FIUMICINO WATERFRONT

*SOGGETTO ESECUTORE E FINANZIATORE*

GIUBILEO 2025 PELLEGRINI DI SPERANZA

*INTERVENTO N. 146*

CITTÀ DI FIUMICINO

*SOGGETTO PROPONENTE ED ATTUATORE*


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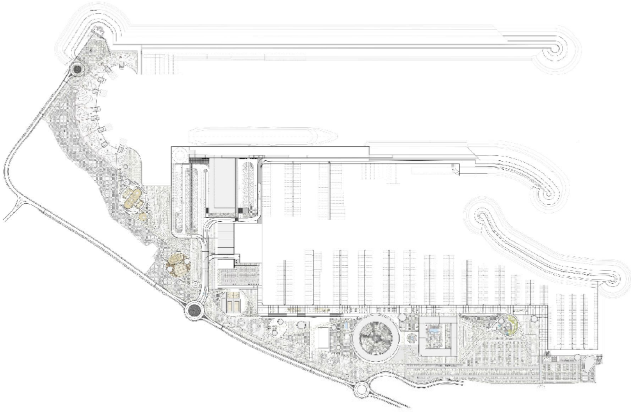
# PORTO TURISTICO-CROCIERISTICO DI FIUMICINO ISOLA SACRA

**CUP:F11I22000320007**

## PROGETTO DI FATTIBILITÀ TECNICO ECONOMICA

ODASSO ALESSANDRO
ORDINE DEGLI INGEGNERI DELLA PROVINCIA DI GENOVA
Ingegnere
07.08.2023 09:15:17 UTC



00_INQUADRAMENTO GENERALE

AMBIENTE E PAESAGGIO

# RAPPORTO DI CAMPO - INDAGINE RIFLESSIONE SISMICA ONSHORE: ANNO 2022

| COMMESSA | SERVIZIO | LOTTO | OPERA | DISCIPLINA | TIPO | PROG. | REV. | SCALA |
|---|---|---|---|---|---|---|---|---|
| P0031150 | D | 0 | MP00 | AM | REL | 11 | 00 | - |

| REV. | DESCRIZIONE | REDATTO | VERIFICATO | APPROVATO | DATA |
|---|---|---|---|---|---|
| 00 | Emissione per approvazione | V. DIMICHINO | P. RAVASCHIO | A. ODASSO | Luglio 2023 |
| - | - | - | - | | - |
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| - | - | - | - | - | - |
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# PREMESSA

Il presente documento è stato redatto, in lingua inglese, nell'ambito dell'attività di definizione del Master Plan del progetto "Porto di Fiumicino Isola Sacra", consegnato ad Ottobre 2022 e commissionato dalla Royal Caribbean Group Ltd, quale titolare, all'epoca, della relativa concessione.

Il rapporto, in considerazione della sua validità, è ora integrato nel corpo documentale appartenente alla attuale fase di Progetto di Fattibilità Tecnico Economica del Porto turistico-crocieristico di Fiumicino Isola Sacra, commissionato dalla Fiumicino Waterfront Srl, subentrata nella titolarità di detta concessione.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| CDP | Common Depth Point |
| NMO | Normal Move Out |
| AGC | Automatic Gain Control |
| CMP | Common Mid-Point |
| CVS | Constant Velocity Stack |
| 2D | Two Dimensional |
| RMS | Root Mean Square |
| H1 to H7 | Geophysical Horizon 1 to Geophysical Horizon 7 |

# EXECUTIVE SUMMARY

This report highlights all activities concerning geophysical investigations performed for the Cruise Project of Isola Sacra, located in Fiumicino, Lazio Region.

The geophysical investigation has been acquired along the beach situated from the Fiumicino city center until the Fiumicino touristic port, located near to the Tevere river estuary (Figure 1.1).

The study was planned to characterize soils, rocks and the geological structure of the subsoil, giving information for the design and the planning of the Isola Sacra Cruise Project.

The principal purpose of the investigation has been the definition of the geological structure of the subsoil through the seismic reflection methodology, to provide a 2D section along the coast, correlating some of the geotechnical boreholes drilled for the same purpose, providing thus a more complete assessment of the subsoil for the planning of further investigations campaign and for the final design of the project.

Resuming, the purposes of the geophysical survey were:

- ✓ Reconstruction of the geological structure of the subsoil along the coast arc connecting Fiumicino to the touristic port.
- ✓ Reconstruction of the interval seismic velocities field variations of P waves along the same section.
- ✓ Identification of geophysical structures that could represent a geological anomaly to be further investigated.

To achieve the prefixed objectives, a high-resolution seismic reflection investigation was performed, technically planned to have both a good resolution and the required investigation depth penetration of around 100 meters from the surface.

In the end the seismic survey made it possible to identify, on the basis of geophysical similarities of the seismic signal and RMS velocities, seven horizons and some discontinuities and/or faults.

Furthermore, the geophysical profile allowed to reconstruct the position of the contact between an area of lower superficial velocities and the substratum, and it shows some anomalies in the distribution of the RMS velocities that may be correlated to geological structures.

This report highlights all activities performed in the field, the method of processing of the experimental data and the interpretation conclusions, basically made by a geophysical criterion.

# 1 INVESTIGATIONS PERFORMED

## 1.1 SEISMIC DATA ACQUISITION

The geophysical investigation has been acquired along the coast starting from the Fiumicino city center and ending at the Fiumicino touristic port, located near to the Tevere river estuary (Figure 1.1).

The geophone spread has been located directly on the beach (Figure 1.2), as required by the Client during the site visit performed on 2022, July 5th.

Field data acquisition was performed on 2022, July 22nd.


Figure 1.1: Investigation area location (area in red).

Figure 1.2: Detail of the geophone spread on the ground.

The line has been acquired using an accelerated weight, carried by a tracked vehicle (Figure 2.1), that allow a good seismic intensity and a stable signal for stacking acquisition.

Source points were located at each geophone of the spread and have been acquired using arrays of 48 active geophones spaced by 5 meters, connected through 2 seismographs in series.
The methodology foresaw the acquisition of a shot point at each geophone and 6 external shot points for each side of the array, to reach the necessary investigation depth and the adequate reflection coverage.
The exact location of geophones and shot points has acquired by a high precision GNSS device; the coordinates were calculated to define the exact geometric factor of the line, to give the topographic correction to the experimental data.
The seismic line location is showed in the annexes and in Figure 1.3.


**Figure 1.3: Seismic line location**

## 1.2 SURVEY SPECIFICATIONS

Details of the performed survey are showed in the chart below:

**Table 1.1: Seismic reflection survey specifications**

| Seismic line | Geophone distance mt | Length mt | Shot point N° | Geophones N° |
|---|---|---|---|---|
| 1 | 5 | 990 | 206 | 192 |

Seismic acquisition was performed using the following setting parameters:

- ✓ Geophone spacing: 5 meters.
- ✓ Geophone frequency: 60 Hz.
- ✓ Shot interval: 5 meters.
- ✓ Nominal multiplicity: 2400%.
- ✓ Sample interval: 0.250 msec.
- ✓ Time window length: 2 sec.
- ✓ Source: accelerated weight on tracked vehicle (Figure 2.1).

# 2 EQUIPMENT, TECHNICAL STAFF AND QUALITY STANDARDS

## 2.1 EMPLOYED EQUIPMENT

Equipment employed to carry out the geophysical study are listed in the following table:

Table 2.1: Seismic equipment employed

| N° | Equipment |
|---|---|
| 2 | Seismograph GEOMETRICS “GEODE” 24 ch |
| 48 | Vertical geophones with frequency of 60 Hz |
| 4 | Connecting cables for geophones and for seismographs |
| 1 | notebook HP, with MGOS SOFTWARE |
| 1 | Propelled seismic generator PEG40 – RT Clark (Figure 2.1) |
| 1 | GPS Geomax Zenith 35 Pro |

Figure 2.1: Energy source employed: accelerated weight on tracked vehicle.

Figure 2.2: Seismograph GEOMETRICS "GEODE" and notebook

Figure 2.3: Acquisition phase

Figure 2.4: Geophones near BHT03

## 2.2 TECHNICAL STAFF

Specialists involved in the geophysical study, both in the field acquisition and in the data interpretation, are listed below.

**Table 2.2: Technical staff involved**

| Assignment | Specialist |
|---|---|
| Site Manager | Paolo De Santis |
| Data acquisition | Filippo Giorgi |
| QA manager for data acquisition | Filippo Giorgi |
| Topographic survey | Duccio Notari |
| Seismic reflection survey design | Francesco Bianchi |
| Data interpretation | Francesco Bianchi<br>Filippo Giorgi |
| Verification and final report redaction | Duccio Notari<br>Massimiliano Mondet |
| Editing | Duccio Notari<br>Massimiliano Mondet |

# 3 TECHNICAL SPECIFICATION AND METHODOLOGY

## 3.1 DATA ACQUISITION

Lines were acquired using a 48 geophones array, connected by cables to two seismographs (GEODE- by GEOMETRICS) placed in series, and finally connected to a laptop. The lines were acquired placing additional consecutive 48 geophones arrays until reaching the desired total length. Single 48 geophones array were joined during data processing using six external shot points deployed outside the geophone spread.

Resuming, main characteristics of the survey are:

- ✓ Geophone spacing: 5 meters.
- ✓ Active geophones: 48.
- ✓ Total geophones of the line: 192.
- ✓ Shot interval: 5 meters.
- ✓ Total shot point acquired: 240, both inside and outside the geophone spread.
- ✓ Nominal multiplicity: 2400%.
- ✓ Sample interval: 0.250 msec.
- ✓ Time window length: 2 sec.
- ✓ Source: accelerated weight.

## 3.2 DATA PROCESSING

### 3.2.1 Introduction

The processing sequence applied to experimental data is subjected to a data specific analysis in order to take into account the local geological setting, the morphology of the profiles and the access difficulties. A standard steps sequence has been applied to all data. The implemented standard data processing sequence can be subdivided into three main steps:

- ✓ Pre-processing, for data preparation;
- ✓ Processing in shot domain, mostly devoted to enhance signal to noise ratio;
- ✓ Processing in Common Depth Point (CDP) domain, comprehending velocity analysis, normal move out (NMO) and stack, the very basic data processing operations.

### 3.2.2 Pre-processing

In the pre-processing step field data in SEG2 format are transformed into PC-SEGY, standard seismic format, following the operations:

- ✓ PC data upload;
- ✓ SEG2 - standard PC-SEGY data conversion;
- ✓ Field geometry input in each trace of SEGY data header;
- ✓ First arrival muting and surgical mute in the shot domain.

### 3.2.3 Processing in shot domain

Shot domain data processing step is aimed at increasing the quality of each trace, following the operations listed as below:

- ✓ Frequency spectrum analysis
- ✓ Resampling to 0.5 msec
- ✓ AGC (automatic gain control).
- ✓ Pass band frequency filtering
- ✓ FK domain conversion and filtering

- ✓ Spiking deconvolution
- ✓ Offset domain muting (top/bottom or internal mute)
    - Data sorting in CDP domain

Prior to the processing beginning, the possibility to resample the data to bring field sampling interval to 0.5 msec, was positively verified. Therefore, data were pre-filtered with a high cut of 950-955 Hz, and thus resampled to 1.0 msec.

Frequency spectrum analysis allowed to recognize that seismic reflection signal band was peaked between a minimum of 20 Hz and a maximum of 250 Hz for the line LH01 and from 15 to 90Hz for the lines LH02 and LH03; by applying a pass band filter within this range, it has been possible to further reduce the coherent noise with a low apparent velocity (peaking at 10-15 Hz).

Each trace was subsequently processed with the application of a spiking deconvolution operation, through a specifically designed operator. Operator design is done with a trial-and-error procedure, the effectiveness of which is controlled by comparing the trace autocorrelation before and post deconvolution. Deconvolution operation is aimed at reducing the repetitiveness of each wavelet in the trace and at shortening its wavelength by increasing the frequency content. In the present work a spiking type of deconvolution was used, with an operator of 80 msec and a prewhitening of 10% for the line LH01 and an operator of 60 msec and a prewhitening of 10% for the line LH02 and LH03.

When this procedure is considered to be satisfactory, it is possible to reorganize the data from shot domain grouping to CDP domain grouping, an operation named as CDP-sorting. CDP is a group of traces pertaining to different shots but sharing the same midpoint between the shot and the receiver (CDP-common depth point or CMP-common mid-point). The number of traces in each CDP depends on coverage: 1200% coverage means that there are 12 traces for each CDP. Data have a real minimum coverage of 1200%, with local peaks of 2400%.

### 3.2.4 Processing in the C.D.P. domain

Now processing is devoted to convert this family of traces into one single final trace for each CDP. Data processing proceeded as follows:

- ✓ Pre-stack.
- ✓ Static corrections.
- ✓ Velocity analysis every 5 CDP.
- ✓ Normal Move-Out correction.
- ✓ Muting.
- ✓ Stack.
- ✓ CDP summation (Stack).
- ✓ Post-stack.
- ✓ Residual static corrections.
- ✓ Migration.
- ✓ Filter, FK, 3 traces mix;
- ✓ Time to depth conversion.

Velocity analysis have been performed every 5 CDP with semblance and CVS (Constant Velocity Stack) techniques, using a velocity interval from 2,000 m/s to 5,000 m/s.

Velocity picking were chosen with a maximum coherency criterion; therefore they correspond to the velocity value that has a maximum amplitude of stacked traces after NMO correction. The result is a two-way-time velocity function every group of CDP. Therefore, all the CDPs are NMO-corrected with the corresponding velocity function and then all the traces in each CDP become summed up (stacked) in one single trace. A seismic stacked section is produced with all CDP traces. Afterwards the stacked section undergoes to migration, an operation aimed at focusing the diffracted energy at single reflecting points and at correcting the dip of reflecting events.

The final product is a migrated seismic profile, in two-way-time, that for each profile tract is showed in the upper part of annexes. Seismic data are presented with wiggle trace and red (negative) and blue (positive) amplitudes.

# 4 RESULT ANALYSIS

## 4.1 INTERPRETATION CRITERION

Data interpretation results are represented in 2D seismic sections, concerning the seismic section in travel time, the interval velocity in depth, the seismic interpretation in depth, and the interpretation section.

Sections are represented in scale 1:1,000 and presented in annex at this report.

**Table 4.1: Appendix and its subject**

| APPENDIX A | Subject |
| --- | --- |
| Seismic Reflection chart_01 | Investigation location map<br>Seismic line 1: travel time<br>Seismic line 1: interval velocity in depth<br>Seismic line 1: seismic interpretation in depth |
| Seismic Reflection chart_02. | Investigation location map<br>Seismic line 1: interpretation section |

The seismic interpretation in depth allowed the reconstruction of the geological structure and the interval velocity of P waves model.

The structural model has been represented superposed to the seismic section migrated in depth and on the interval velocity section, in the way to provide the necessary information to read the structural features associating them to seismic velocity variations or anomalies in the subsoil.

It's important to clarify that p-waves seismic velocities derived by seismic reflection are RMS (Root Mean Square) velocities of each reflected event by the surface and for that reason it is difficult to strictly associate them to soils or rocks properties.

If, instead, those velocities are used to calculate the velocity of each couple of RMS velocity, interval velocity can be assumed with more reliability even if, however, it remains influenced by superficial anisotropies.

Therefore, interval velocity analysis can be used to analyze the velocity variation trend, concentrating the attention in particular to relative variations inside the analyzed section, not considering as totally reliable the absolute value of P-waves velocities for geotechnical correlations.

For that reason, interval velocity sections, represented as colorimetric sections, will be analyzed with a relative interpretation, describing increasing or decreasing values into the subsoil of the investigates area.

The geophysical interpretation of the travel time section has showed the existence of vertical and horizontal structures, associated to discontinuities or faults and lithological contacts, respectively.

The graphic representation of the interpretation is fundamentally based on a geophysical criterion, using different colors and line thickness. The interpretation criterion is based on the following features:

- ✓ Reflective horizons: identified on the basis of differences in the seismic signal.
- ✓ Discontinuities and faults: traced and discriminated on the basis of the seismic signal surrounds, like velocities variations, geometrical effects on the organized reflective waves trends, geometrical effects on the horizontal reflective horizons.

For the graphical representation of the seismic interpretation, it has been chosen to diversify the lithological horizons with different colors, and to assign major thickness lines to the principal reflective horizons while minor thickness lines have been assigned to reflective events of minor relevance.

The same graphical criterion has been used to differentiate discontinuities or faults.

The geophysical interpretation could be improved calibrating the seismic depth sections with direct geological and geotechnical information, both for the depth positioning and quality distinction.

## 4.2 RESULTS ANALYSIS

The seismic reflection investigation allowed a proper subsoil structure reconstruction, as per prefixed objectives:

Results can be synthetically resumed as follow:

- ✓ The seismic line (Figure 4.1) allowed a 2D continuous subsoil reconstruction, represented with a seismic interpretation section and RMS velocity profile, in depth.
- ✓ The seismic prospection allowed the subsoil characterization up to 150 meters of depth.
- ✓ The geophysical interpretation showed 7 horizons (identified on the section with acronym H1 to H7), differentiated with 4 different colors, based on geophysical similarities of the seismic signal and RMS velocities.
- ✓ The seismic section highlights some discontinuities and/or faults, even if the features that allowed its identification may not be so defined and clear, maybe because of the subsoil lithotypes characteristics that constitute the area.

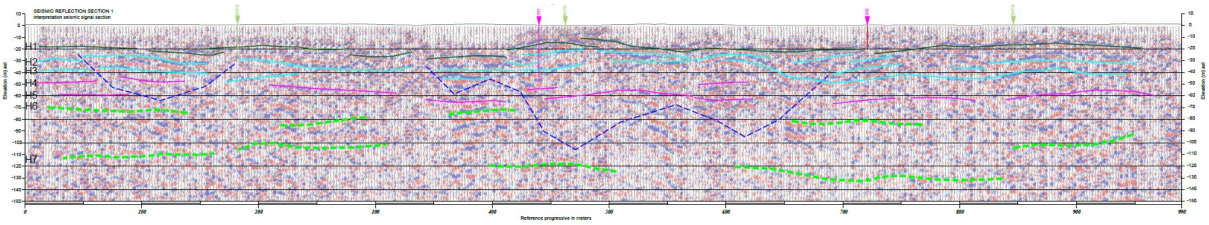


**Figure 4.1: seismic interpretation section**

- ✓ The RMS velocity profile (Figure 4.2) shows a general and smoothed contact between an area of lower superficial velocities and the substratum, located between 30 and 40 meters of depth. Furthermore, it shows some anomalies, with lower velocities, highlighted with blue lines, located at the following profile progressives:
  - from the progressive 75 to 175 up to 60 meters of depth;
  - from the progressive 330 to 400 up to 80 meters of depth;
  - from the progressive 430 to 500 up to 130 meters of depth;
  - from the progressive 570 to 650 up to 120 meters of depth.

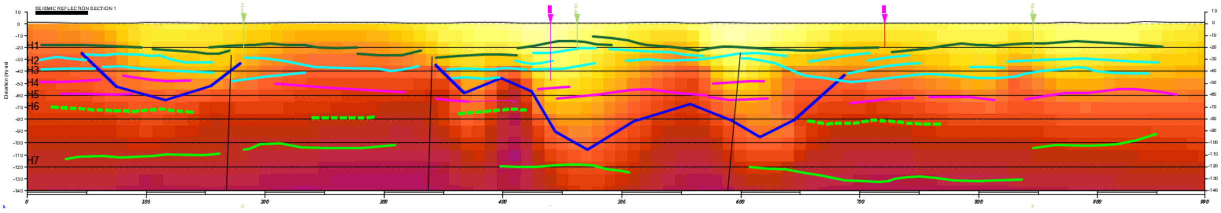


**Figure 4.2: RMS velocity profile**

The present phase of the geophysical investigation has been redacted to allow a detailed 2D reconstruction, essentially based on a geophysical criterion, of the alignment chosen by the Client.

At present, the geotechnical and geophysical logs of the shallow boreholes made along the shoreline allow the individuation of the first refractor H1 as the geological contact between the upper sands and the lower clays located at around 20m from the surface.

However, a more detailed and calibrated interpretation could be performed on the basis of deep geological and geotechnical investigations located along the seismic line; this operation could improve the depth location of the principal and secondary horizons and a more detailed lithologic association of each horizon highlighted.

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# Appendix A

## Charts

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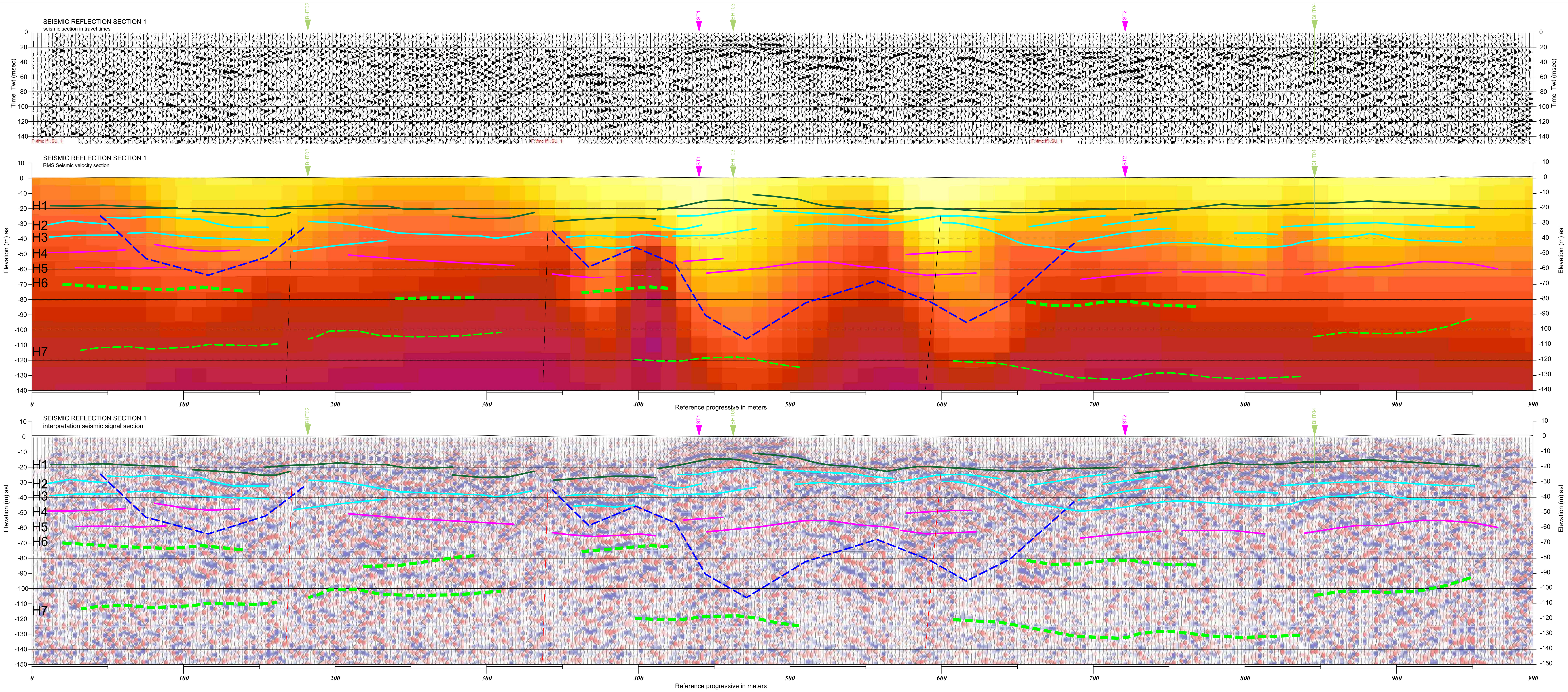
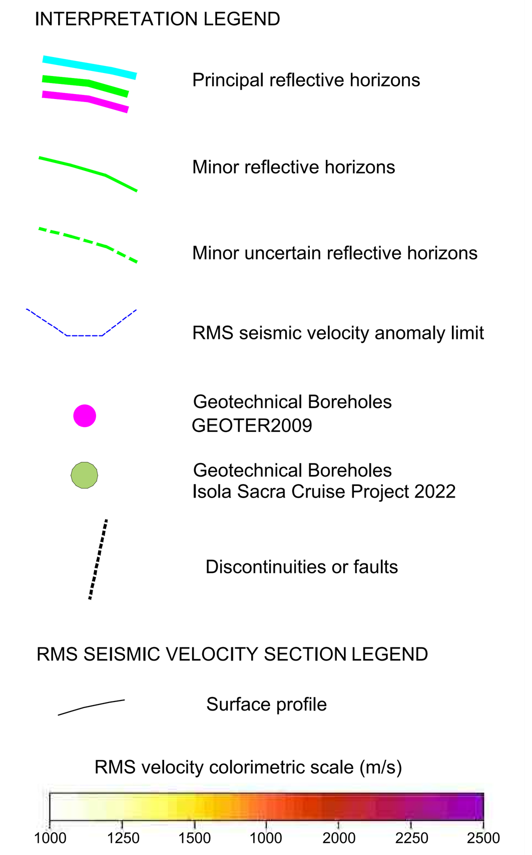
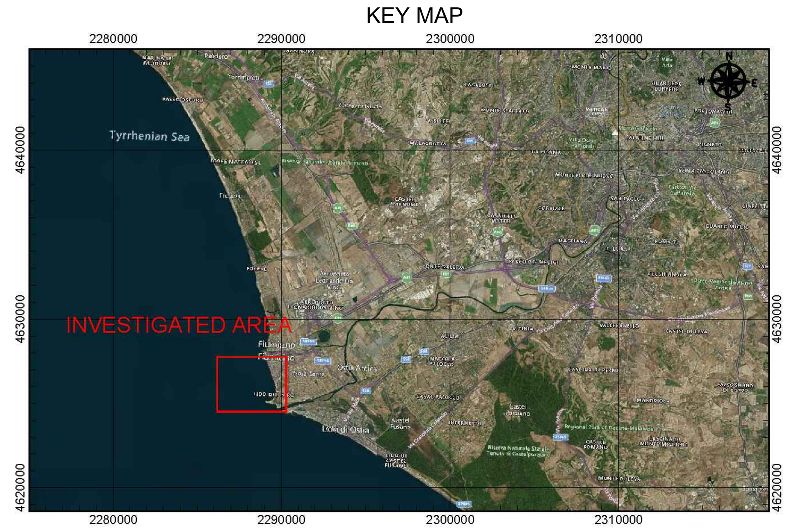




KEY MAP




GEODETIC PARAMETERS

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| **Inverse flattening** | : 297 |
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| REV | DATE | DESCRIPTION | PREPARED BY | CHECKED BY | APPROVED BY |
|---|---|---|---|---|---|
| 0 | 16/12/2022 | FINAL | MM | PDS | VD/PR |

PROJECT

ISOLA SACRA CRUISE PROJECT

CLIENT

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TITLE

# Seismic Reflection Onshore Survey

- Seismic Line: Travel Time Seismic
- Seismic Line: Interval Velocity in Depth
- Seismic Line: Seismic Interpretation in Depth

| | SIGNATURE | DATE | | |
|---|---|---|---|---|
| PREPARED BY | MM | 16/12/2022 | IDENTIFICATION No.: P00311340-1-H9 | SHEET 01 |
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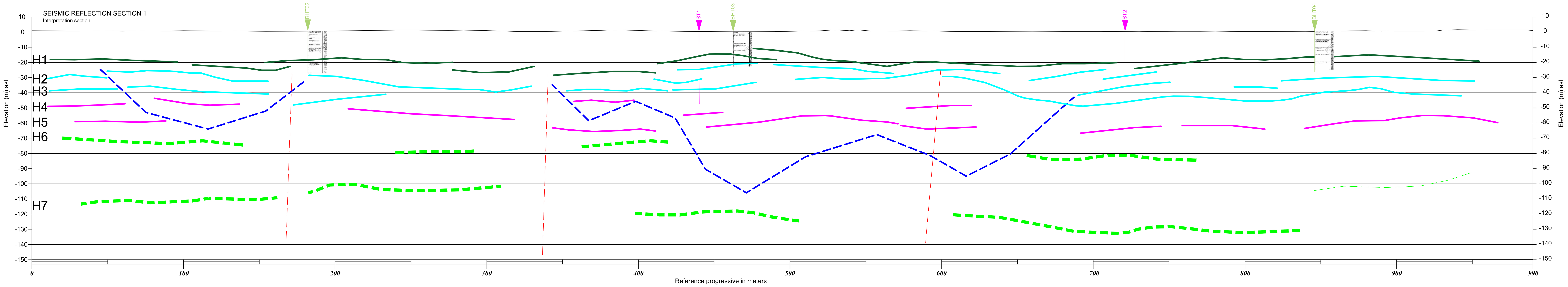
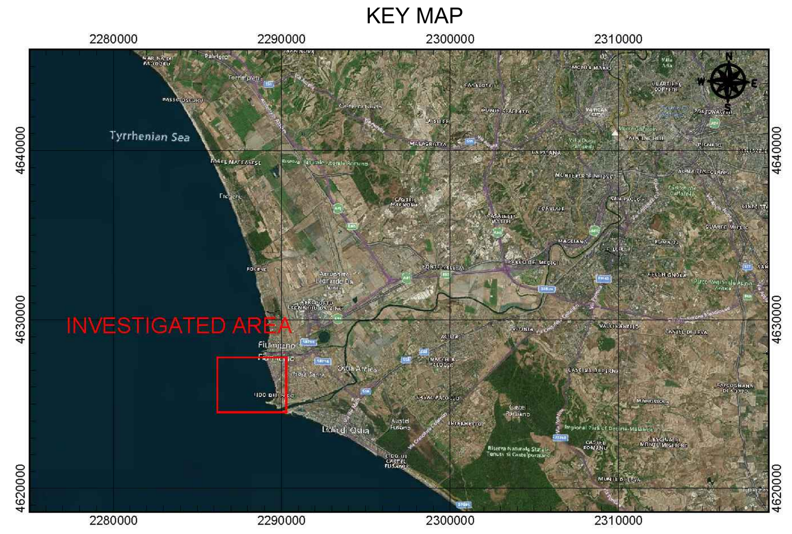



INTERPRETATION LEGEND

- Principal reflective horizons
- Minor reflective horizons
- Minor uncertain reflective horizons
- RMS seismic velocity anomaly limit
- Geotechnical Boreholes GEOTER2009
- Geotechnical Boreholes Isola Sacra Cruise Project 2022

KEY MAP

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| **Inverse flattening** | : 297 |
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PROJECT

ISOLA SACRA CRUISE PROJECT

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TITLE

# Seismic Reflection Onshore Survey

- Seismic Line: Interpretation Section

| | SIGNATURE | DATE |
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| CONTROLLED BY | PDS | 16/12/2022 |
| APPROVED BY | VD/PR | 16/12/2022 |

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