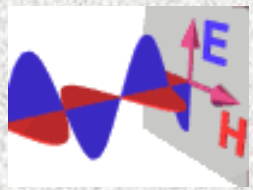
GROUND PENETRATING RADAR

for

STRUCTURE EVALUATION STUDIES

for: Foundation Performance Association Meeting

March 24, 2004

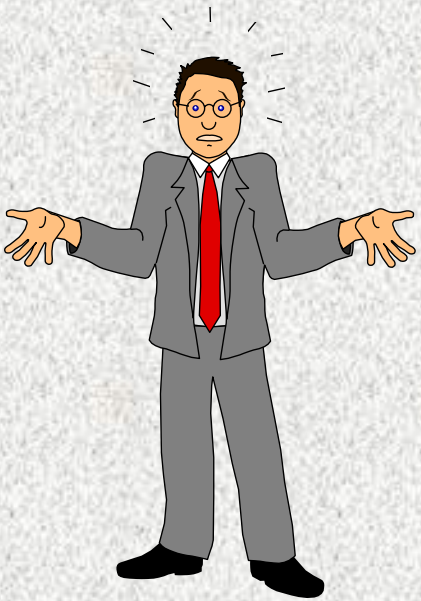


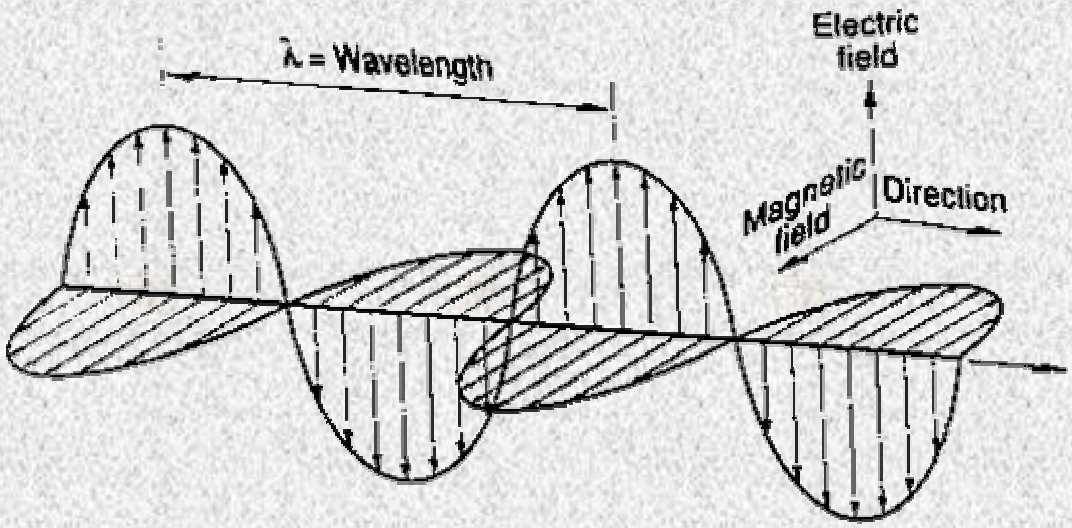
by: Michael Gehrig, P.E.

BRYANT CONSULTANTS

- What is GPR?
- How does GPR work?
- Various Applications
- Signal Interpretation
- Example of GPR Radargrams

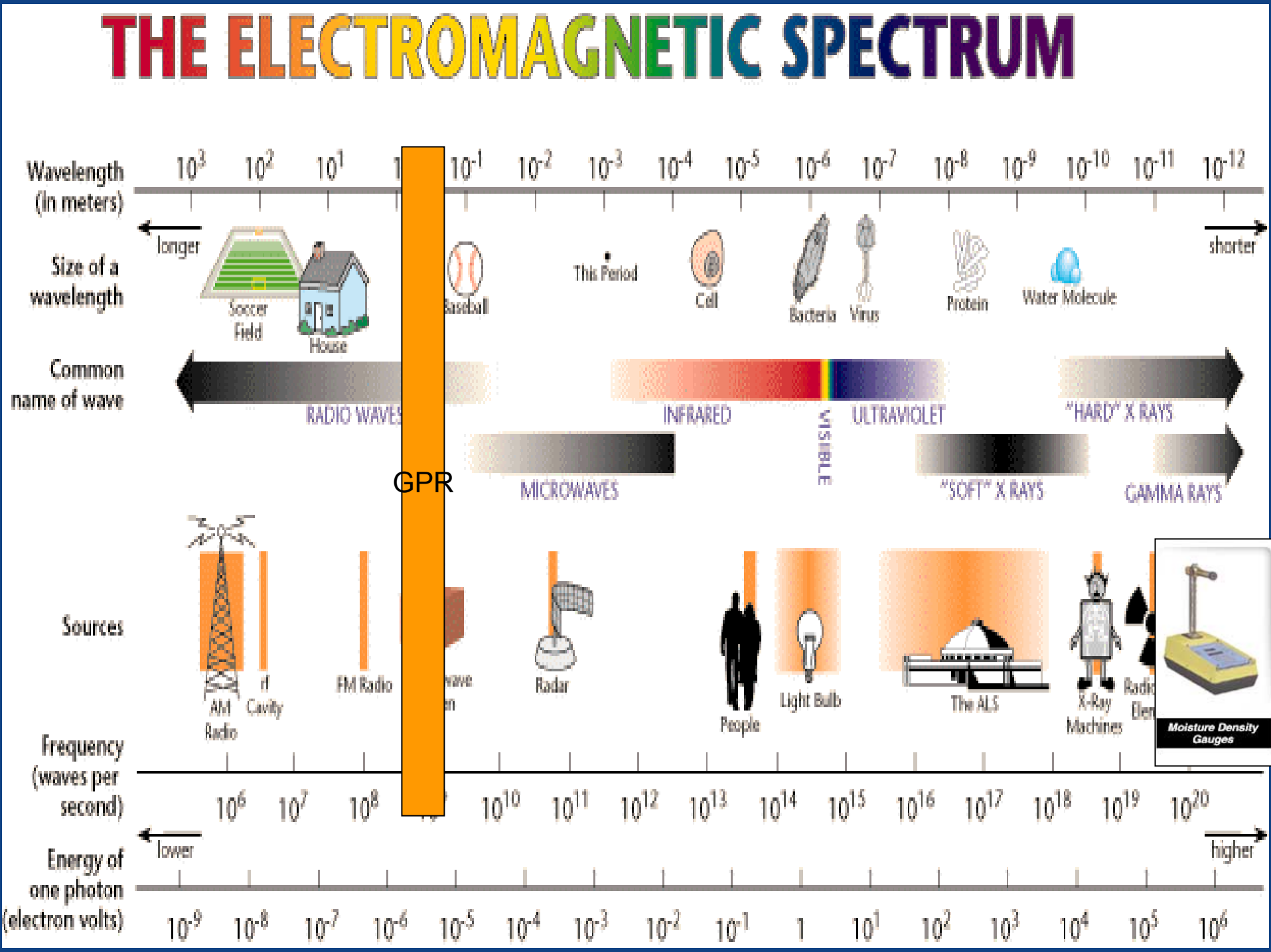
What Is Ground Penetrating Radar?





- GPR is a geophysical technique that radiates **electromagnetic energy** into the subsurface. When this pulse strikes an interface between layers of materials with different electrical properties, part of the wave reflects back, and the remaining energy continues to next interface.

THE ELECTROMAGNETIC SPECTRUM

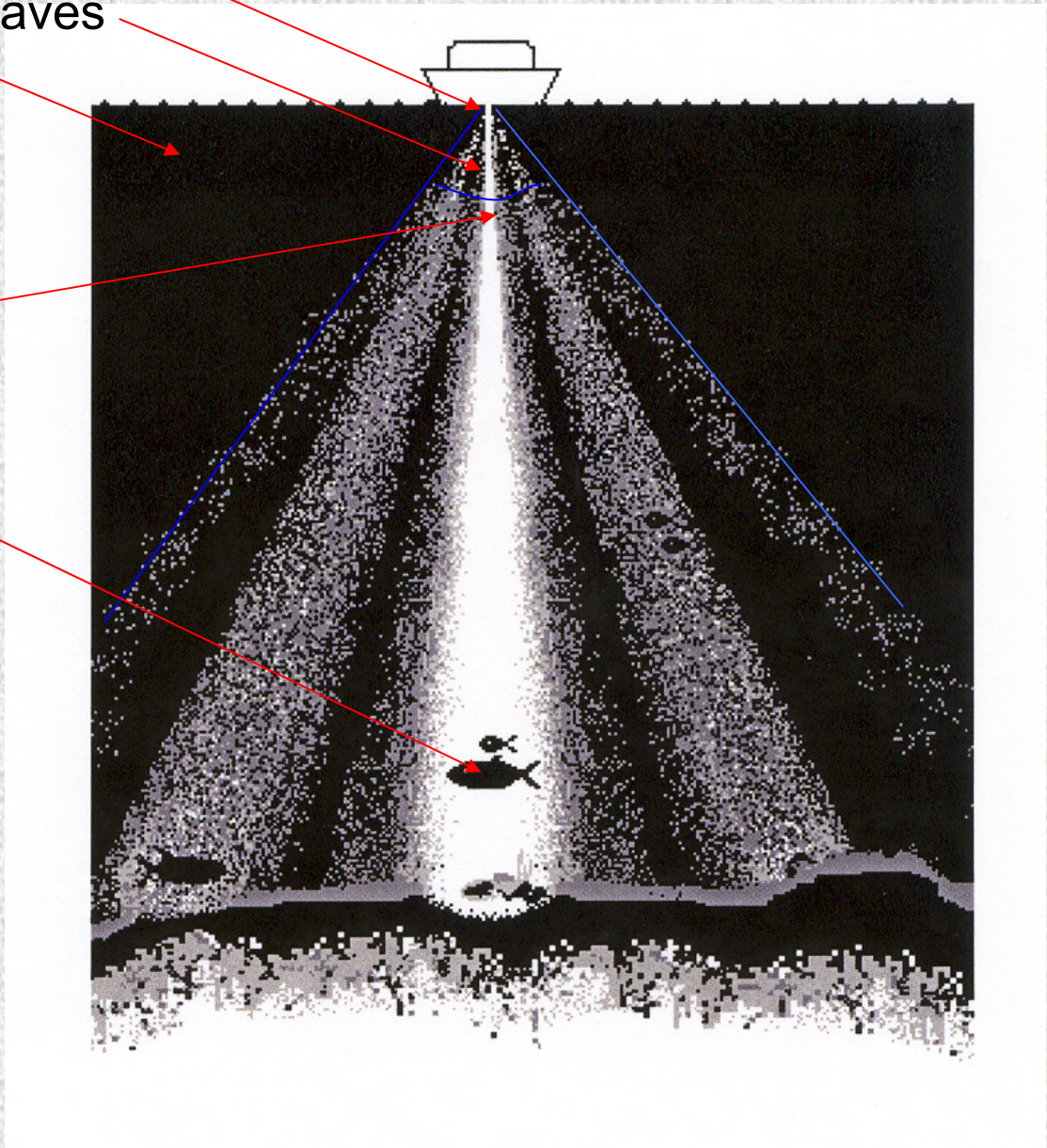


How does GPR Work?

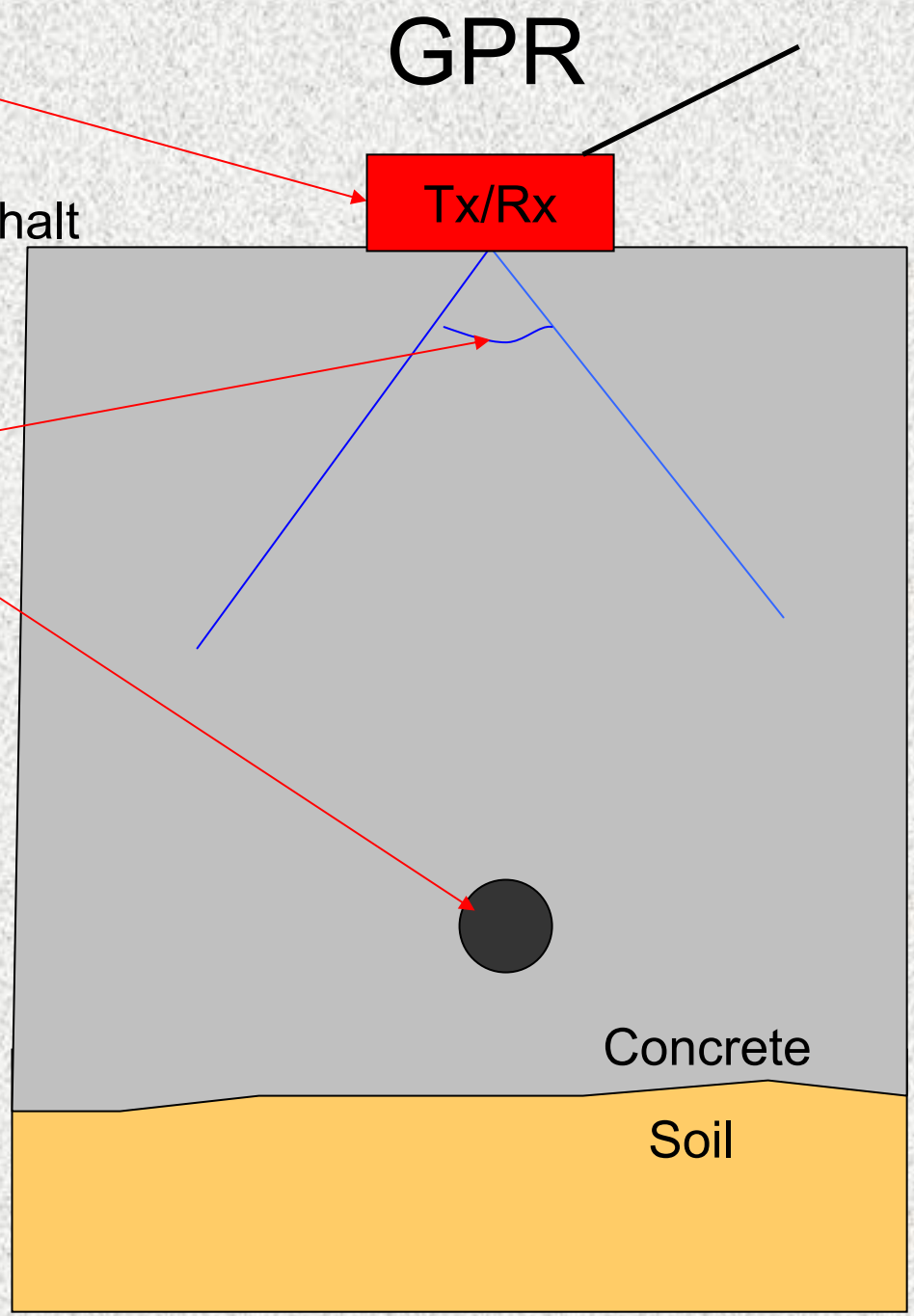
LOWRANCE
X-15

Sonar

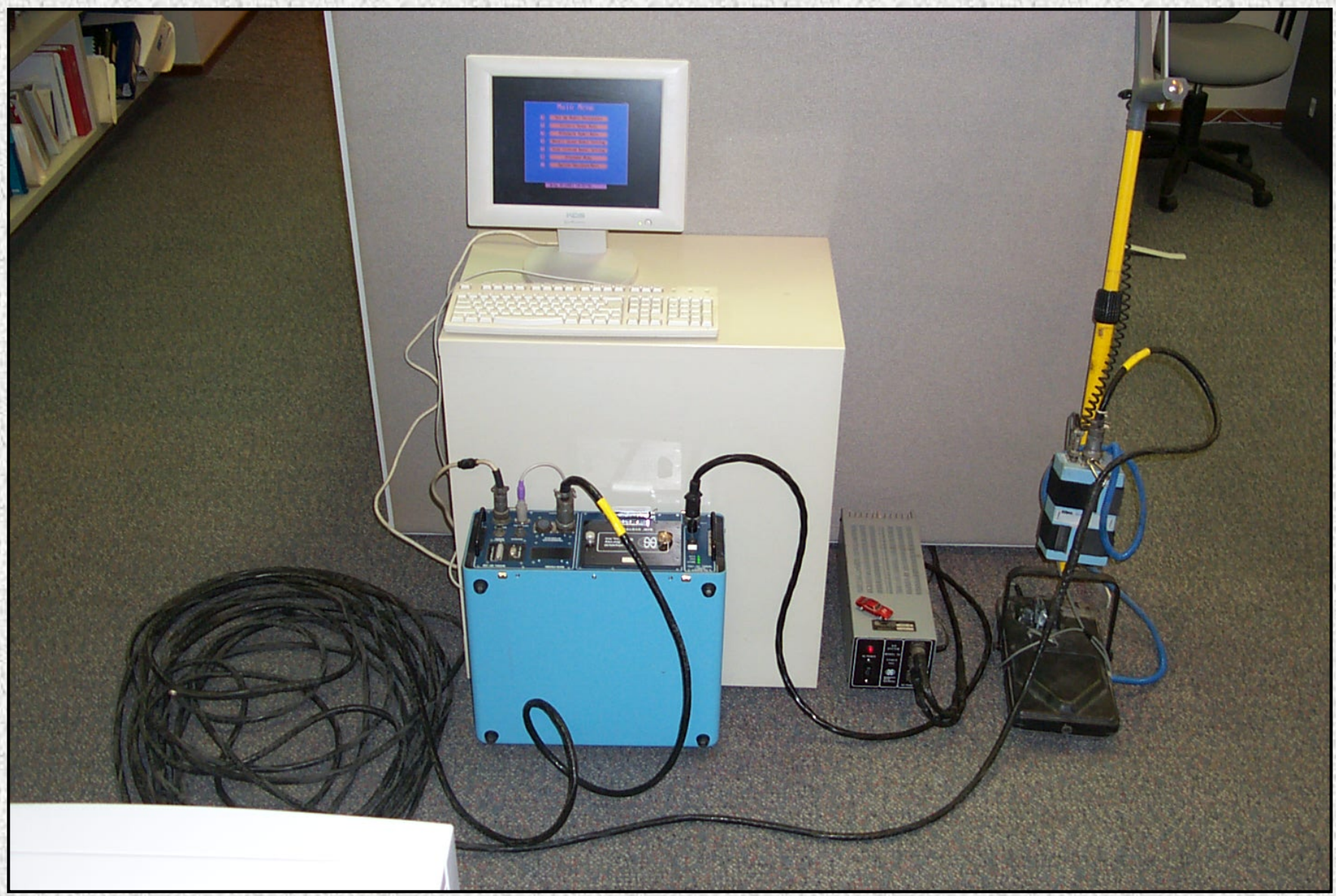
- Energy Generation – Transducer
- Energy Source – Ultrasonic Waves
- Propagation Medium – Water
- Wave Speed - ~1500 m/s
- Frequency ~ 400 kHz
- Cone Angle ~ 10 degrees
- Target - fish



- Energy Generation – Antennae
- Energy Source – Electromagnetic
- Propagation Medium – Concrete/Asphalt
- Wave Speed - ~100000000 m/s
- Frequency ~ 1000 to 1500 MHz
- Cone Angle ~ 60 to 90 degrees
- Target – pipe, rebar, voids, etc.



EQUIPMENT



Various Applications of GPR For Structure Evaluation

TYPE OF STRUCTURE

TUNNELS

PARKING LOTS

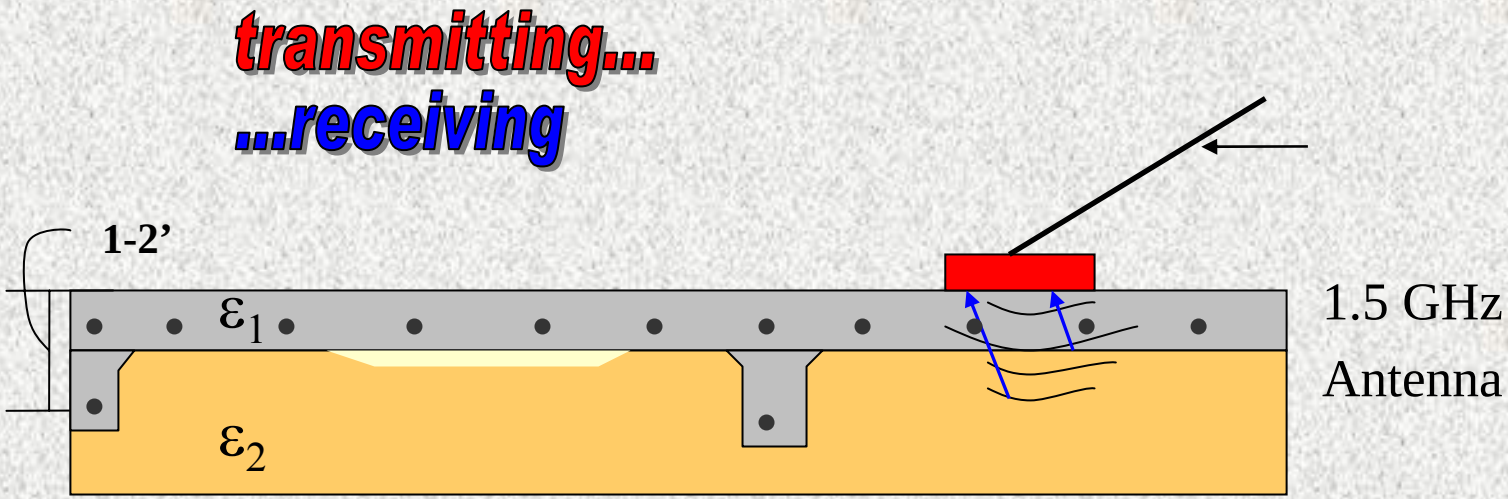
RETAINING WALLS

STREETS/HIGHWAYS

TILT WALL PANELS

FOUNDATION SLABS

GROUND PENETRATING RADAR

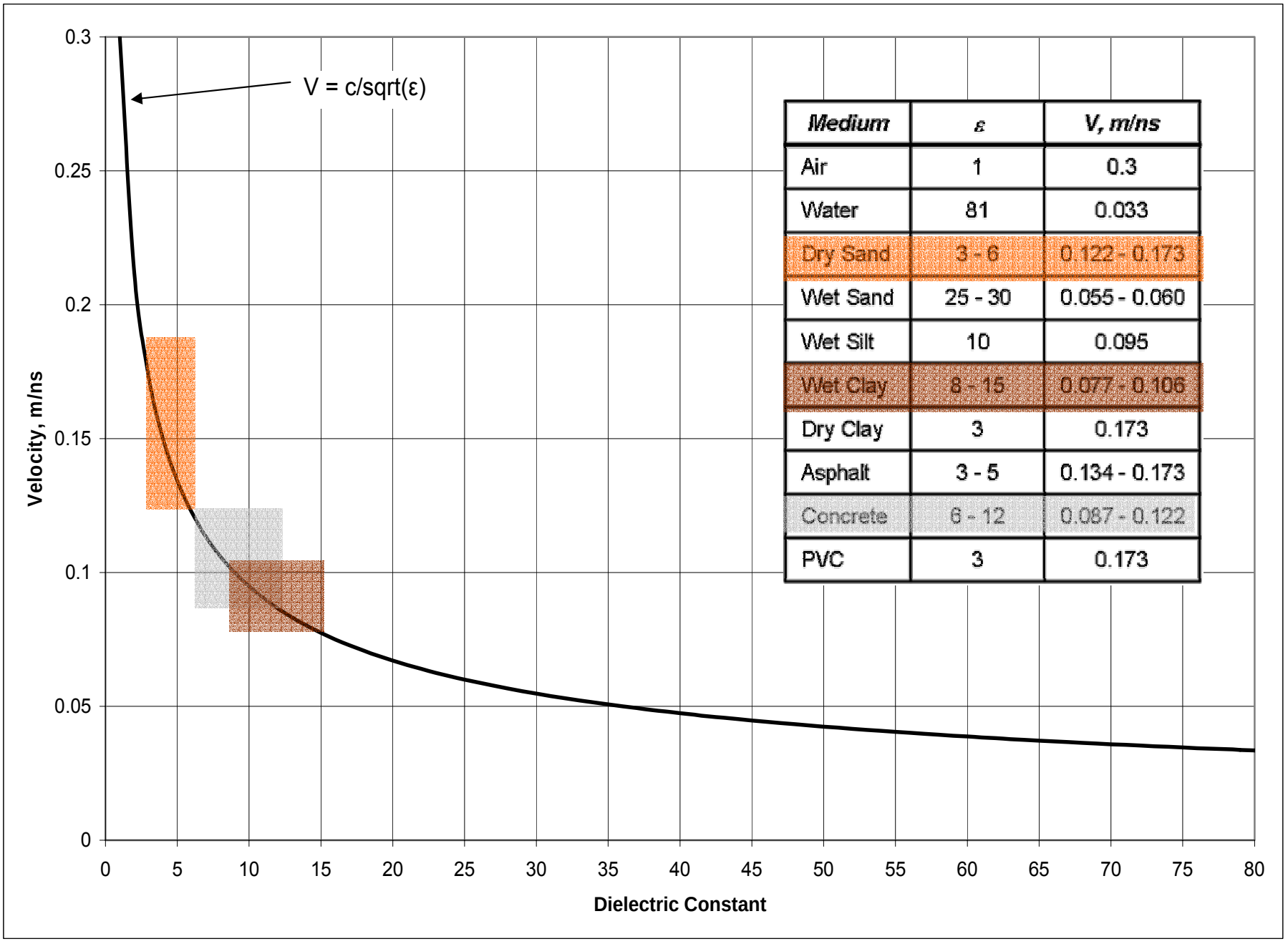


Useful for detecting/quantifying:

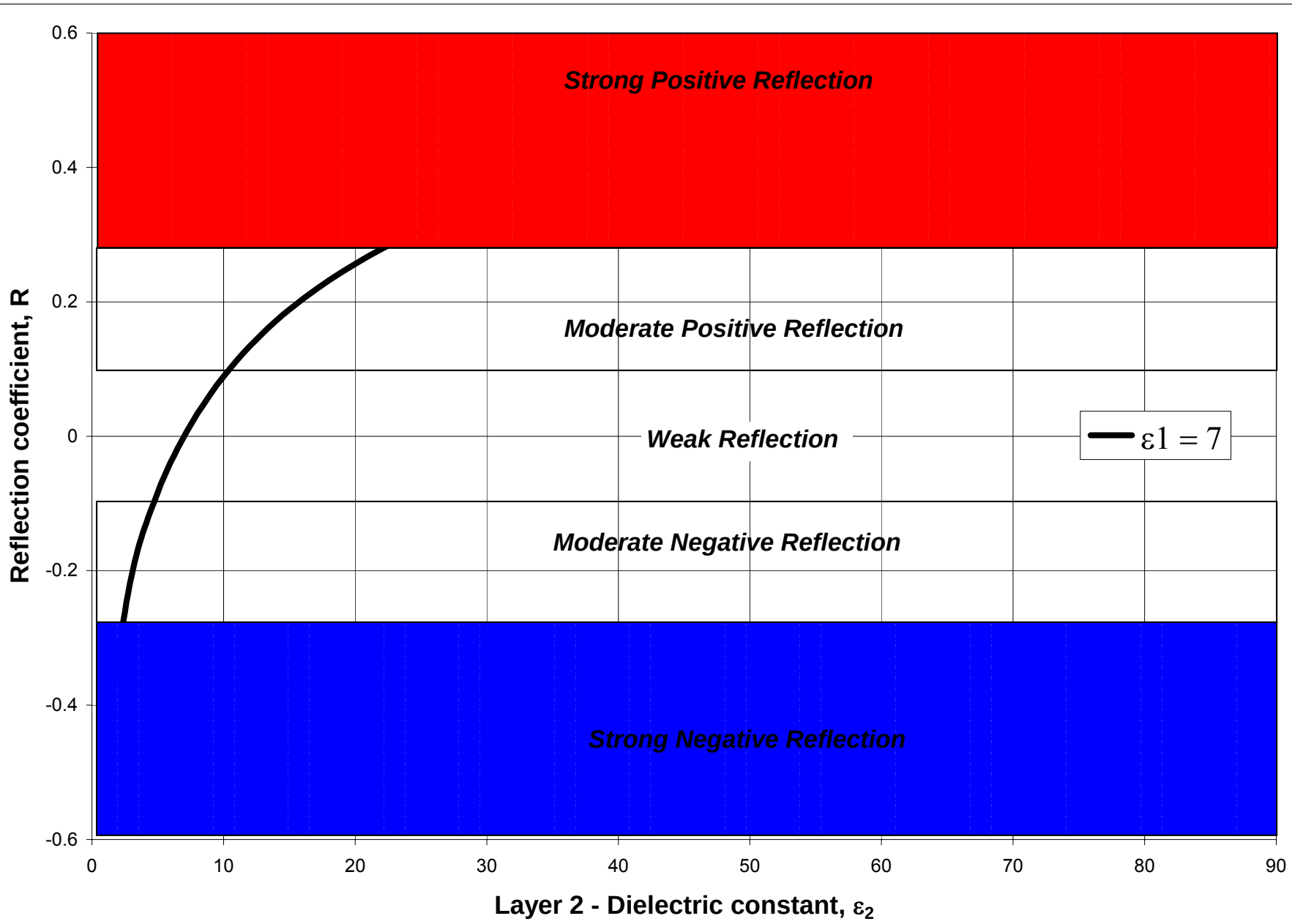
- Pavement/slab thickness
- Grade beam location/depth
- Reinforcement placement (vertical/horizontal)
- Subsurface Void detection (water/air filled)
- Utility lines

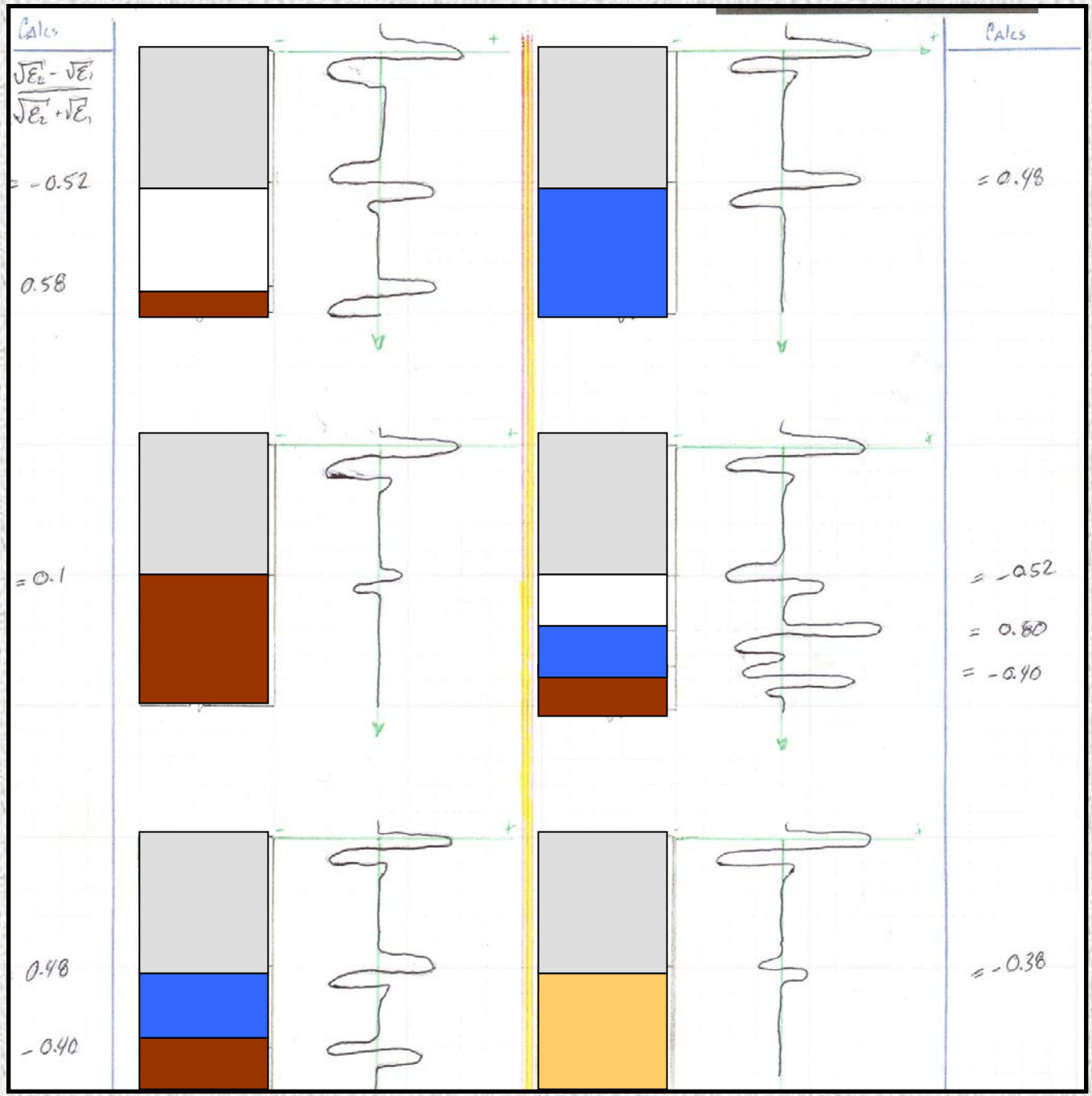
- **HIGH RESOLUTION**
- **LIMITED DEPTH**

Signal Interpretation



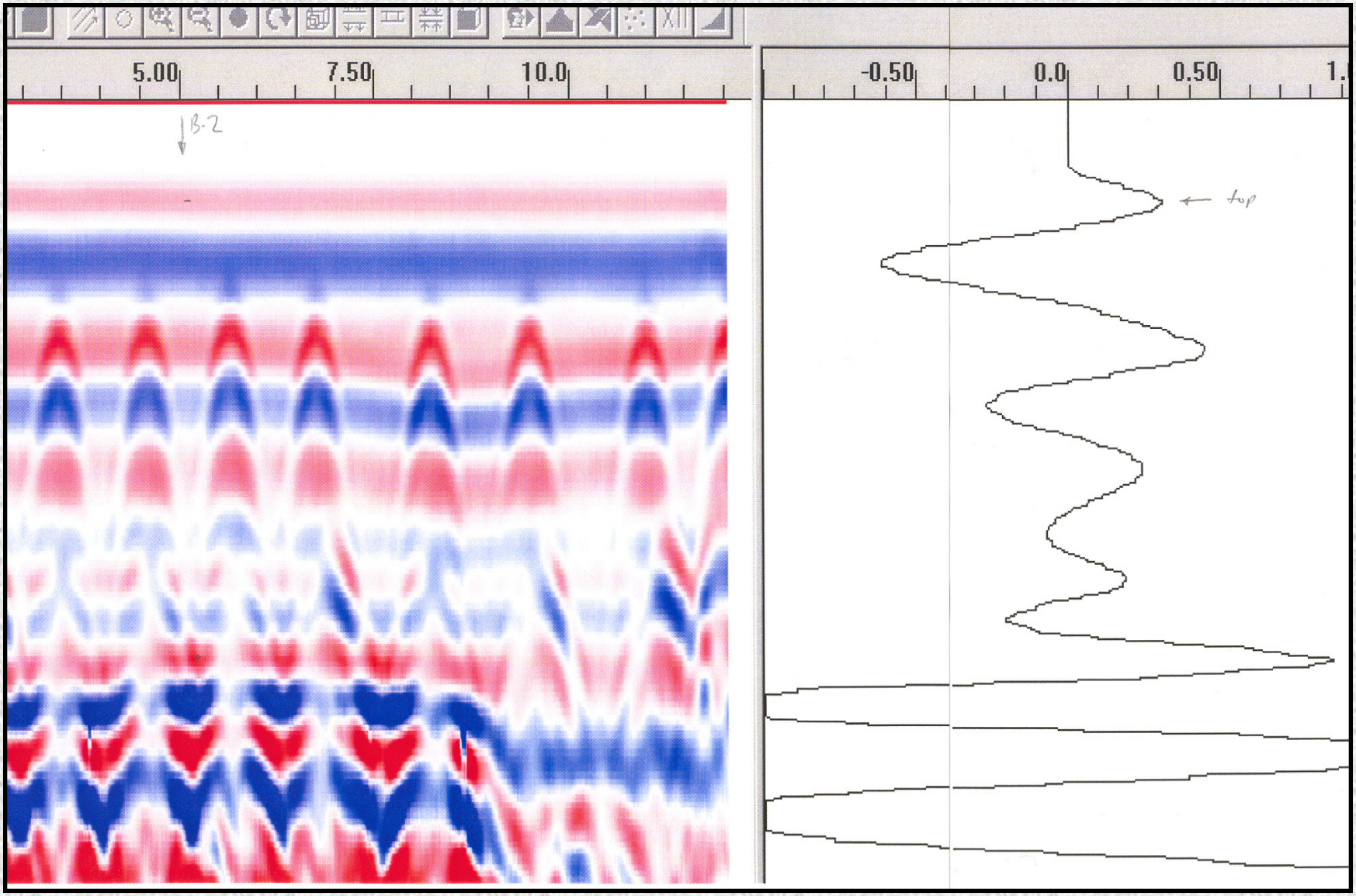
Medium	*ε*	*V, m/ns*
Air	1	0.3
Water	81	0.033
Dry Sand	3 - 6	0.122 - 0.173
Wet Sand	25 - 30	0.055 - 0.060
Wet Silt	10	0.095
Wet Clay	8 - 15	0.077 - 0.106
Dry Clay	3	0.173
Asphalt	3 - 5	0.134 - 0.173
Concrete	6 - 12	0.087 - 0.122
PVC	3	0.173


Strong Positive Reflection
Moderate Positive Reflection
Weak Reflection
Moderate Negative Reflection
Strong Negative Reflection
ε1 = 7
Reflection coefficient, R
Layer 2 - Dielectric constant, ε2
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
10
20
30
40
50
60
70
80
90

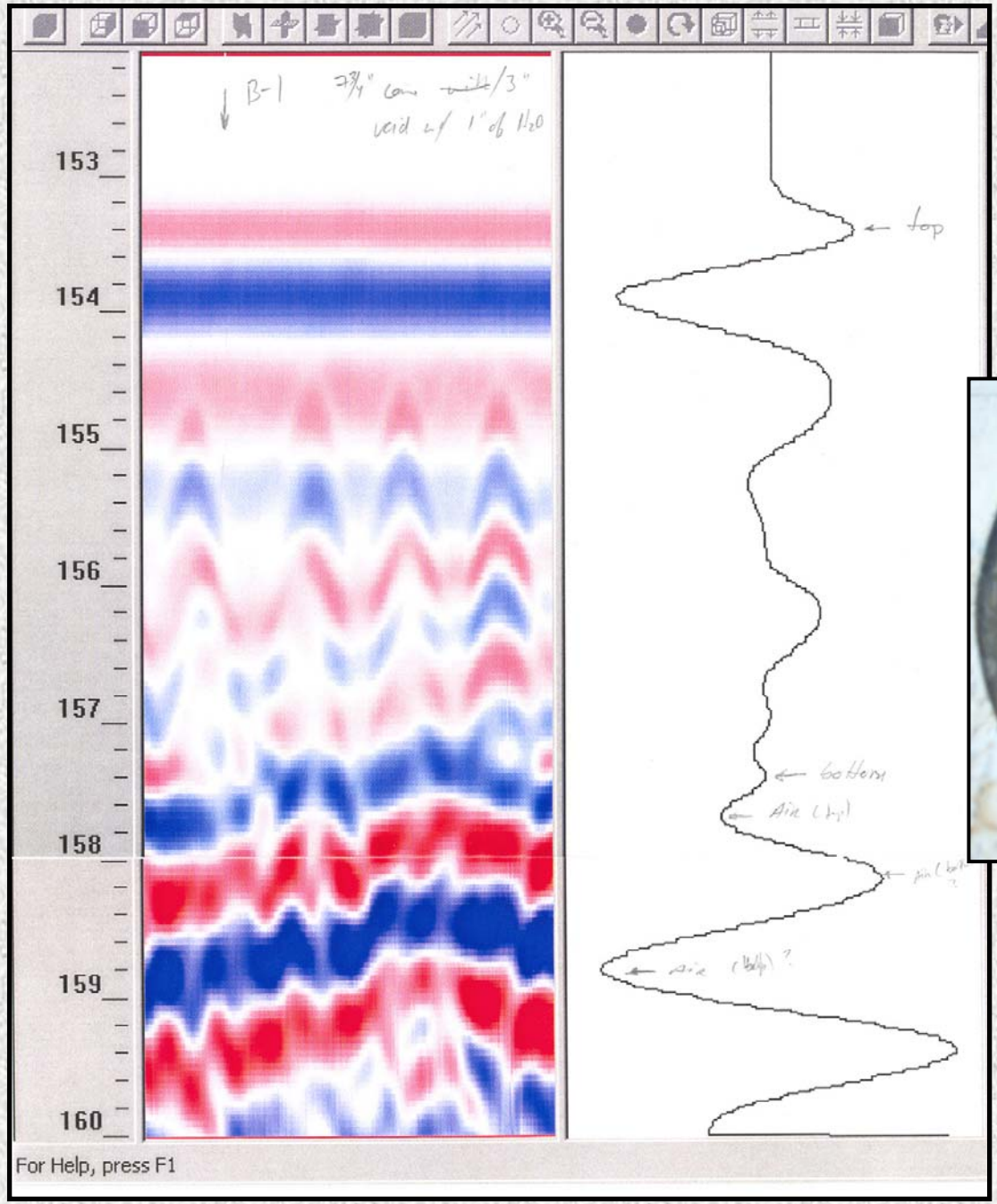

Calcs
$\frac{\sqrt{\varepsilon_2}-\sqrt{\varepsilon_1}}{\sqrt{\varepsilon_2}+\sqrt{\varepsilon_1}}$
= -0.52
0.58
= 0.1
0.48
-0.40
Calcs
= 0.48
= -0.52
= 0.80
= -0.40
= -0.38
CONCRETE
WET SOIL
AIR
DRY SOIL
WATER

Examples of GPR Radargrams

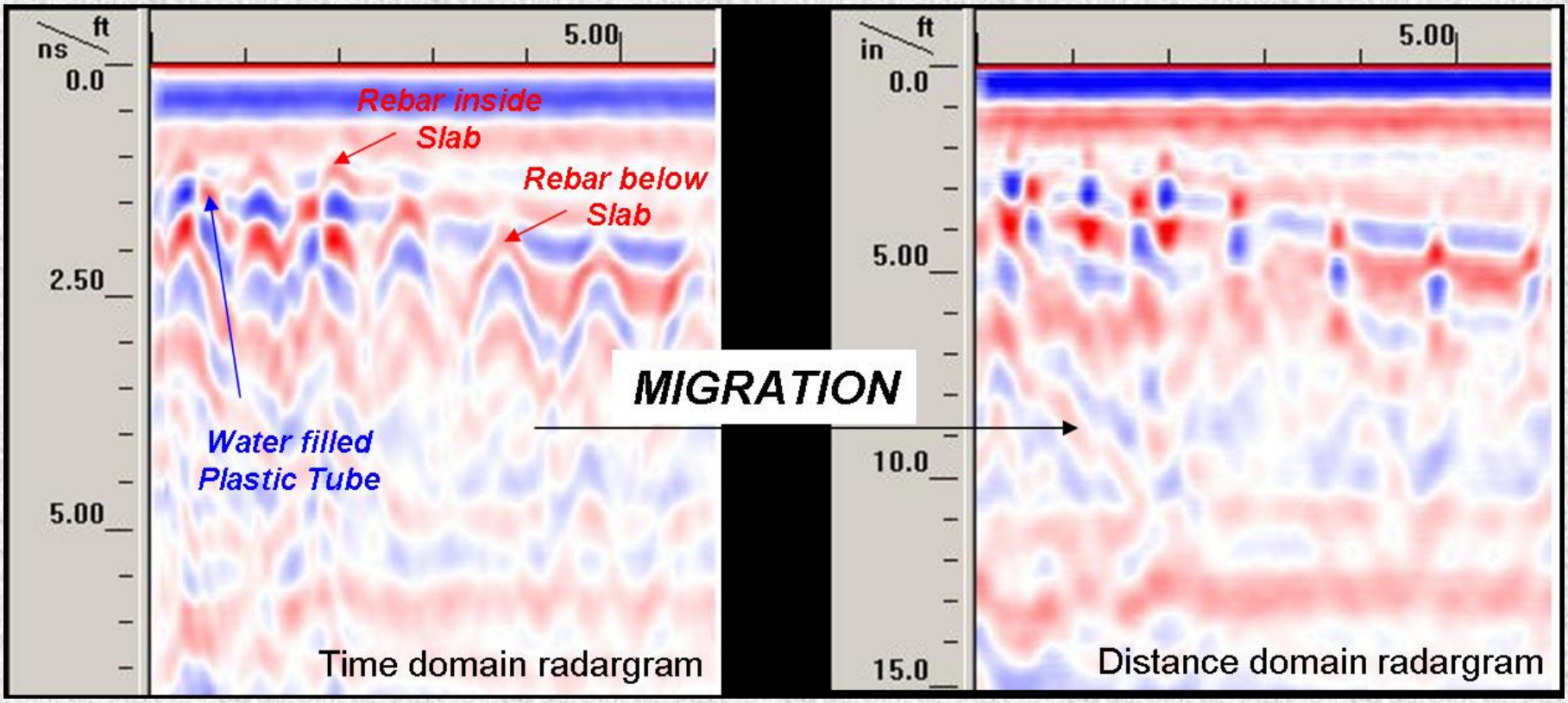
Example 1 – *Concrete/Water* Interface



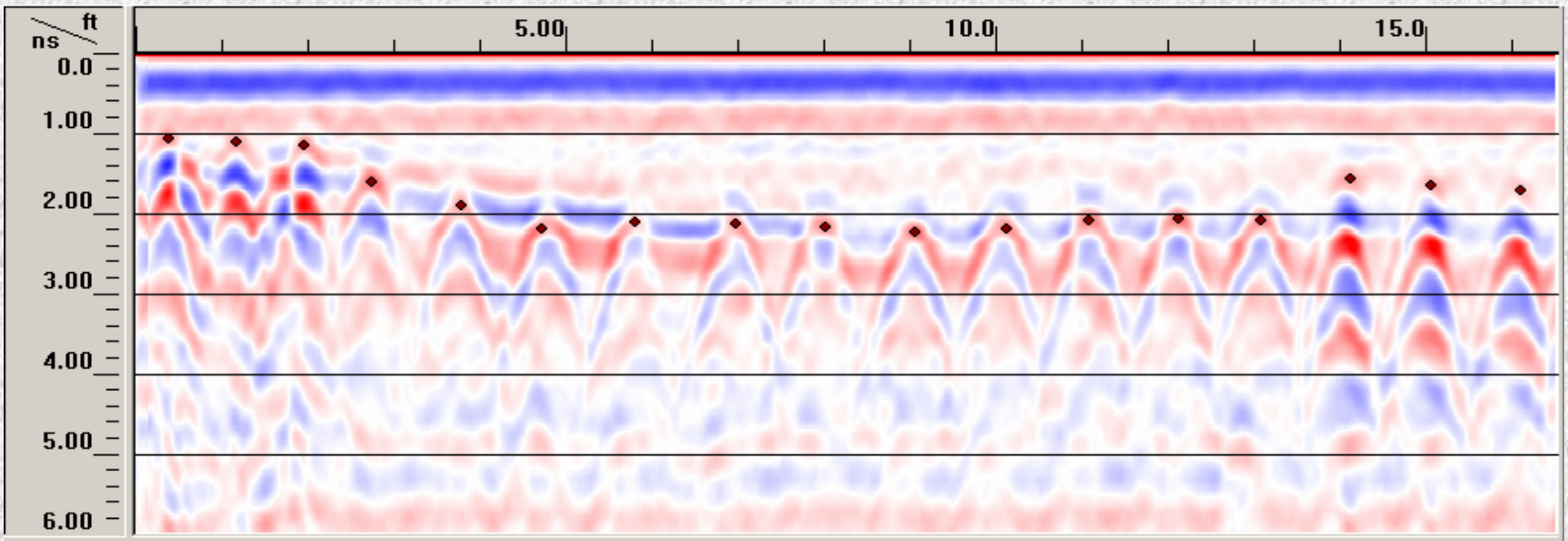
Example 2 – *Concrete/Air* Interface

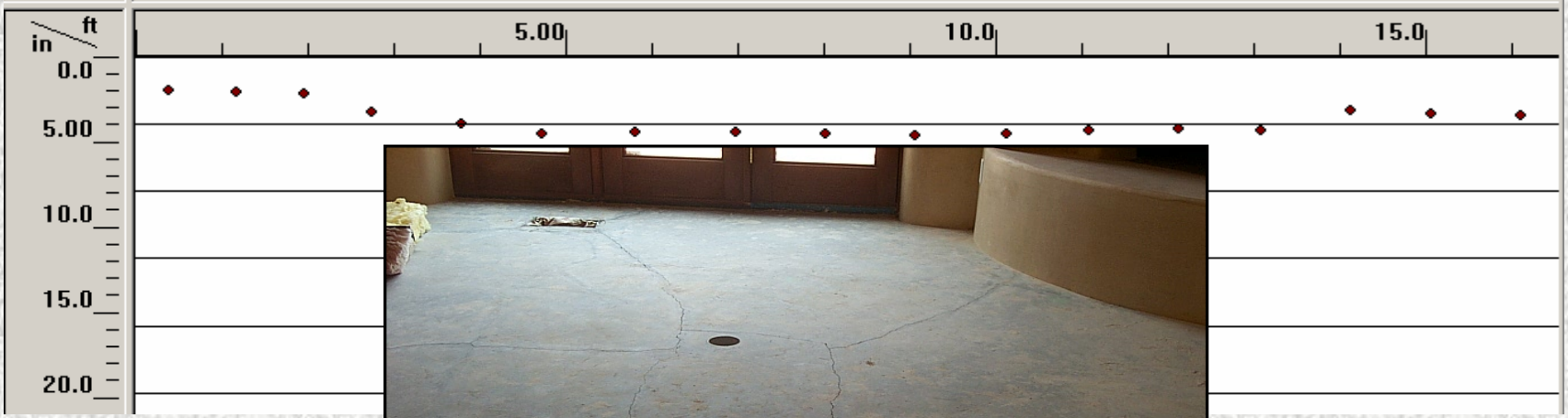


Example 3 –
Data Migration

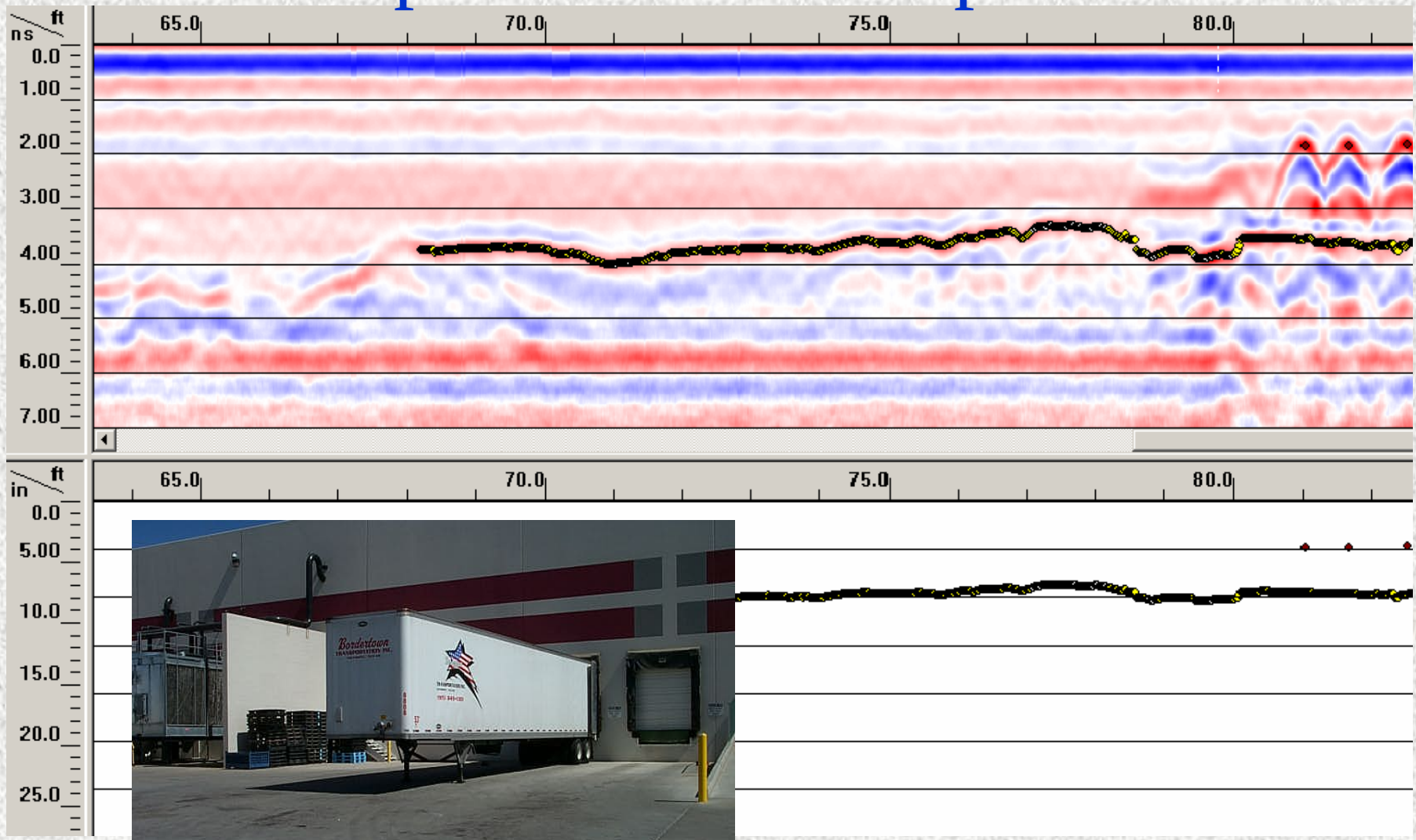


Example 4 – Rebar *below* concrete slab

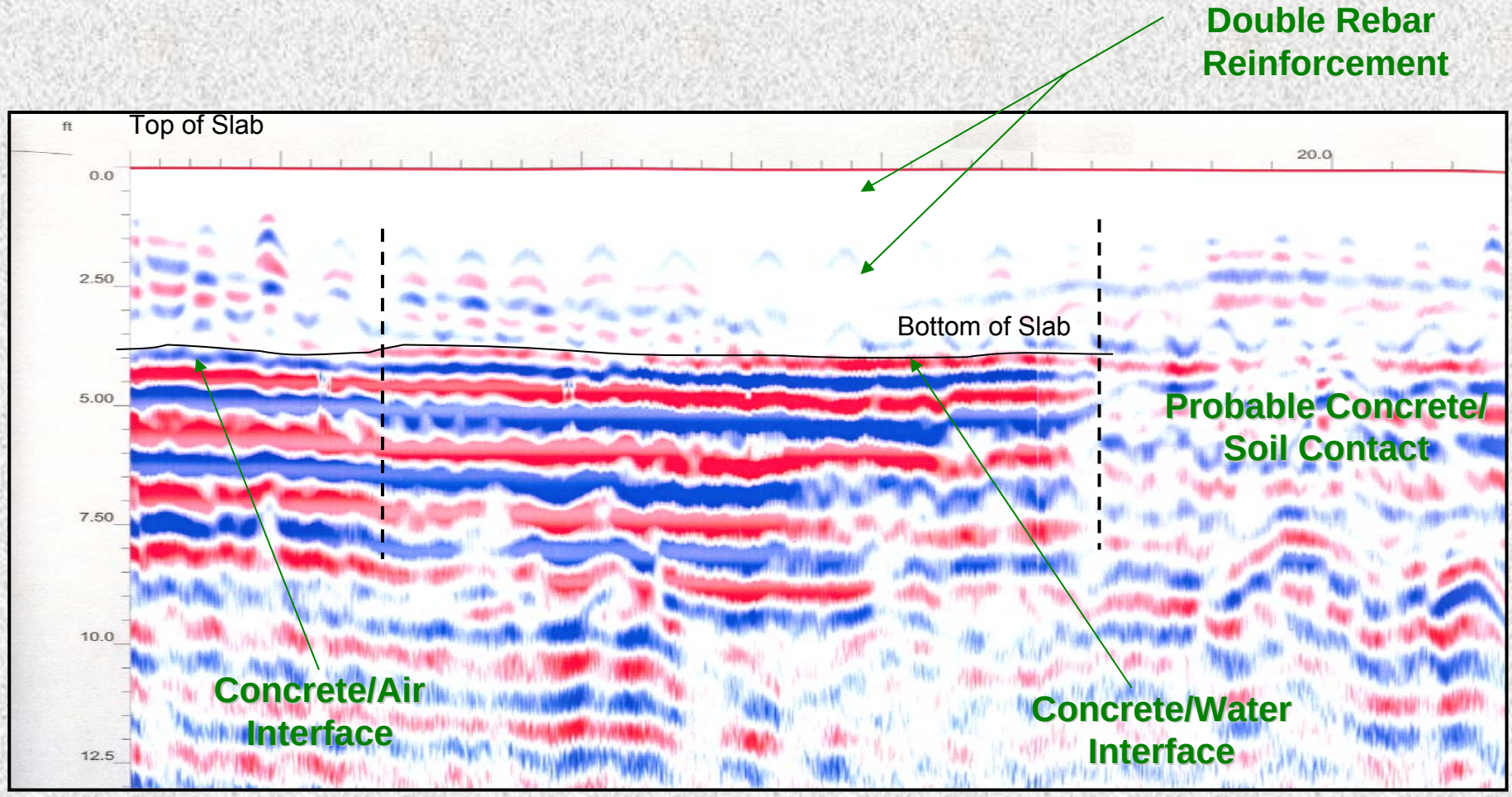




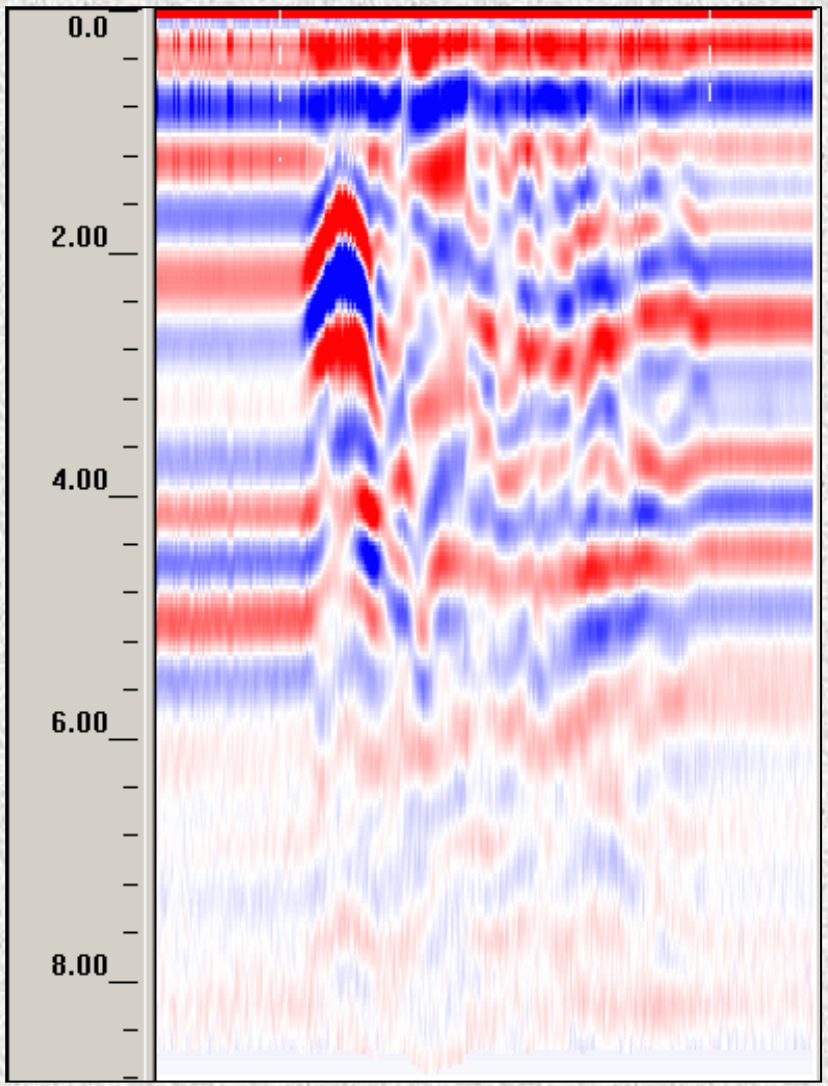
Example 5 – *No* rebar present



Example 6 – Varying Interfaces beneath concrete slab

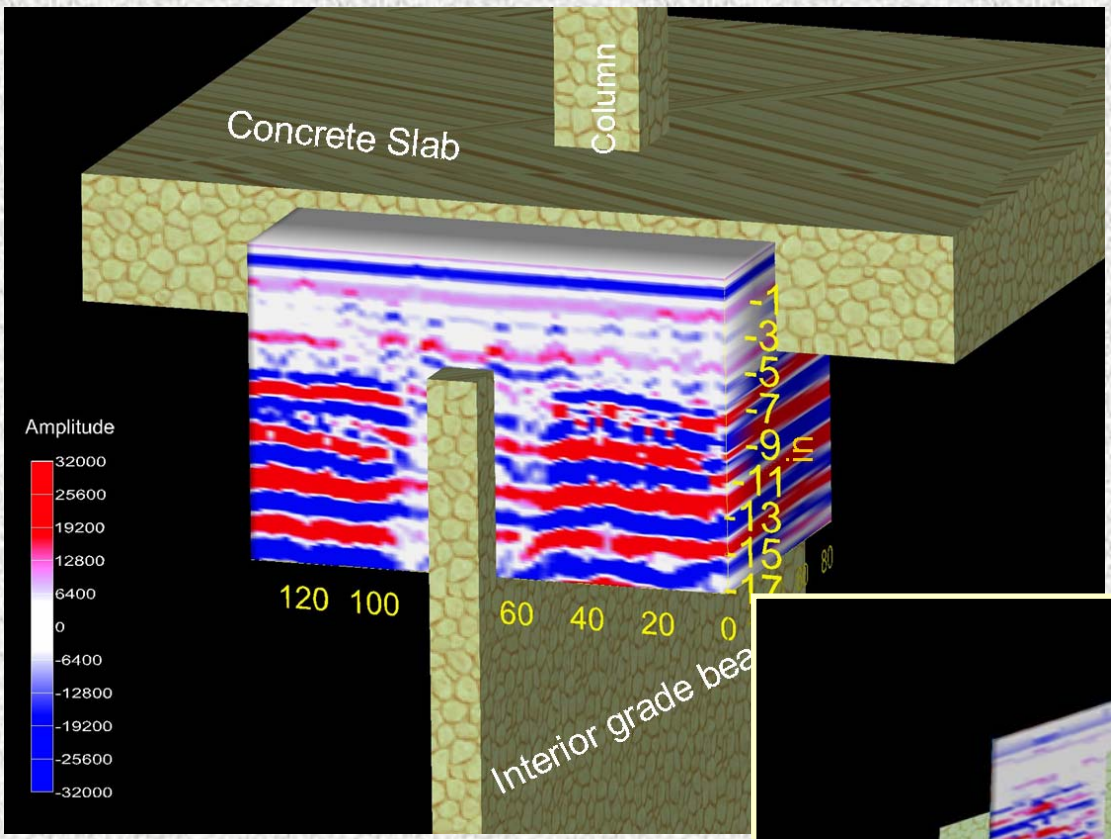


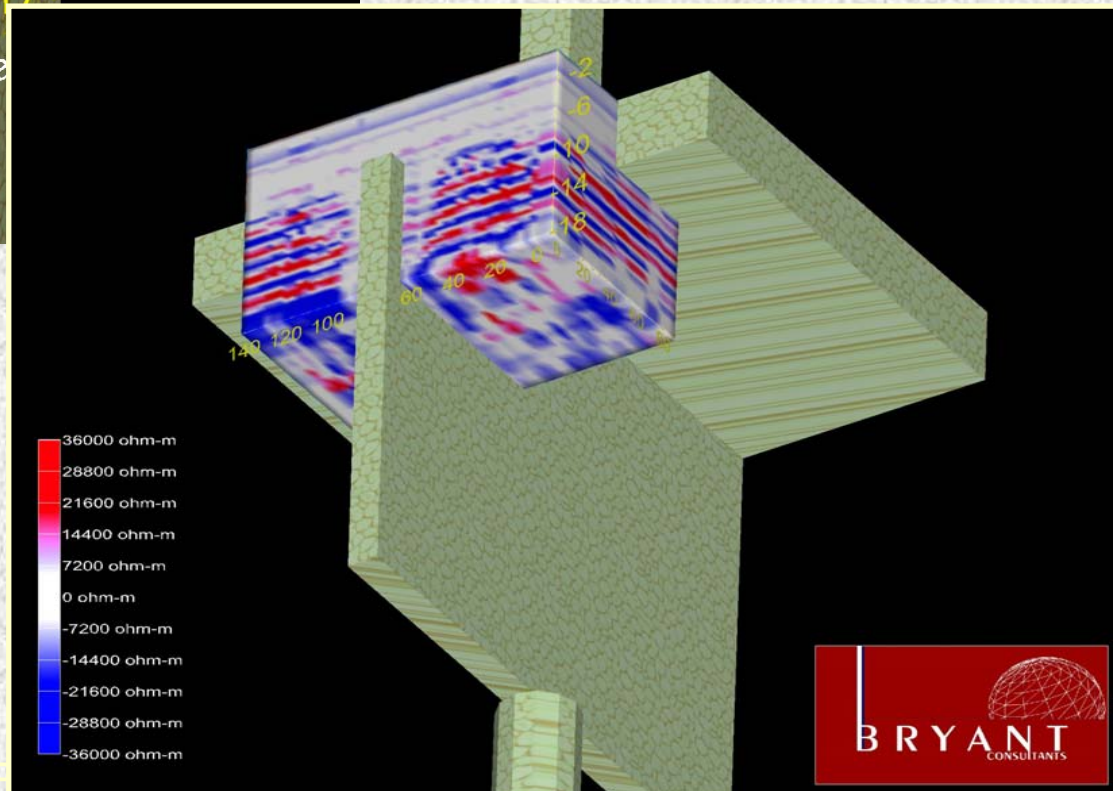
Example 7 – *Grade Beam Scans*

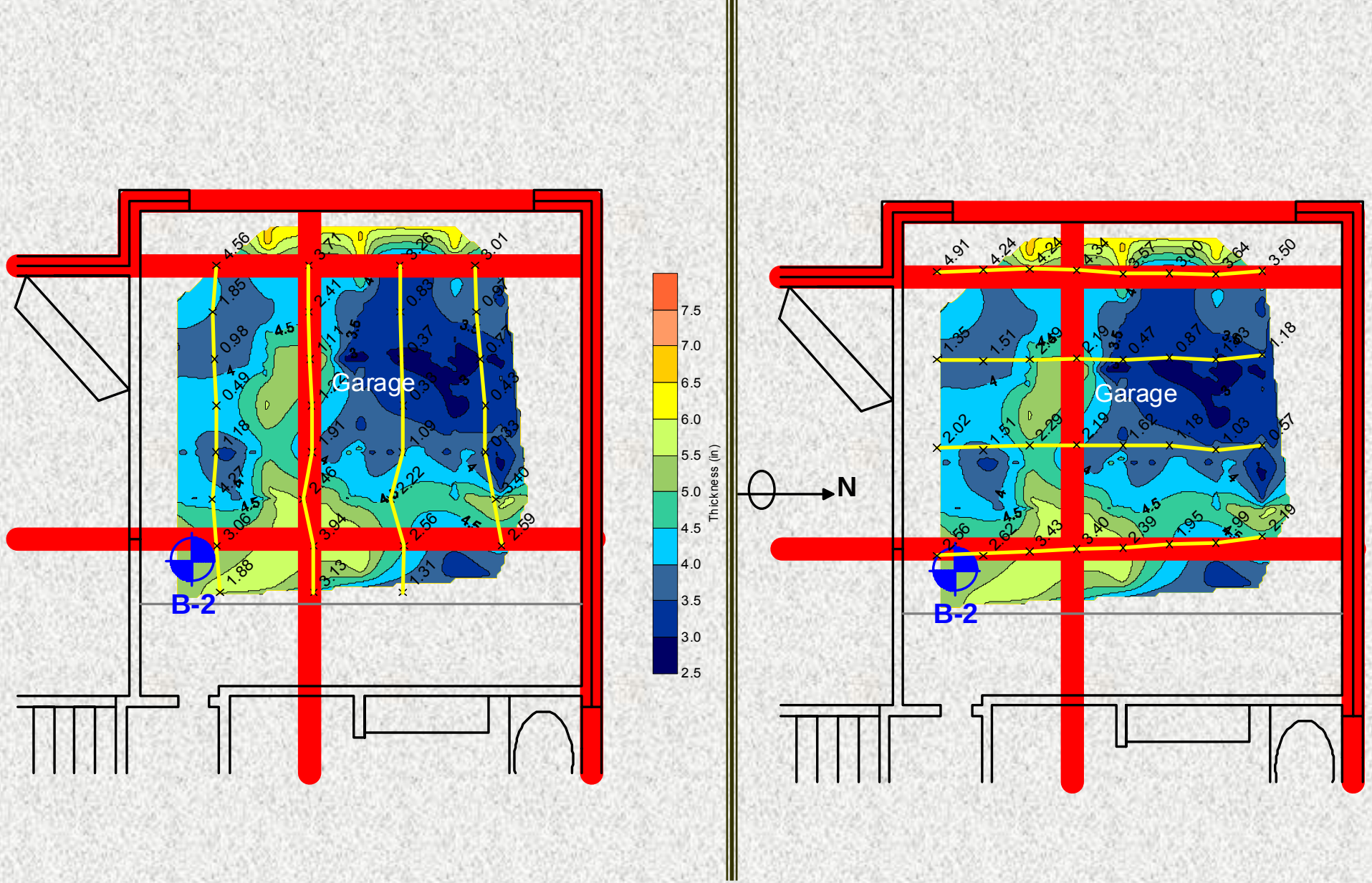


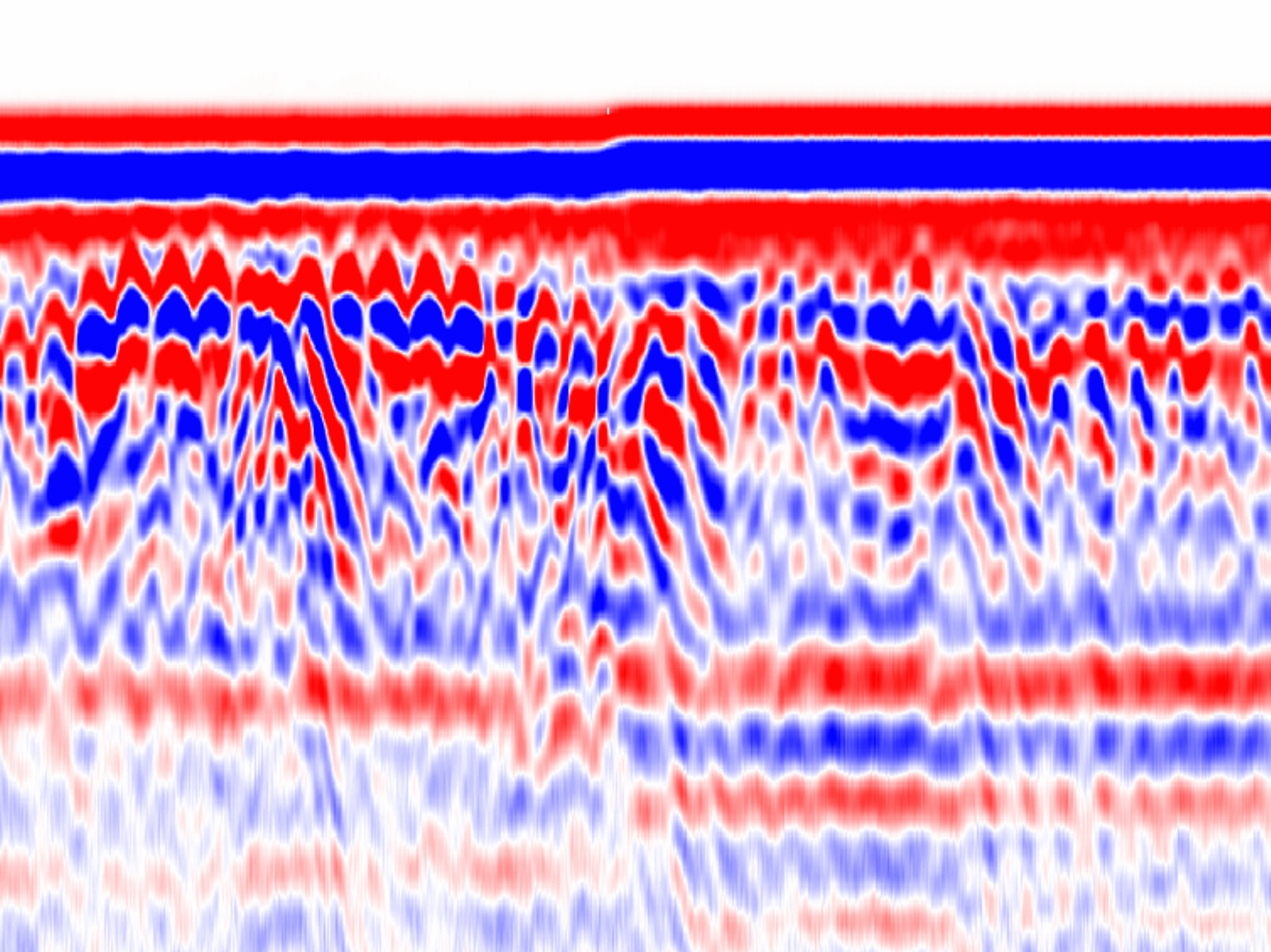
Grade Beam Lift Off

Example 6 – *3D Model (oversized grade beam)*







Final Data Processing Generation

Masonry Retaining Wall Project