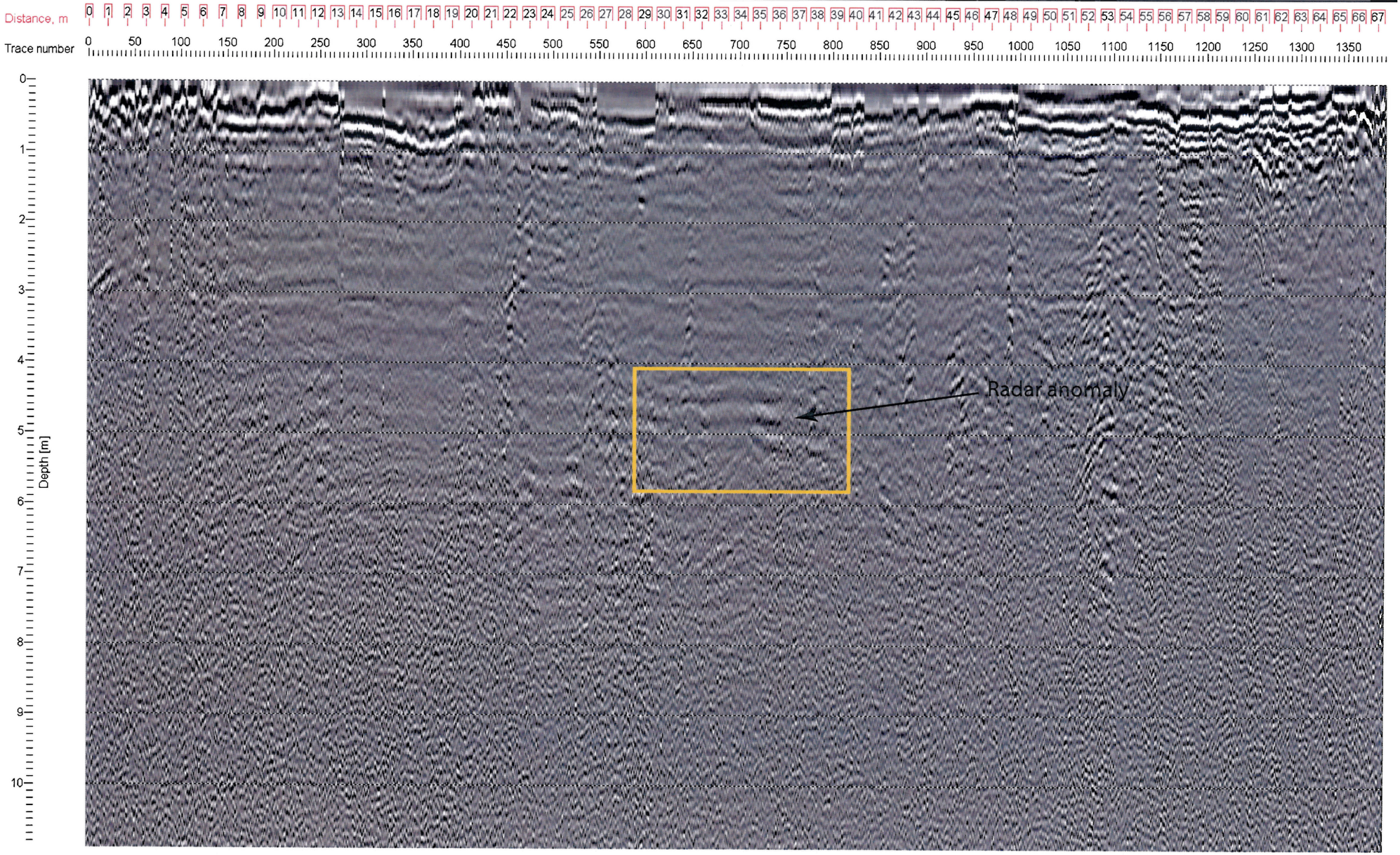
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-18
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



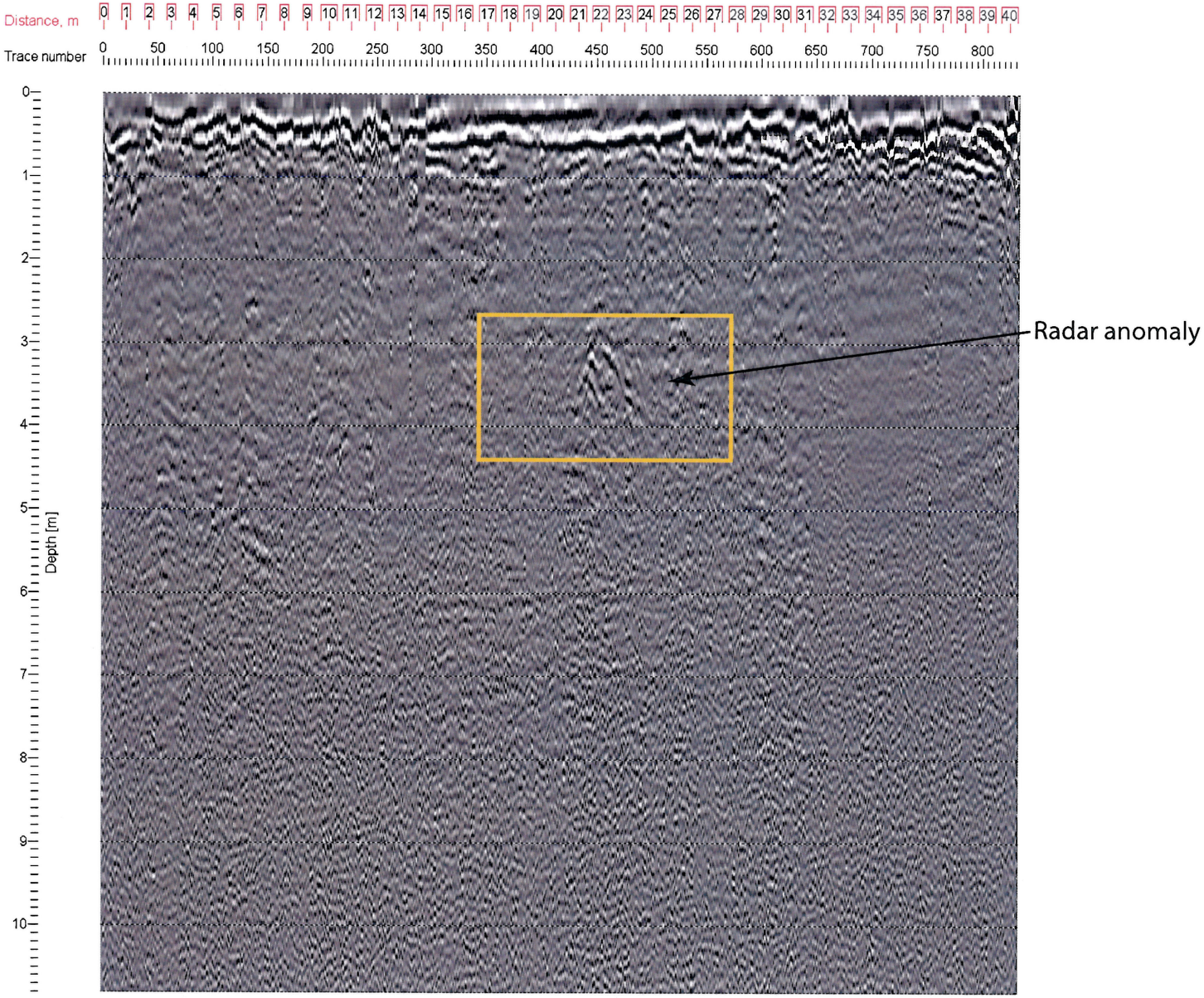
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-19
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



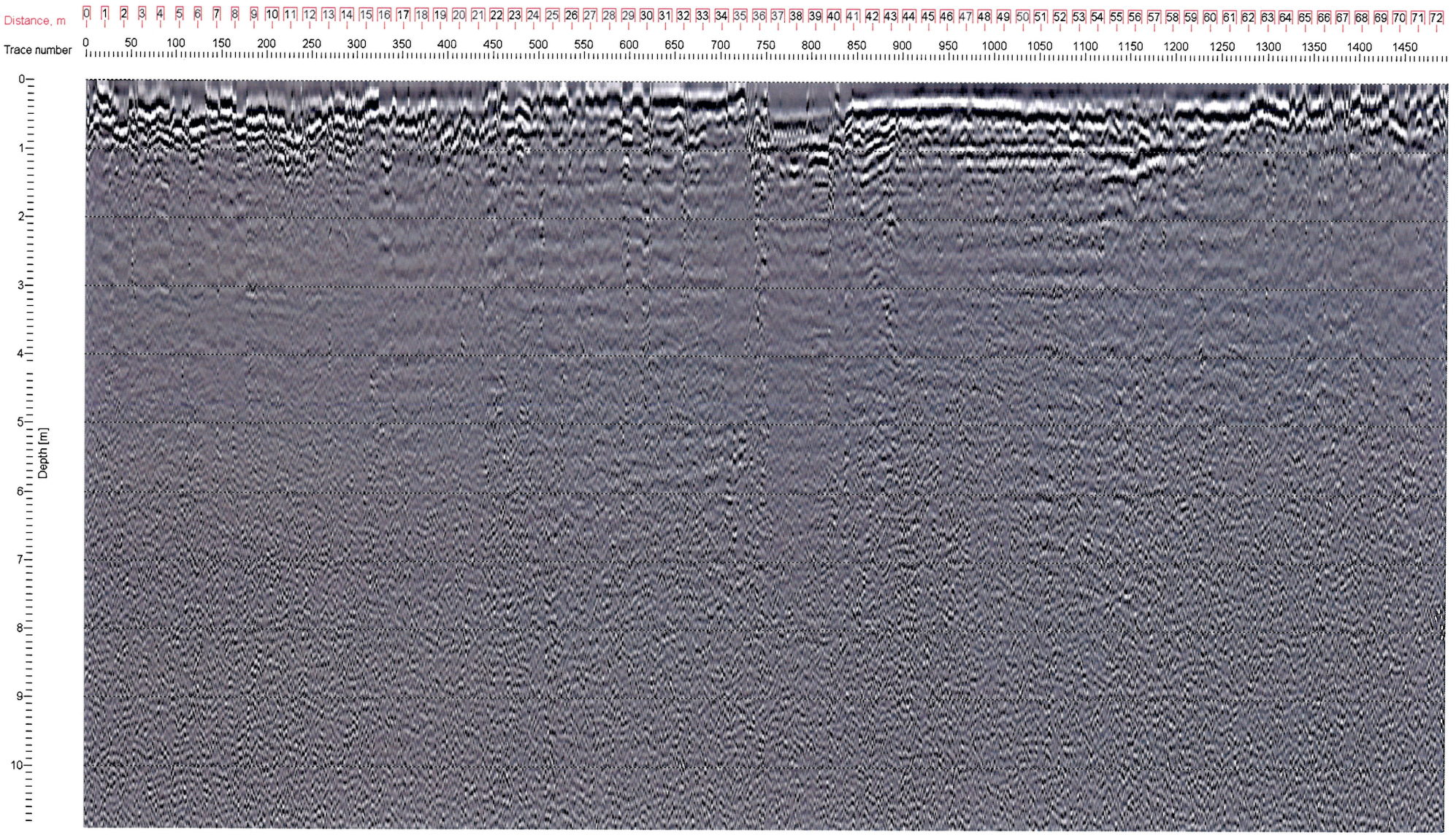
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-20
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



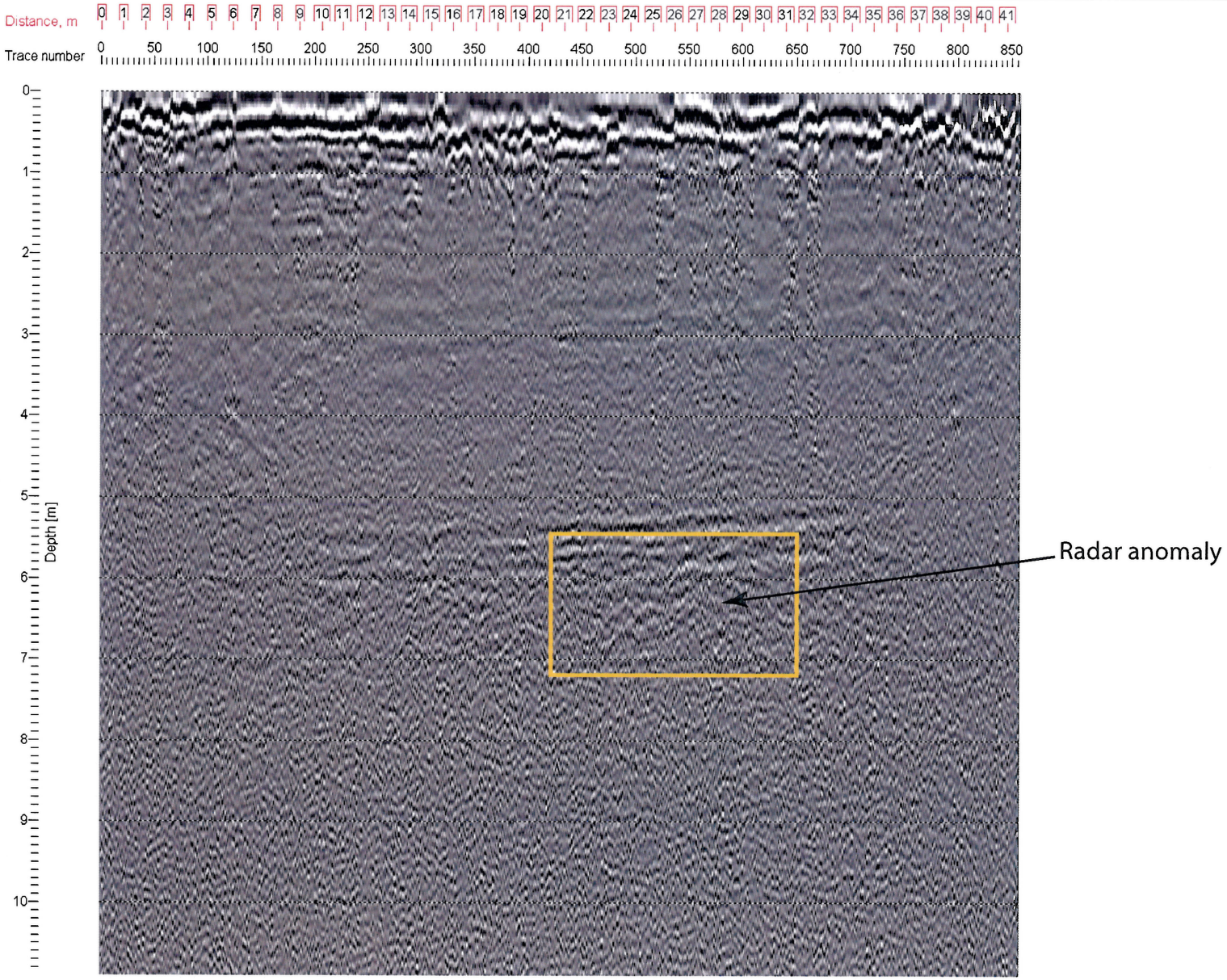
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-21
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



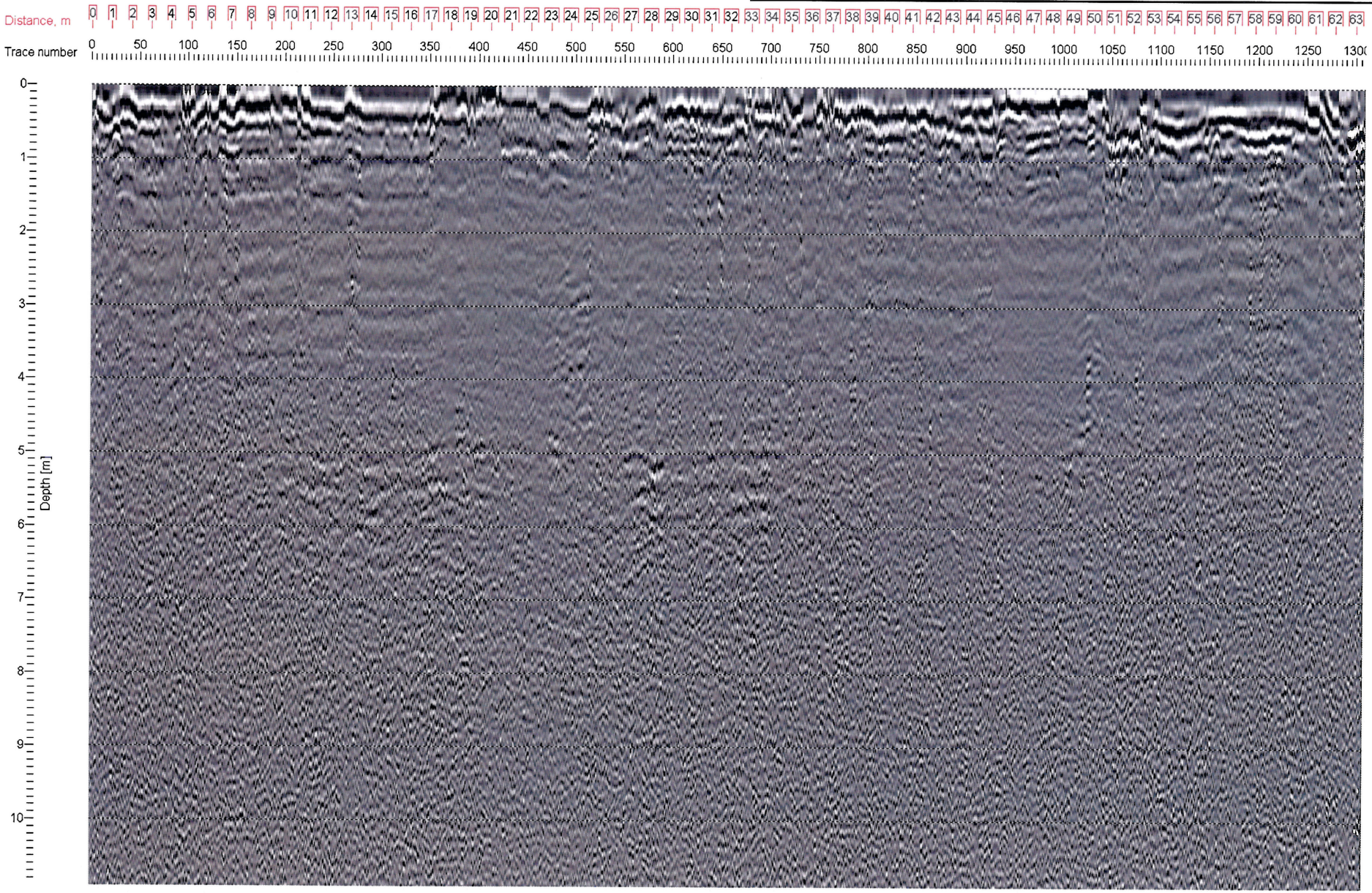
HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-22
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



HYDROGÉO-SOL

Place:	High Commission of Canada, Barbados
Project:	Ground penetrating radar data 053-P015952-0170-SC-0001-00
Line:	L-23
Antenna type:	250 MHz
Distance between antennas:	0,31 m
Date:	20 february 2008



Appendix 4 Borehole Log Reports (4 pages)

DESSAU

BOREHOLE REPORT

Client : D.F.A. I.T. Canada

Project: **Geotechnical investigation - High Commission of Canada** File n°: **P015952-160**

Location: **Bishop's Court Hill, St-Michael, Barbados** Borehole n° : **BH-01-08**

Coordinates (m): **1449108.00 N** **218059.00 E** **Dates :** **2008-02-29** **Drilling equipement :** **Devis, USA**

Reference Datum: **Arbitrary**
Elevation: **100.41 m**

Bedrock depth m
End of borehole depth 12.19 m

Sample condition: Intact | Remoulded | Lost | Core

SAMPLE TYPE

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Core Sample, gauge
TO	Open Tube
LA	By Washing
TA	Auger
MA	Bulk sample
TF	Split Tube
PW	LVM-Fondatec Mega-Sampler

TESTS

L	Consistancy Limits
W_L	Liquid Limit (%)
W_P	Plastic Limit (%)
I_P	Plasticity Index (%)
I_L	Liquidity Index
W	Natural Water Content (%)
AG	Grain Size Analysis
S	Hydrometer analysis
R	Refusal
P_{80}	Grain Size Analysis by washing at the 80 µm sieve
M.O.	Organic Matter (%)
K	Permeability (cm/s)
KL	Lefranc Permeability (cm/s)
UW	Unit Weight (kN/m³)
A	Absorption (l/min. m)
U	Uniaxial Compresses strength (MPa)
RQD	Rock Quality Designation (%)
AC	Chemical Analysis
P_L	Limit Pressure (kPa)
E_M	Pressuremeter Modulus (kPa)
E_r	Modulus of subgrade reaction (kPa)
	Water Level
N	Standard Penetration test (blows/150mm)
Nc	Dynamic Penetration test (blows/300mm) ●
σ'p	Preconsolidation Pressure (kPa)
σ'vo	Effective Pressure (kPa)
Shear Strength	Field / Laboratory
Cu	Undisturbed (kPa) ▲ ■
Cur	Remoulded (kPa) △ □

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOILS OR ROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	CALIBER	CONDITION	RECOVERY %	BLOWS / 150mm	N or RQD	RESULTS
		100.41	Ground level									
1		0.00 / 100.26	Grass and topsoil			SS-1			67	6-16 28-16	44	
2		0.15				SS-2			82	11-50 /100	R	
3	1	99.55	Coral rock fragments. Fragment sizes smaller than 2.5 cm			RC-3			60		32	
4		0.86 / 99.37										
5			Massive coral rock with very close to closely spaced discontinuities. (spaced from 6 cm to 7 cm)									
6	2	1.04				RC-4			15		8	
7		97.36										
8		3.05	Coral rock fragments. Fragment sizes smaller than 2.5 cm									
9	3											
10						RC-5			5		0	
11												
12	4											
13												
14						RC-6			20		0	
15	5											
16												
17												
18	6											
19						RC-7			53		0	
20												
21	7											
22												
23		92.66										
24		7.75	Massive coral rock with voids of approximately 2.5 cm in size created from dissolution process with very close to closely spaced discontinuities (spaced from 6 cm to 10 cm). Powdery material.			RC-8			97		65	UW = 12.7 kN/m³
25	8											
26												
27												
28	9											
29												
30						RC-9			93		0	
31	10											
32												
33		89.74										
34		10.67	Massive coral rock with voids of approximately 2.5 cm in size created from dissolution process with very close to closely spaced discontinuities (spacing of approximately 8 cm). Powdery material. In the last 20 cm coral rock with well developed corals. Discontinuity spacing of approximately 5 cm.			RC-10			92		30	
35	11											
36												
37												
38	12	88.22										
39		12.19										
40			END OF BOREHOLE									
41	13											
42												
43												
44	14											
45												
46												
47												
48												
49												

FIELD AND LABORATORY TESTS

WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100

UNDRAINED SHEAR STRENGTH OR DYNAMIC PENETRATION — 20 40 60 80 100

Remarks: - Coral rock of middle reef terraces Formation (MRT)
- Elevation with respect to center point of catch bassin in parking lot (see plan 033-P015952-0160-GE-0001-00) BM = 100.00 m)

Prepared by: David Noël sr. tech. | Approved by: Nancy Verreault, Eng., M.A.Sc. | 2008-04-16 | Page: 1 of 1

DESSAU

BOREHOLE REPORT

Client : D.F.A. I.T. Canada

Project: **Geotechnical investigation - High Commission of Canada** File n°: **P015952-160**

Location: **Bishop's Court Hill, St-Michael, Barbados** Borehole n° : **BH-02-08**

Coordinates (m): **1449118.00 N** **218070.00 E** **Dates :** **2008-02-29** **Drilling equipement :** **Devis, USA**

Reference Datum: **Arbitrary**
Elevation: **100.60 m**

Bedrock depth m
End of borehole depth 10.67 m

Sample condition
Intact | Remoulded | Lost | Core

SAMPLE TYPE

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Core Sample, gauge
TO	Open Tube
LA	By Washing
TA	Auger
MA	Bulk sample
TF	Split Tube
PW	LVM-Fondatec Mega-Sampler

TESTS

L	Consistancy Limits	M.O.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Standard Penetration test (blows/150mm)
W_P	Plastic Limit (%)	KL	Lefranc Permeability (cm/s)	Nc	Dynamic Penetration test (blows/300mm) ●
I_P	Plasticity Index (%)	UW	Unit Weight (kN/m³)	σ'p	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	A	Absorption (l/min. m)	σ'vo	Effective Pressure (kPa)
W	Natural Water Content (%)	U	Uniaxial Compresses strength (MPa)		
AG	Grain Size Analysis	RQD	Rock Quality Designation (%)		**Shear Strength** (Field / Laboratory)
S	Hydrometer analysis	AC	Chemical Analysis	Cu	Undisturbed (kPa) ▲ ■
R	Refusal	P_L	Limit Pressure (kPa)	Cur	Remoulded (kPa) △ □
P_{80}	Grain Size Analysis by washing at the 80 µm sieve	E_M	Pressuremeter Modulus (kPa)		
		E_r	Modulus of subgrade reaction (kPa)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOILS OR ROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	CALIBER	CONDITION	RECOVERY %	BLOWS / 150mm	N or RQD	RESULTS
		100.60	Ground level									
1		0.00	Grass and topsoil.									
2		100.52	Fine to medium sand backfilled									
3	1	0.08										
4		99.56	Coral rock fragments. Fragments sizes smaller than 8 cm			RC-1			53		0	
5		1.04										
6						RC-2			29		0	
7	2											
8						RC-3			44		0	
9												
10	3											
11						RC-4			13		0	
12												
13	4											
14												
15												
16	5					RC-5			8		0	
17												
18												
19	6											
20												
21						RC-6			12		0	
22												
23	7											
24		92.98										
25		7.62	Coral rock fragments. Fragments sizes of 8 cm on average.									
26	8											
27						RC-7			50		7	
28												
29		91.46										
30	9	9.14	Coral rock fragments. Fragments sizes smaller than 5 cm. Interbedding with more massive coral rock with well developped coral layers of approximately 10 cm in length. Powdery material.									
31												
32												
33	10					RC-8			20		7	
34												
35		89.93										
36	11	10.67	END OF BOREHOLE									
37												
38												
39	12											
40												
41												
42	13											
43												
44												
45												
46	14											
47												
48												
49												

FIELD AND LABORATORY TESTS

WATER CONTENT AND LIMITS (%)
Wp W WL
20 40 60 80 100

UNDRAINED SHEAR STRENGTH OR DYNAMIC PENETRATION
20 40 60 80 100

Échelle verticale = 1 : 125

Remarks: - Coral rock of middle reef terraces Formation (MRT)
- Elevation with respect to center point of catch bassin in parking lot (see plan 033-P015952-0160-GE-0001-00) BM = 100.00 m)

Prepared by: David Noël sr. tech. | Approved by: Nancy Verreault, Eng., M.A.Sc. | 2008-04-16 | Page: 1 of 1

DESSAU

BOREHOLE REPORT

Client : D.F.A. I.T. Canada

Project: **Geotechnical investigation - High Commission of Canada** File n°: **P015952-160**

Location: **Bishop's Court Hill, St-Michael, Barbados** Borehole n° : **BH-03-08**

Coordinates (m): **1149095.00 N** **218061.00 E** **Dates :** **2008-03-03** **Drilling equipement :** **Devis, USA**

Reference Datum: **Arbitrary**
Elevation: **100.45 m**

Bedrock depth m
End of borehole depth 13.72 m

Sample condition: Intact | Remoulded | Lost | Core

SAMPLE TYPE

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Core Sample, gauge
TO	Open Tube
LA	By Washing
TA	Auger
MA	Bulk sample
TF	Split Tube
PW	LVM-Fondatec Mega-Sampler

TESTS

L	Consistancy Limits
W_L	Liquid Limit (%)
W_P	Plastic Limit (%)
I_P	Plasticity Index (%)
I_L	Liquidity Index
W	Natural Water Content (%)
AG	Grain Size Analysis
S	Hydrometer analysis
R	Refusal
P_{80}	Grain Size Analysis by washing at the 80 µm sieve
M.O.	Organic Matter (%)
K	Permeability (cm/s)
KL	Lefranc Permeability (cm/s)
UW	Unit Weight (kN/m³)
A	Absorption (l/min. m)
U	Uniaxial Compresses strength (MPa)
RQD	Rock Quality Designation (%)
AC	Chemical Analysis
P_L	Limit Pressure (kPa)
E_M	Pressuremeter Modulus (kPa)
E_r	Modulus of subgrade reaction (kPa)
	Water Level
N	Standard Penetration test (blows/150mm)
Nc	Dynamic Penetration test (blows/300mm) ●
σ'p	Preconsolidation Pressure (kPa)
σ'vo	Effective Pressure (kPa)
Shear Strength	Field / Laboratory
Cu	Undisturbed (kPa) ▲ ■
Cur	Remoulded (kPa) △ □

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOILS OR ROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	SAMPLES: TYPE AND NUMBER	CALIBER	CONDITION	RECOVERY %	BLOWS / 150mm	N or RQD	RESULTS
		100.45	Ground level									
		0.00	Concrete slab									
		100.30	Coral crush stone of 10 mm diameter backfilled									
	1	0.15 / 100.20				RC-1			92		50	U = 18 MPa UW = 22.0 kN/m³
		0.25										
		98.93	Coral rock fragments. Fragment size smaller than 5 cm. Interbedding with more massive coral rock.									
	2	1.52				RC-2			37		0	
		97.40										
	3	3.05	Coral rock fragments with voids of approximately 1 cm size created from dissolution process. Fragment sizes of approximately 7-8 cm.			RC-3			53		0	
		95.88										
	4	4.57	Coral rock fragments. Average sizes between 5 cm to 8 cm. Powdery material.			RC-4			37		0	
	5											
		94.35										
	6	6.10	Coral rock fragments with voids of approximately 1 cm in size created by discolution process. Fragment size smaller than 8 cm			RC-5			47		0	
		93.14										
	7	7.32	Karst (void)									
		92.83	Massive coral rock. Corals are very well developped. Discontinuities are very close to closely spaced (average spaces of 8 cm)			RC-6			83		56	U = 18.5 MPa UW = 14.8 kN/m³
	8	7.62										
		91.38										
	9	9.07	Coral rock fragments. Fragment sizes smaller than 2.5 cm.			RC-7			38		0	
	10											
	11					RC-8			0		0	
		88.26										
	12	12.19	Coral rock fragments. Fragment sizes smaller than 8 cm. Powdery material.			RC-9			33		0	
		86.73										
	13	13.72	END OF BOREHOLE									
	14											

WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100

UNDRAINED SHEAR STRENGTH OR DYNAMIC PENETRATION — 20 40 60 80 100

Remarks: - Coral rock of middle reef terraces Formation (MRT)
- Elevation with respect to center point of catch bassin in parking lot (see plan 033-P015952-0160-GE-0001-00) BM = 100.00 m)

Prepared by: David Noël sr. tech. | Approved by: Nancy Verreault, Eng., M.A.Sc. | 2008-04-16 | Page: 1 of 1

DESSAU

BOREHOLE REPORT

Client : D.F.A. I.T. Canada

Project: **Geotechnical investigation - High Commission of Canada** File n°: **P015952-160**

Location: **Bishop's Court Hill, St-Michael, Barbados** Borehole n° : **BH-04-08**

Coordinates (m): **1449125.00 N** **218101.00 E** **Dates :** **2008-03-03** **Drilling equipement :** **Devis, USA**

Reference Datum: **Arbitrary**
Elevation: **100.72 m**

Bedrock depth m
End of borehole depth 12.19 m

Sample condition: Intact, Remoulded, Lost, Core

SAMPLE TYPE

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Core Sample, gauge
TO	Open Tube
LA	By Washing
TA	Auger
MA	Bulk sample
TF	Split Tube
PW	LVM-Fondatec Mega-Sampler

TESTS

L	Consistancy Limits	M.O.	Organic Matter (%)
W_L	Liquid Limit (%)	K	Permeability (cm/s)
W_P	Plastic Limit (%)	KL	Lefranc Permeability (cm/s)
I_P	Plasticity Index (%)	UW	Unit Weight (kN/m³)
I_L	Liquidity Index	A	Absorption (l/min. m)
W	Natural Water Content (%)	U	Uniaxial Compresses strength (MPa)
AG	Grain Size Analysis	RQD	Rock Quality Designation (%)
S	Hydrometer analysis	AC	Chemical Analysis
R	Refusal	P_L	Limit Pressure (kPa)
P_{80}	Grain Size Analysis by washing at the 80 µm sieve	E_M	Pressuremeter Modulus (kPa)
		E_r	Modulus of subgrade reaction (kPa)

Water Level
N Standard Penetration test (blows/150mm)
Nc Dynamic Penetration test (blows/300mm)
σ'p Preconsolidation Pressure (kPa)
σ'vo Effective Pressure (kPa)

Shear Strength (Field / Laboratory)
Cu Undisturbed (kPa)
Cur Remoulded (kPa)

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOILS OR ROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	CALIBER	CONDITION	RECOVERY %	BLOWS / 150mm	N or RQD	RESULTS
		100.72	Ground level									
		0.00 / 100.57	Grass and topsoil									
	1	0.15	Massive coral rock with very close to closely spaced discontinuities (average spacing of approximately 6 cm)			RC-1			38		7	
	2					RC-2			97		68	U = 10 MPa UW = 22.1 kN/m³
	3	97.04										
	4	3.68	Coral rock fragments. Size of fragments smaller than 5 cm.			RC-3			42		22	
	5	95.69										
		5.03	Karst (void)			RC-4			0		0	
	6	94.32										
		6.40	Coral rock fragments. Size of fragments smaller than 2.5 cm.			RC-5			20		0	
	7	93.10										
		7.62	Coral rock fragments with voids created from discolution process. Powdery material.			RC-6			25		0	
	8	91.58										
	9	9.14	Coral rock fragments with voids created from dissolution process. Interbedding with massive coral rock with well developped coral layers of approximately 10 cm in length.			RC-7			25		7	
	10					RC-8			40		0	
	11											
	12	88.53										
		12.19	END OF BOREHOLE									
	13											
	14											

WATER CONTENT AND LIMITS (%) Wp W WL — 20 40 60 80 100

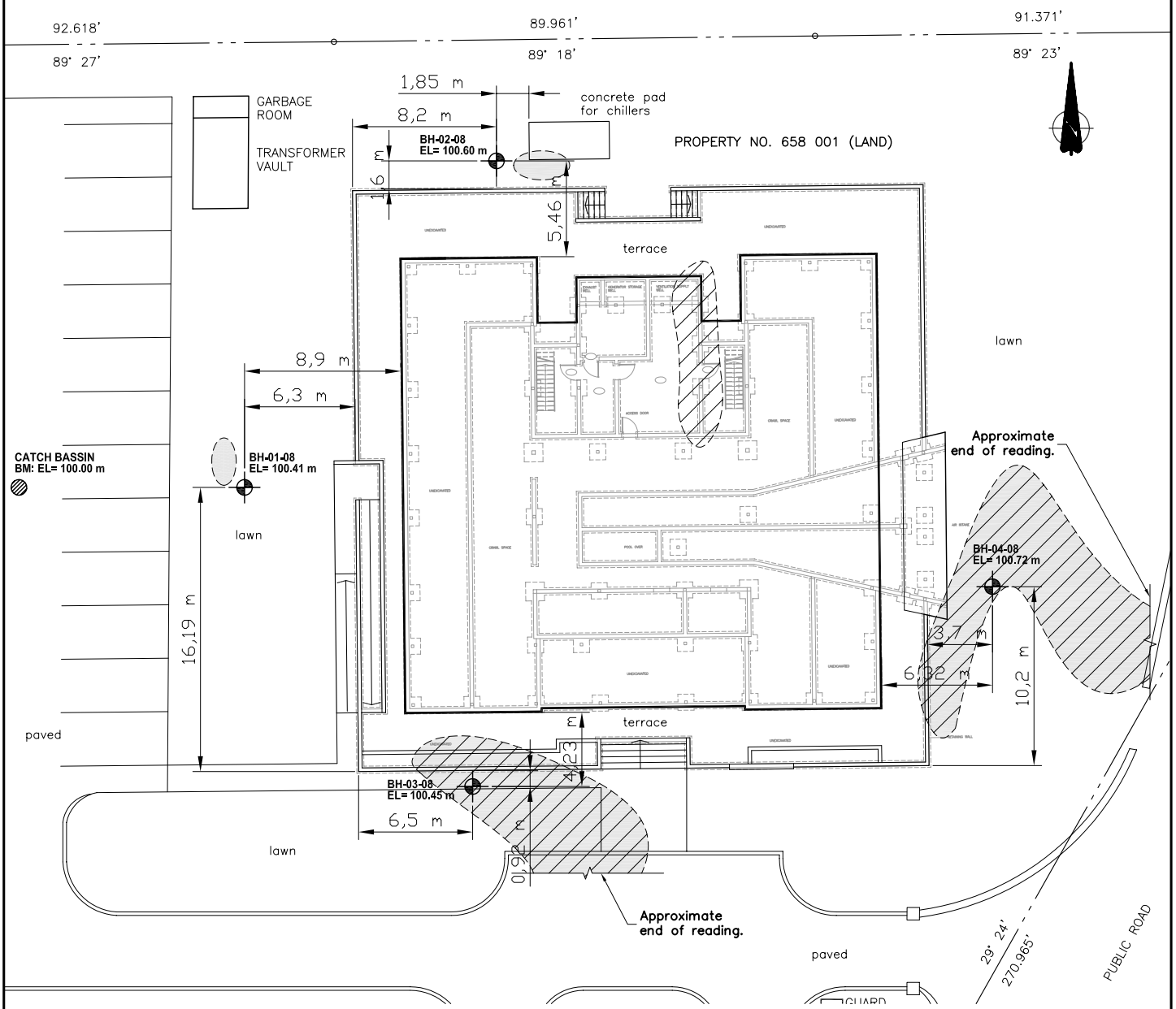
UNDRAINED SHEAR STRENGTH OR DYNAMIC PENETRATION — 20 40 60 80 100

Échelle verticale = 1 : 125

Remarks: - Coral rock of middle reef terraces Formation (MRT)
- Elevation with respect to center point of catch bassin in parking lot (see plan 033-P015952-0160-GE-0001-00) BM = 100.00 m)

Prepared by: David Noël sr. tech. | Approved by: Nancy Verreault, Eng., M.A.Sc. | 2008-04-16 | Page: 1 of 1

Appendix 5 Plans : Location of Boreholes and Known Karstic Formations (3 pages)



Legend:

BH-01-08 = Borehole

BM = Bench mark - Catch basin

= POSSIBLE KARSTIC FORMATION

= COMFIRMED KARSTIC FORMATION

= PROBABLE AREA OF KARSTIC FORMATION BACKFILLED DURING CONSTRUCTION IN 1983

Project

BCR - Chancery Bridgetown Barbados D.F.A.I.T. of Canada

Title

Location Of Boreholes

DESSAU

Dessau inc.
900 de la Carrière Blvd
Gatineau (Québec) J8Y 6S6
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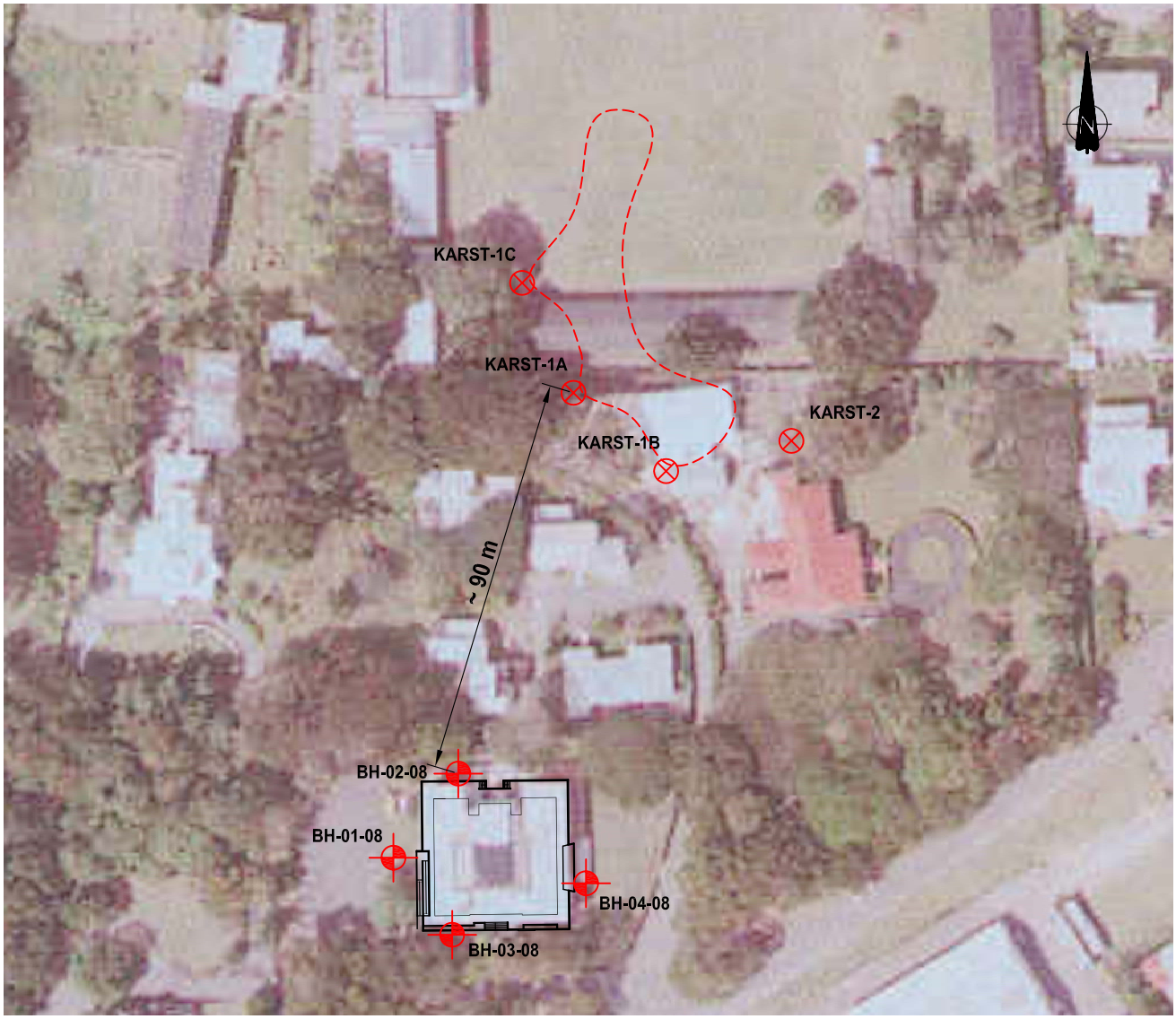
Prepared	J.F Grandmaitre	Discipline	Geological Sciences	Project manager	F. Dionne
Drawn	R. Frenette	Scale	1 : 350	Extract from:	Rev.: 00
Checked	J.F Grandmaitre	Date	2008-03-31		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
034	P015952	0160	000	SC	0001	00



Legend:

KARST-1A ⊗ = Entrance to Karst

KARST-1B ⊗ = South end of Karst

KARST-1C ⊗ = Entrance to Karst beside school

KARST-2 ⊗ = Part of other recorded Karst close to surface

BH-01-08 ⊕ = Borehole

= Approximate Karst limits

Karst-1 characteristics (approximate) :

Height : 3 m - 5.5 m

Depth of bottom : 7.5 m - 9 m

Width : 1.5 m - 15 m

Length : 85 m

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BCR - Chancery Bridgetown Barbados
D.F.A.I.T. of Canada

Title

Approximate Location Of Boreholes And Observed Karstic Formation

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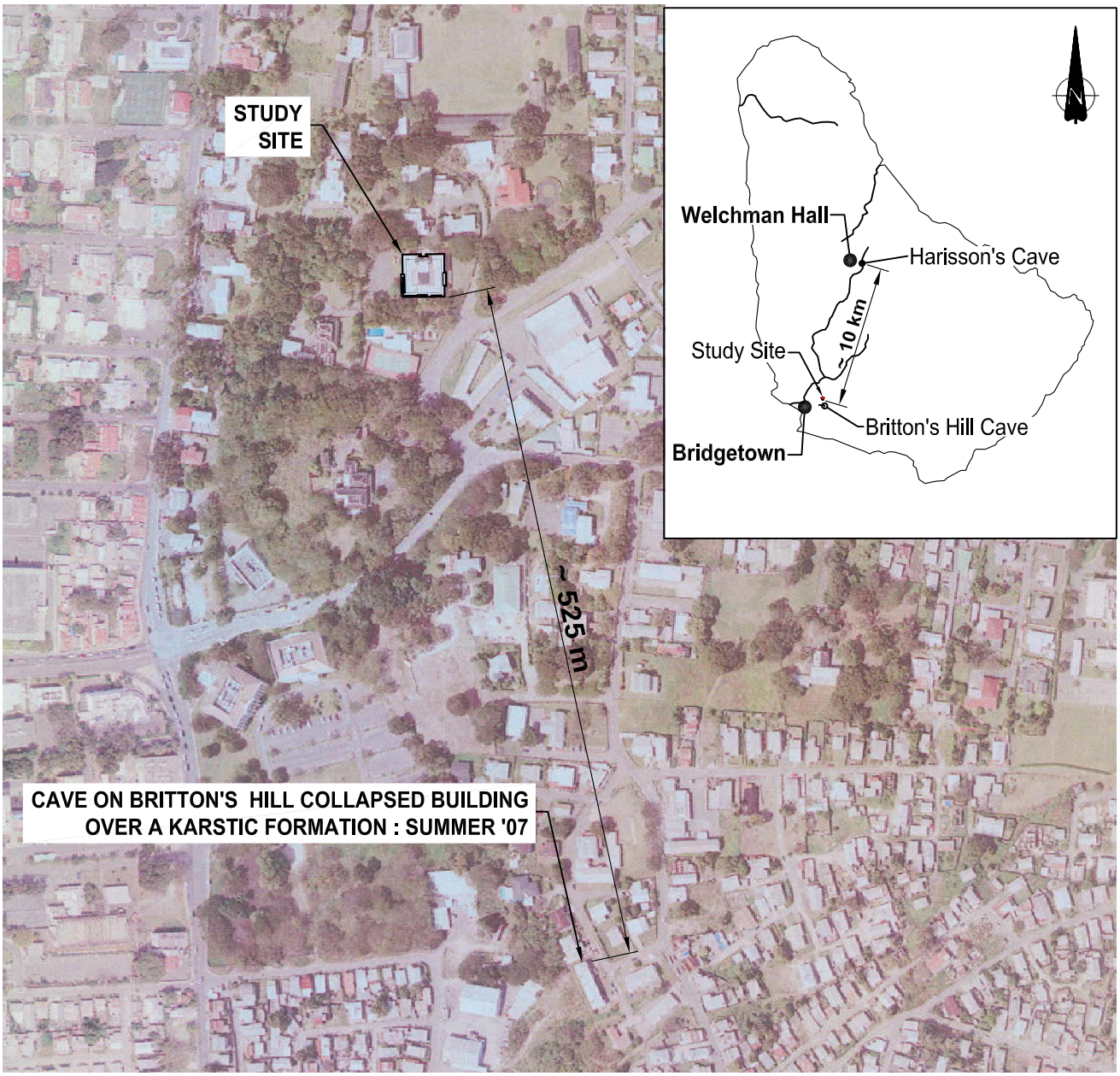
Checked	J.F Grandmaitre	Date	2008-03-31		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
034	P015952	0160	000	SC	0002	00



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Title

Approximate Location Of Known Caves

DESSAU

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Checked	J.F Grandmaitre	Date	2008-03-31		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
034	P015952	0160	000	SC	0003	00