



Remediation of CVOCs in a Residential Area by Electrical Resistance Heating

June/2024

A wide landscape photograph showing a calm lake in the foreground, a dense forest of evergreen trees in the middle ground, and rugged mountains in the background under a cloudy sky.

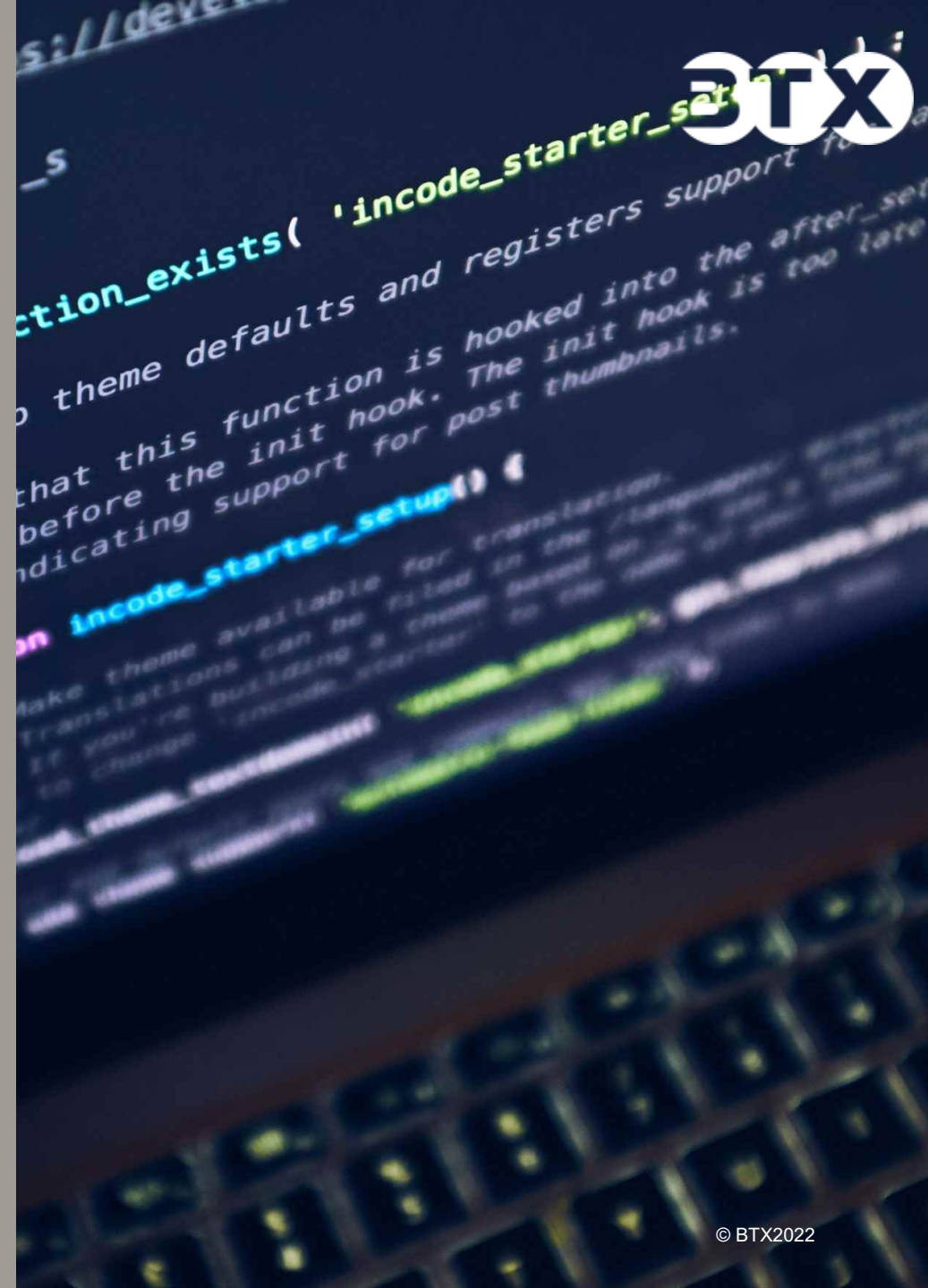
2024 Chlorinated Conference

Remediation of CVOCs in a Residential Area by **ELECTRICAL RESISTANCE HEATING**

Bruna Pioli, Amanda Basaglia, Diana Chang, Marcelo Altafini - BTX
Geologia e Meio Ambiente; Thiago L. Gomes - TRS Doxor, Jacob Seeman
TRS

PRESENTATION STRUCTURE

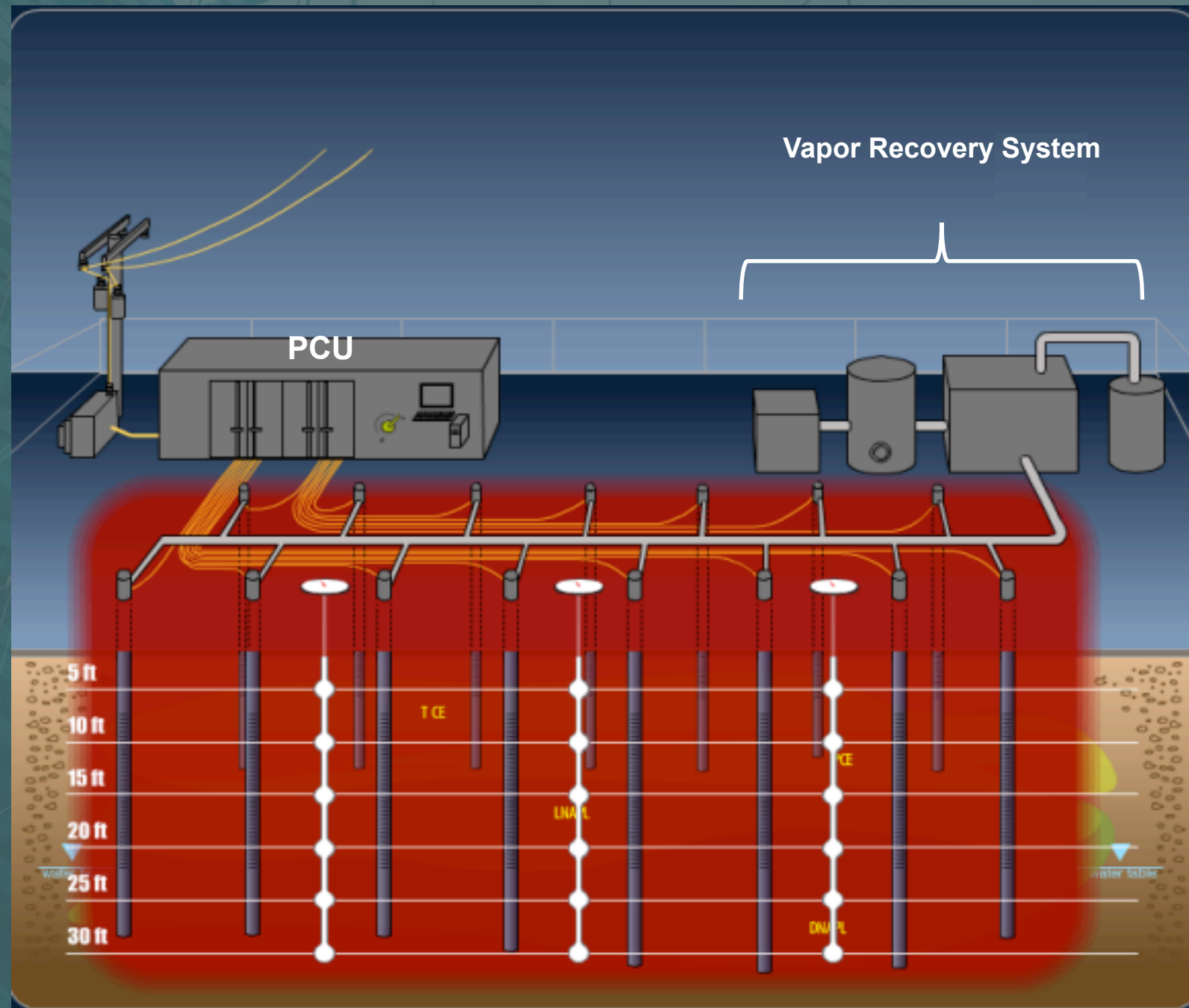
- INTRODUCTION
- TECHNOLOGY SELECTION
- PROJECT DESIGN
- IMPLEMENTATION AND CHALLENGES
- OPERATIONS
- RESULTS
- FINAL THOUGHTS



INTRODUCTION

- The treatment volume was beneath the parking garage of a residential condominium in São Paulo
- There is an extensive track record of environmental management and application of varied remediation techniques at this site already:
 - Soil & Waste Removal
 - Injection of a reducing agent into groundwater, but this did not achieve the remediation targets
- The latest revision to the Intervention Plan defined ERH- Electrical Resistance Heating as the appropriate remediation technique

TECHNOLOGY SELECTION



ERH schematic taken from TRS Doxor, 2022

PROJECT DESIGN

- **Remediation Targets - Shallow Aquifer**

I. TETRACHLOROETHYLENE (PCE)

II. TRICHLOROETHYLENE (TCE)

III. VINYL CHLORIDE (VC)

Risk – Inhalation of vapors in
a Closed Residential
Environment

- **Remediation Goals - Intermediate Aquifer**

I. TETRACHLOROETHYLENE (PCE) – 1% Solubility

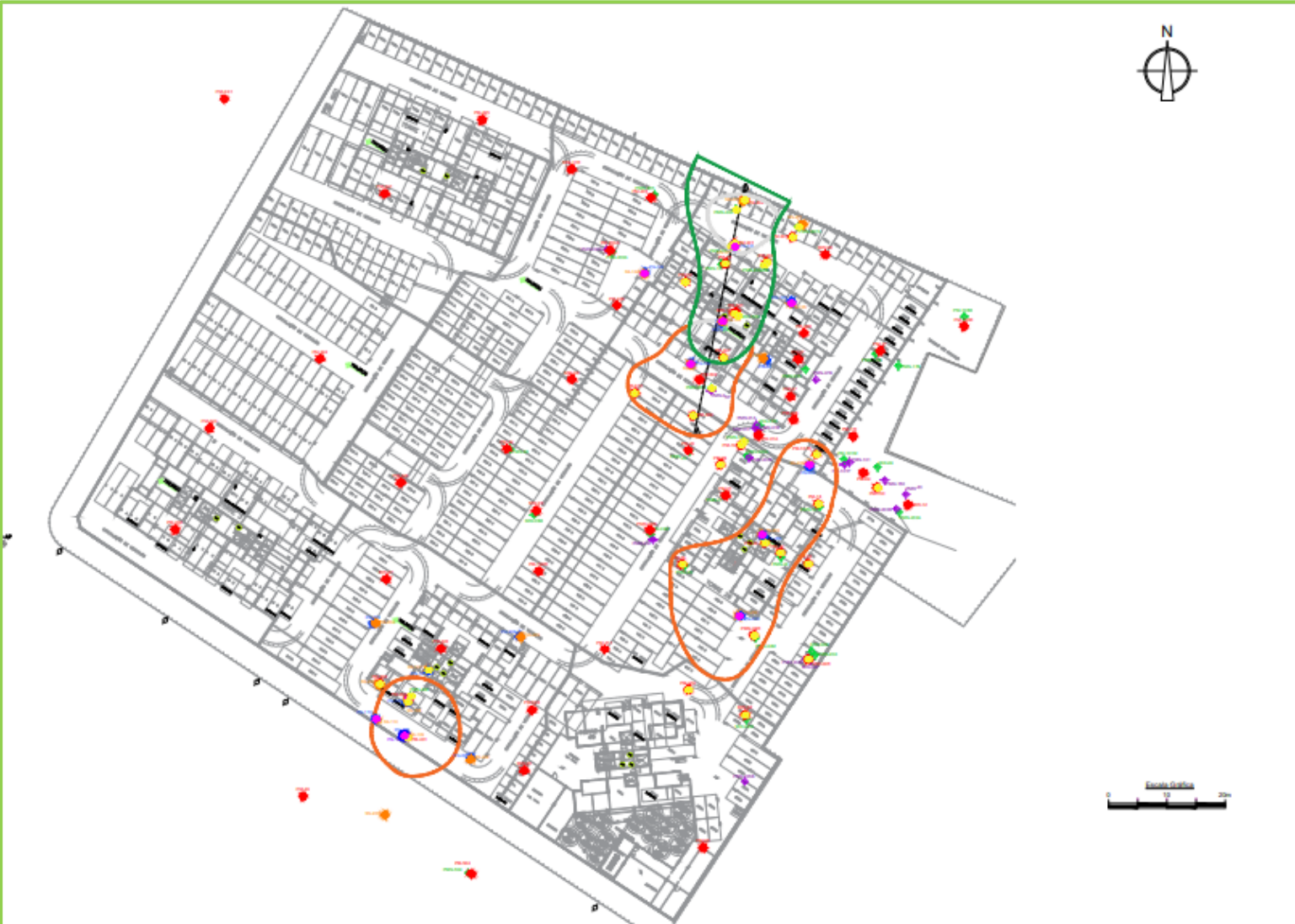
PROJECT DESIGN

- *Current layout of the area and*



PROJECT DESIGN

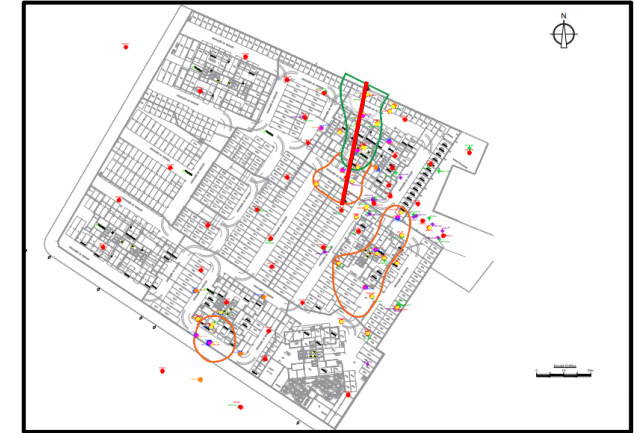
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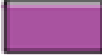
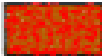


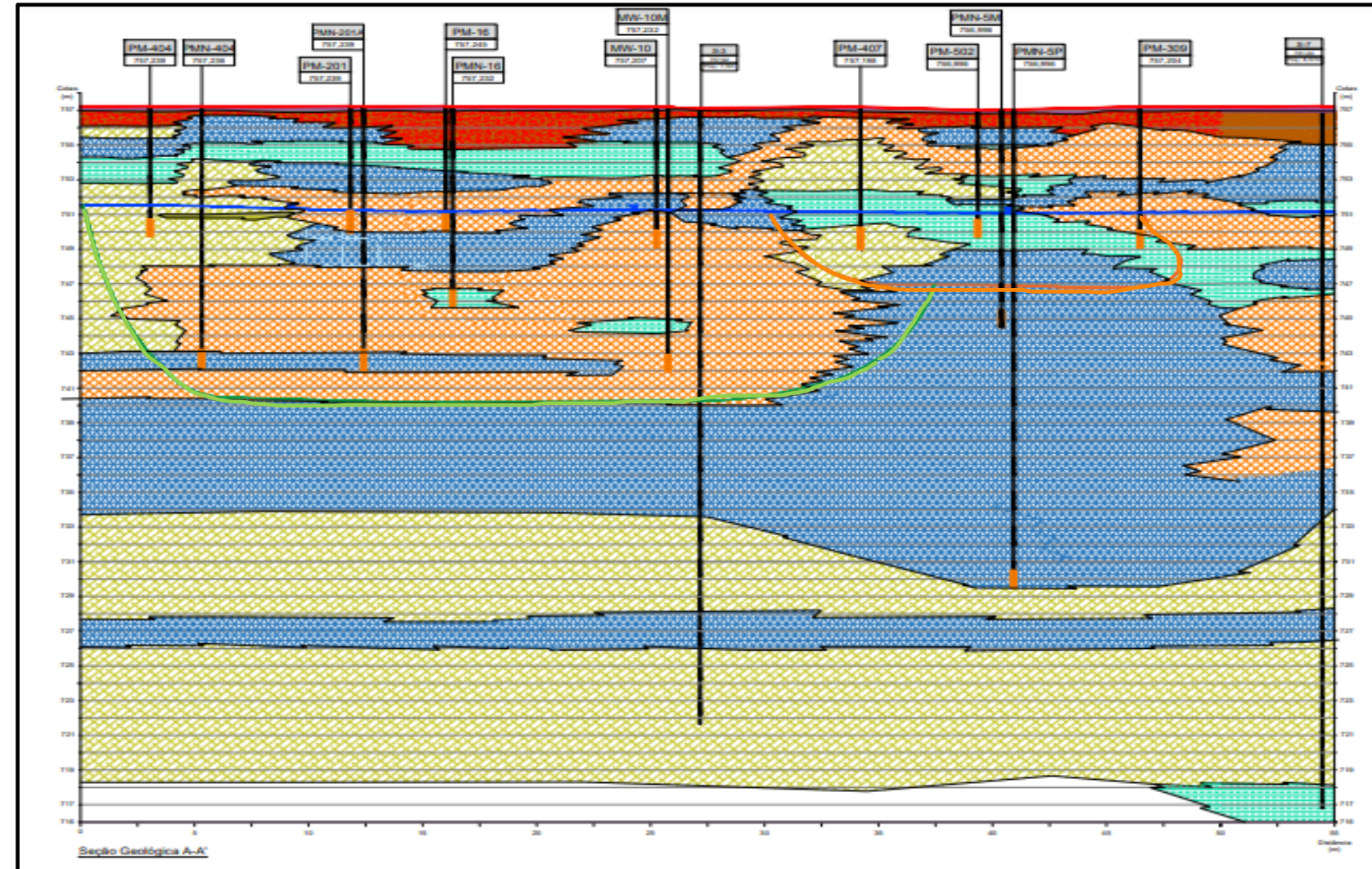
- Remediation Area
Shallow and Intermediate Aquifers—
Heating Interval from 6m to 18m
- Remediation Area
Shallow Aquifer –
Heating Interval from 6m to 10m

PROJECT DESIGN

• Cross Section of the Remediation Area



-  Concrete Floor
-  Landfill – Silty clay with the presence of civil construction materials
-  Sediments of the São Paulo Basin – Clayey package, silt or sandy silt, sometimes with boulder, yellow, gray and purple
-  Sediments of the São Paulo Basin – Sandy or sandy-silty clay, gray and purple
-  Sediments of the São Paulo Basin – Sandy package - fine clayey sand, gray, red, with boulders
-  Medium, slightly clayey, yellow, gray and red sand, with rock fragments



PROJECT DESIGN

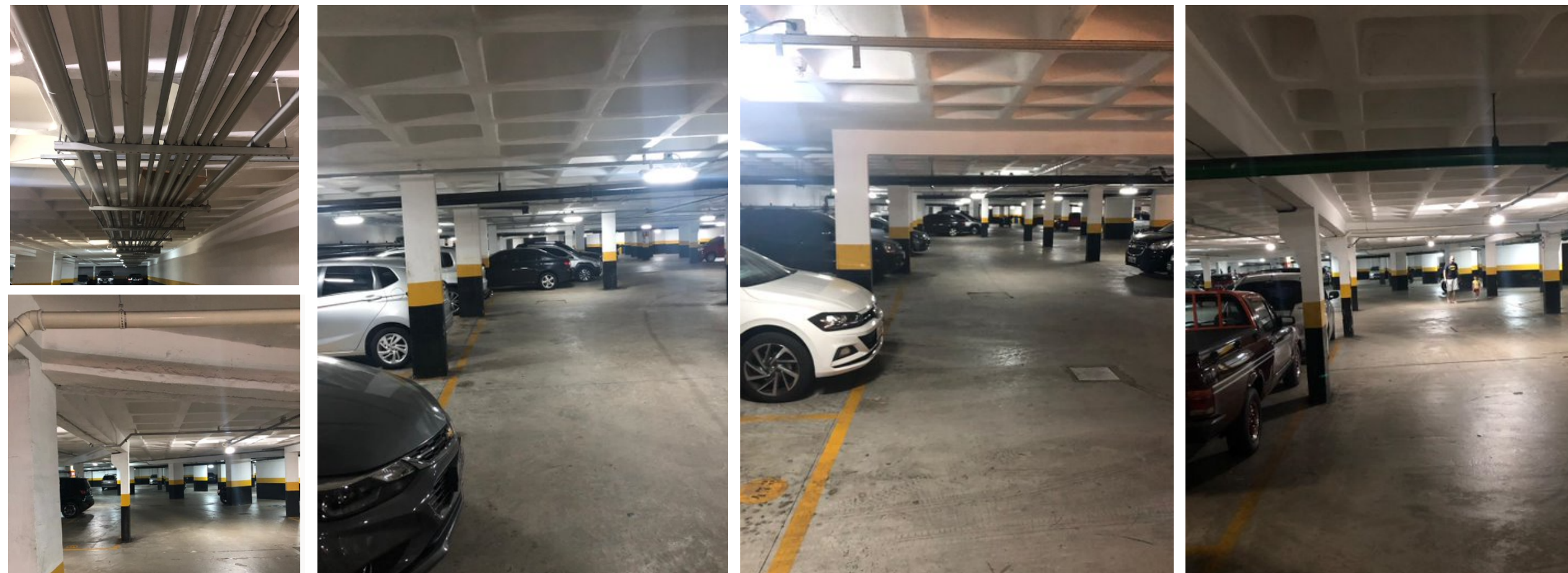
■ Challenges

- Parking garage with high flow of people and cars
- Low ceiling height (~9 ft / 2.7m)
- Presence of underground interference – pillars, beams and footings
- Overhead interference – pipes
- Constant communication with the condominium was required:
 - Access clearance (parking spaces and passage areas)
 - Ensure the safety of residents
- Construction had to be implemented in stages, so as not



PROJECT DESIGN

- Challenges



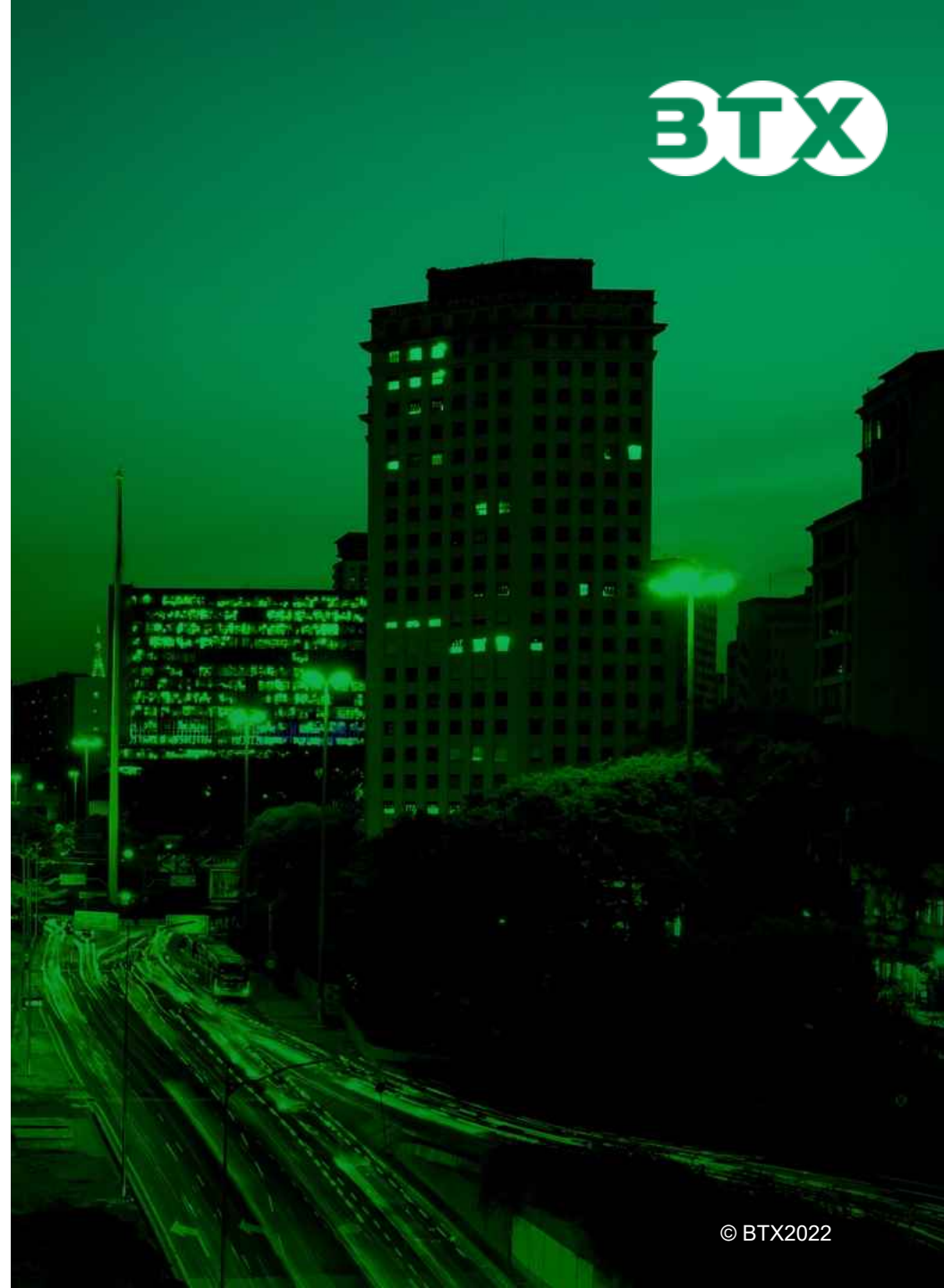


- **Design Considerations**

- Areas and goals set for remediation
- Lithology: Sediments of the São Paulo Basin - clayey package with sandy centimetric intercalations
- Type of contamination: CVOCs
- Maximum groundwater concentration: 54,000.00 µg/L PCE
- Total treatment volume: 11,600.00 m³
- Reduce the mass of the source area by >99%
- Operation of the system in two sequential steps

PROJECT DESIGN

- **Contingency Plan - possible occurrences**
- Escape of vapors (cracks in the floor and underground structures
- Heat hazards
- Access to the components of the system by residents;
- Interference with the structure of the condominium.



PROJECT DESIGN

- **Preventive Measures**
 - I. Daily monitoring: VOCs, Vacuum and Temperature
 - I. Maintained Vacuum Control throughout operations
 - I. The heating interval started at ~6m
 - I. Ambient air sampling with TO-15 analysis on a monthly basis
 - I. Structural report – before and after operations
 - I. Official letter with information on risks to the condominium + signage throughout the remediation area



IMPLEMENTATION AND CONSTRUCTION CHALLENGES

- ELECTRODE BOREHOLES



- Low ceilings
- Isolation of the area
- Clay soil was extremely difficult to drill in

IMPLEMENTATION AND CONSTRUCTION CHALLENGES

• ELECTRODE BOREHOLES



- Mobilization of the Hollow in the garage
- Isolation of the area
- Generation of drilling spoils
- Exhaust fumes management

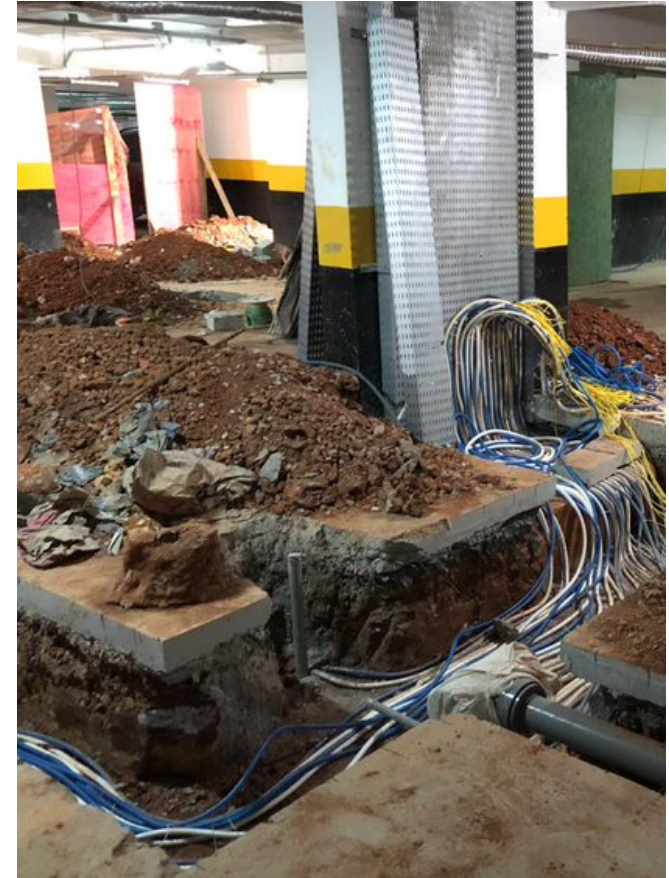
IMPLEMENTATION AND CONSTRUCTION CHALLENGES

- Trenches



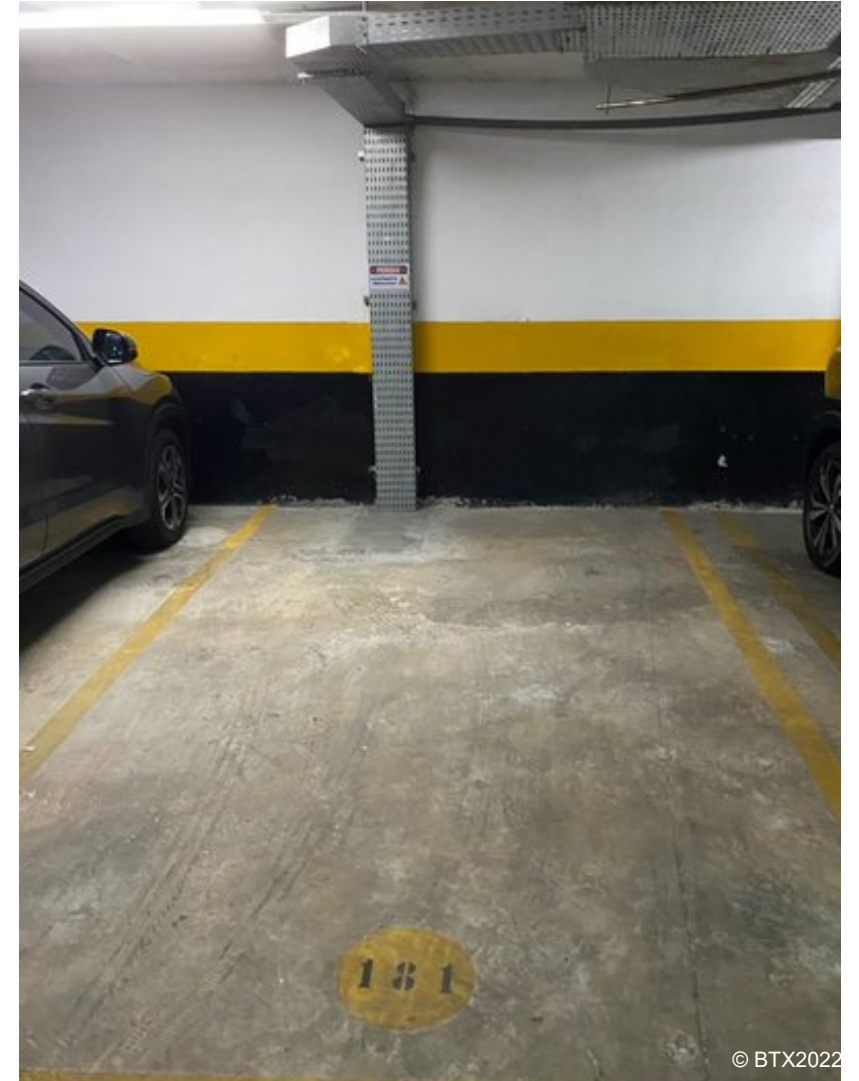
IMPLEMENTATION AND CONSTRUCTION CHALLENGES

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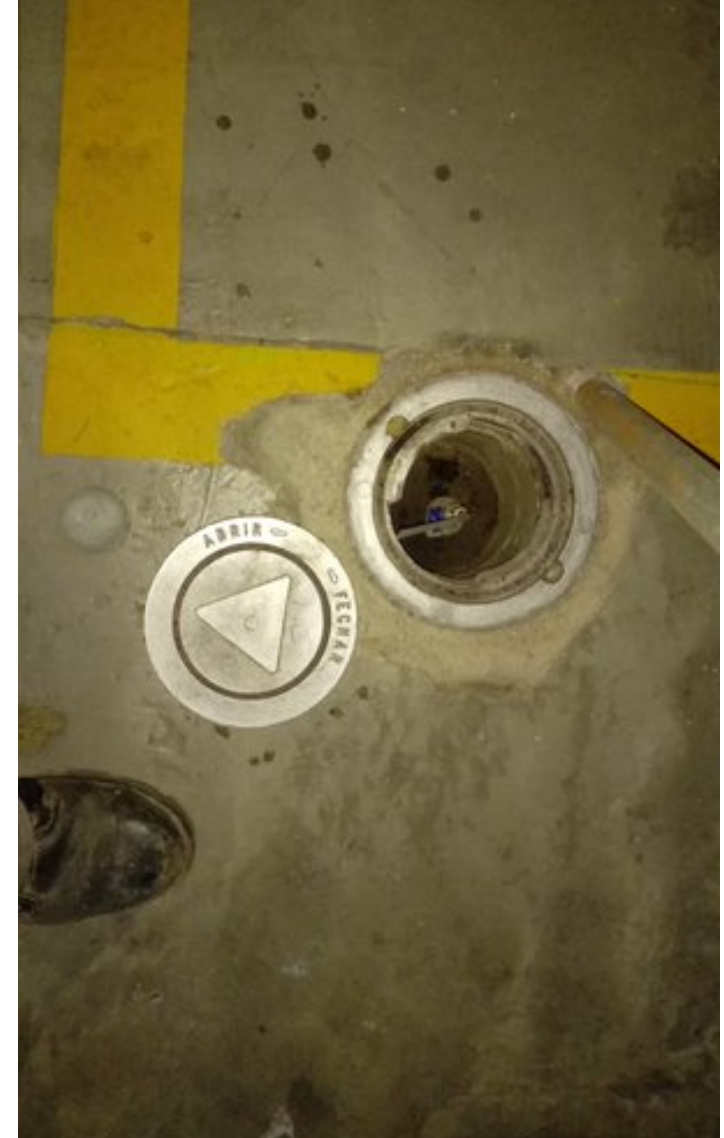
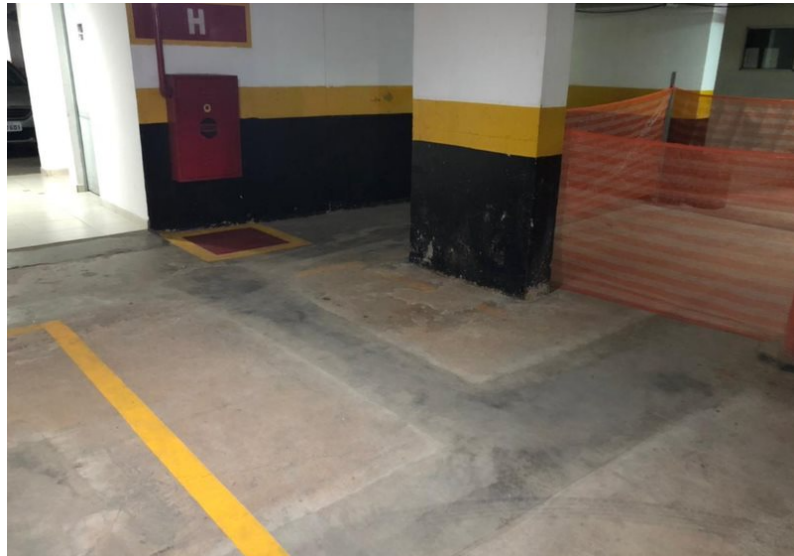
IMPLEMENTATION AND CONSTRUCTION CHALLENGES

- Overhead Vapor Recovery Pipe and Cable Routing



IMPLEMENTATION AND CONSTRUCTION CHALLENGES

- Finishing Touches of Construction



IMPLEMENTATION AND CONSTRUCTION CHALLENGES



IMPLEMENTATION

- Remediation Area
in the Shallow and Intermediate Aquifers –
Heating Zone from 6m to 18m
- Remediation Area
in the Shallow Aquifers –
Heating Zone from 6m to 10m
- ▼ W22 Temperature Monitoring Point
- V22 Electrode
- ERH Equipment Location
- ▨ Overhead Cable Tray Routing
- Trenches (0.5 m)
- - - PHASE 1: 913 m²
- - - PHASE 2: 1016 m²

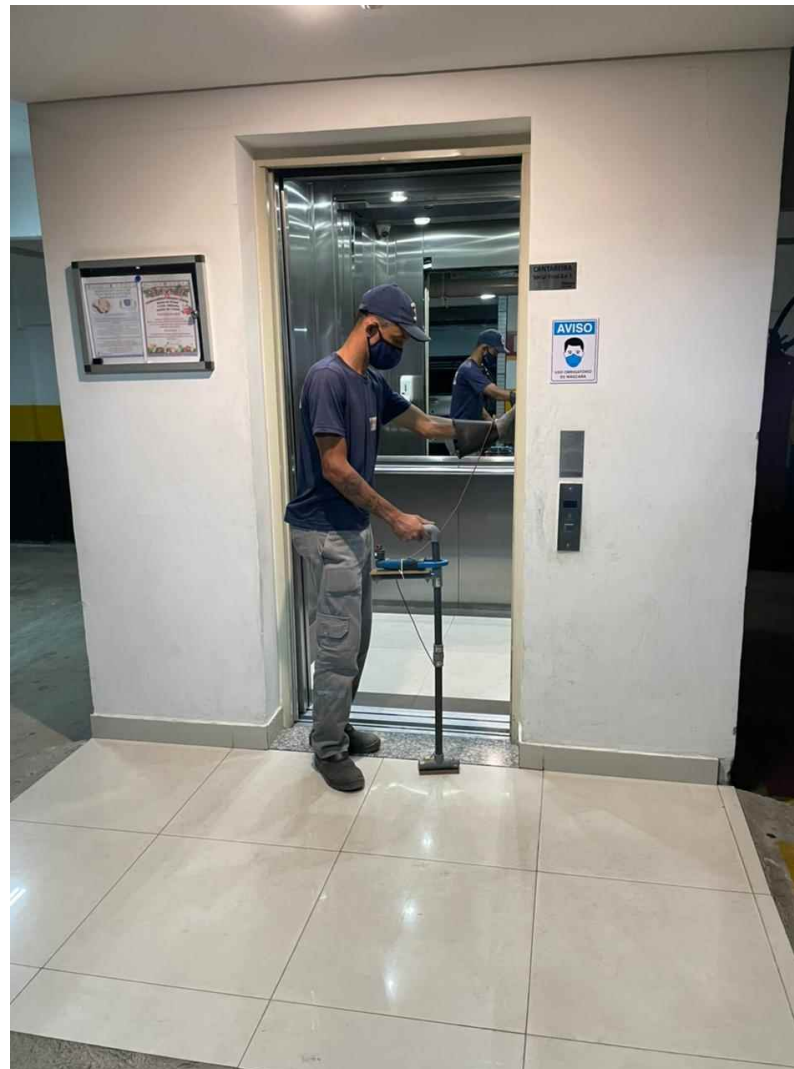


Operations – Startup Testing

Commissioning done at 3:00AM

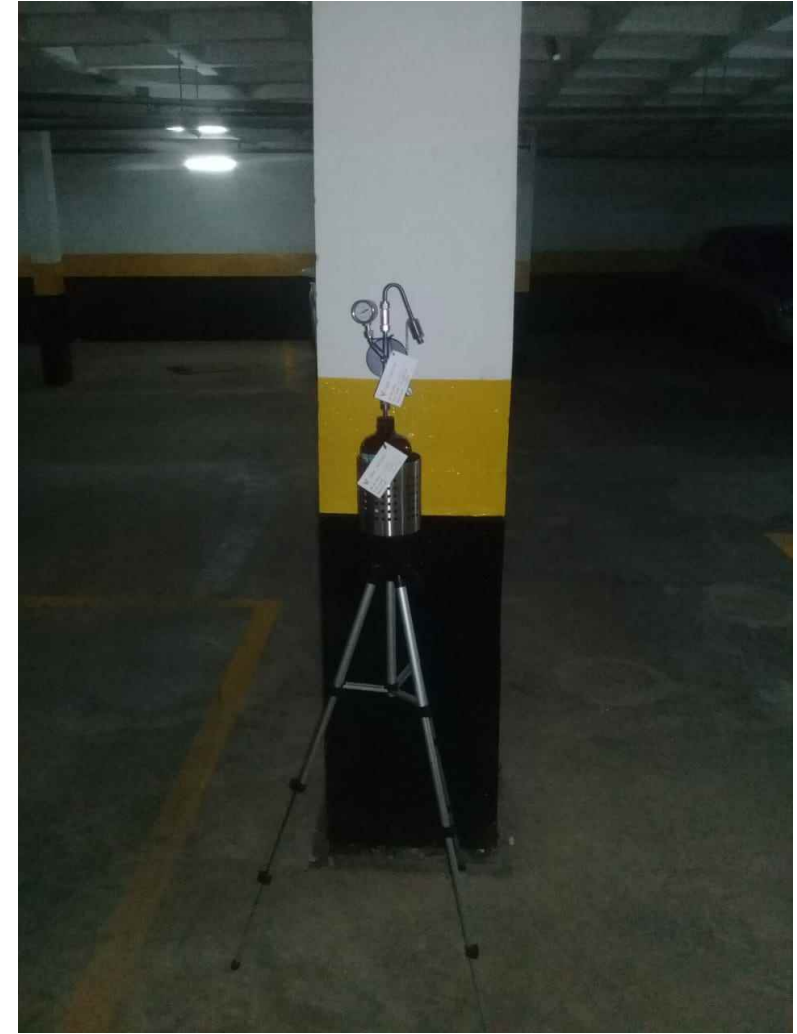


Operations – Startup Testing



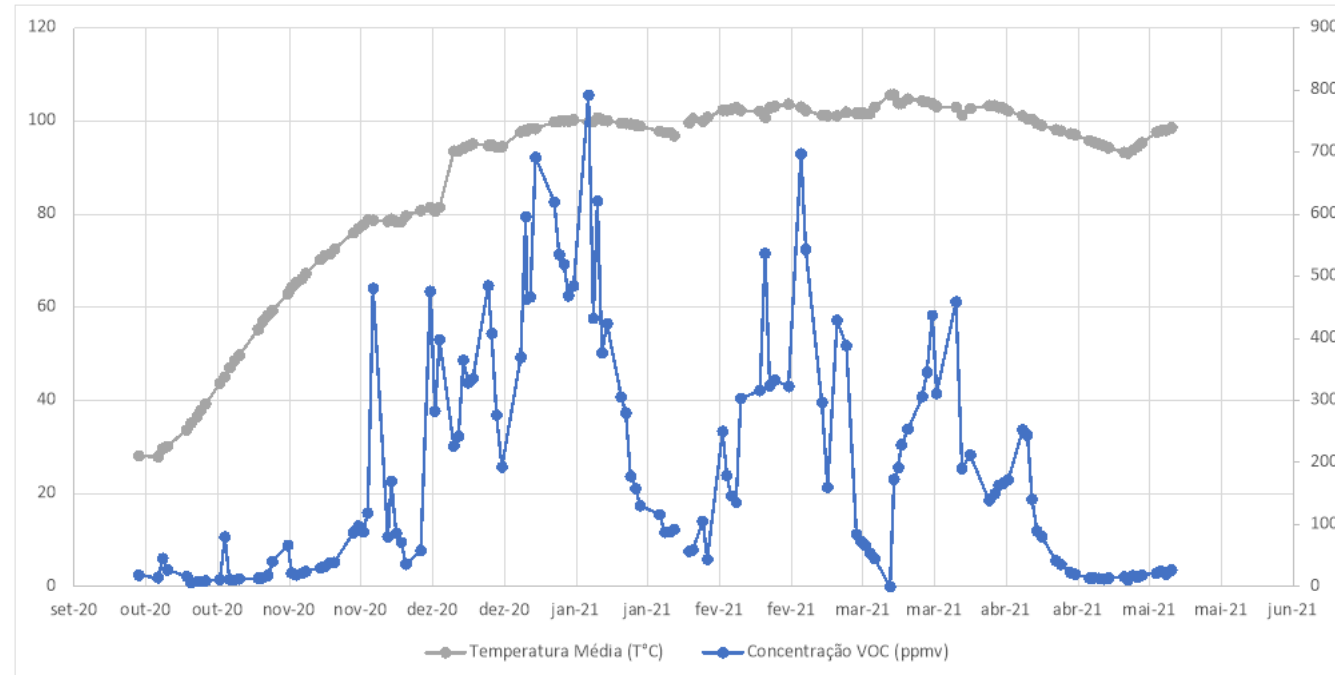
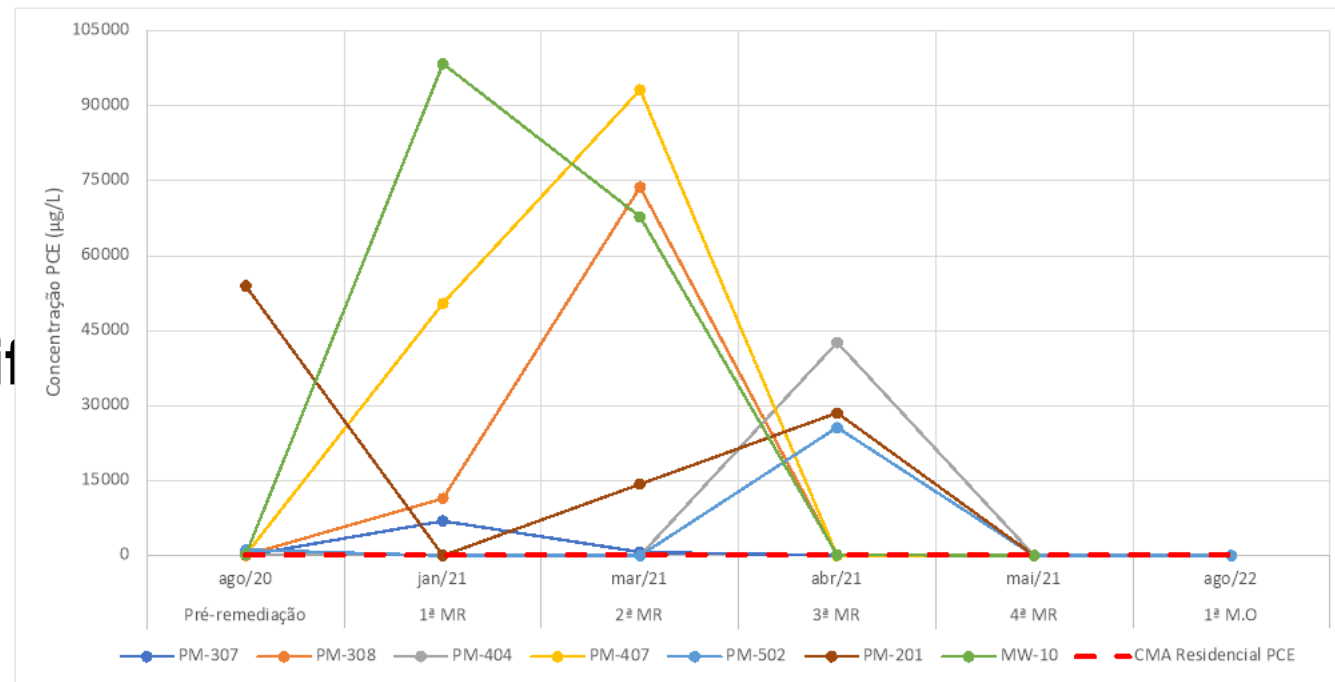
Operations

Ambient Air Monitoring



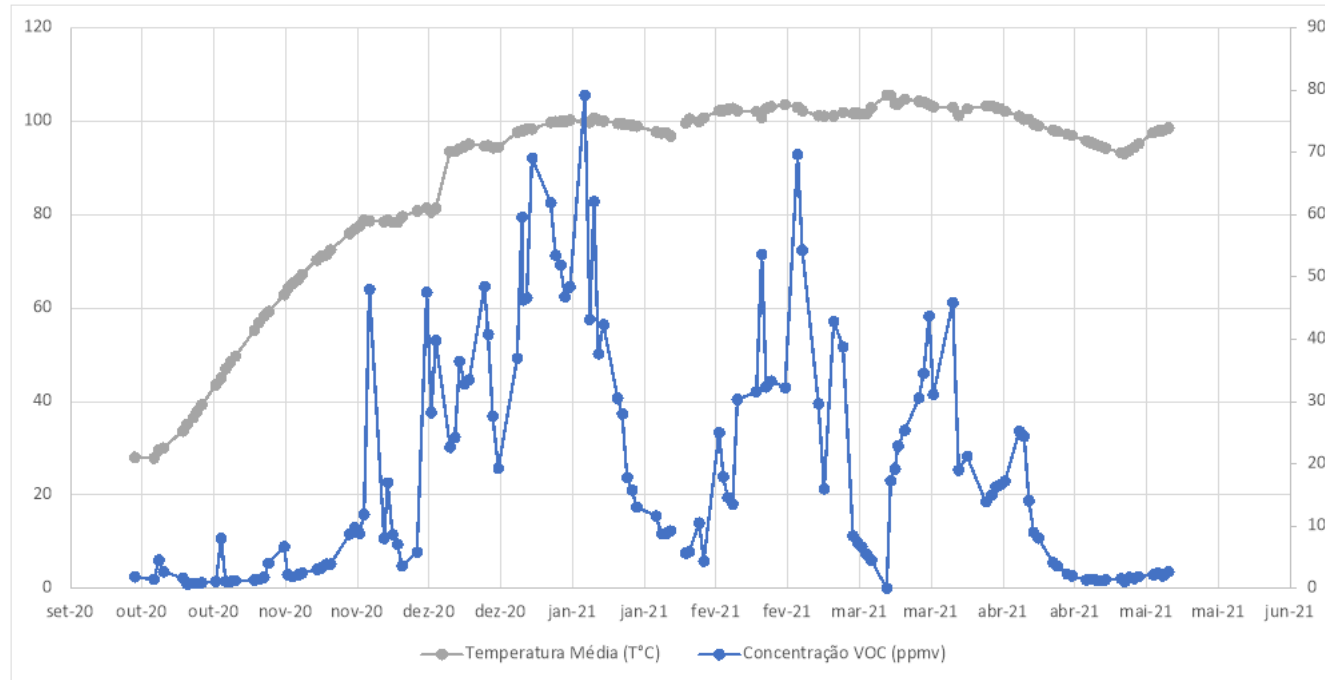
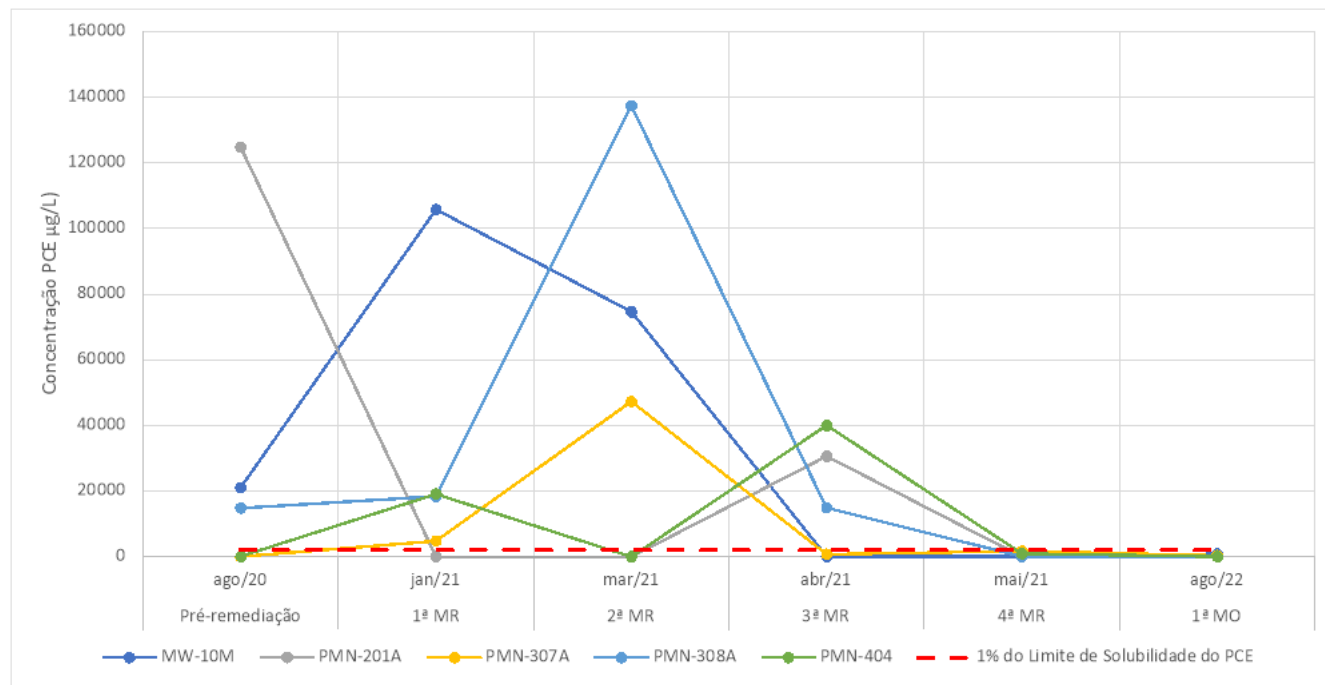
RESULTS

• PHASE 1- Shallow Aquifer



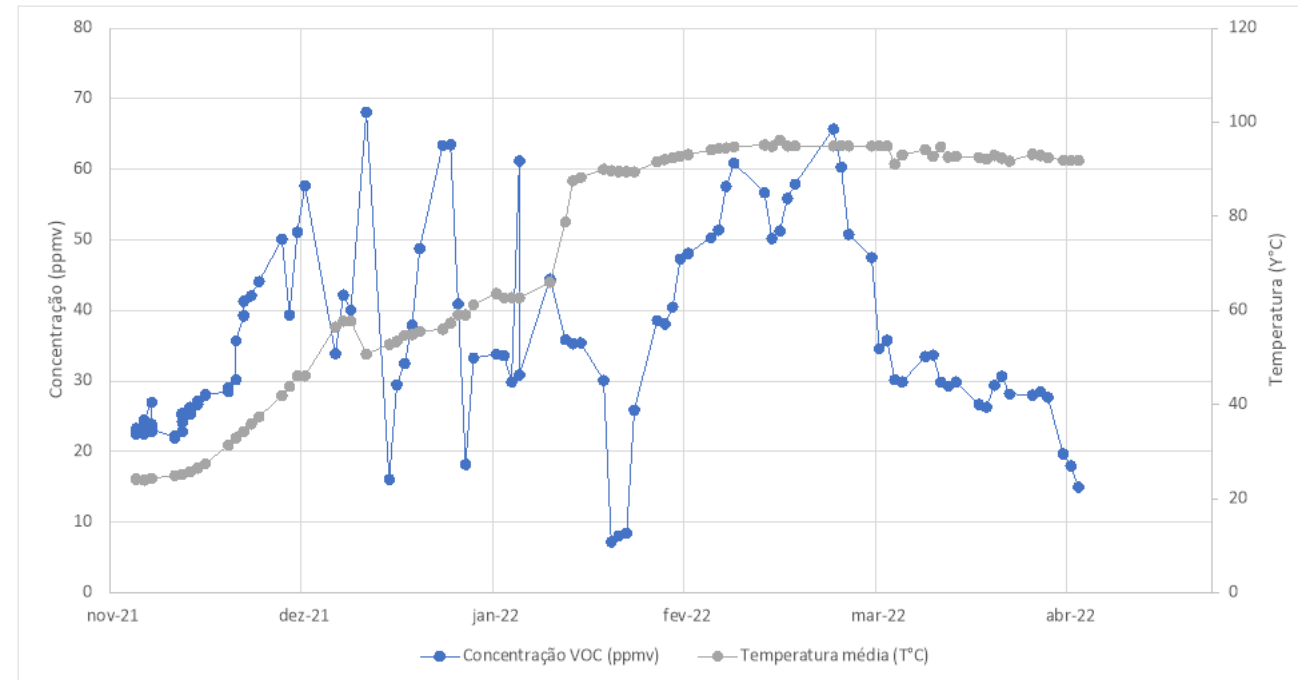
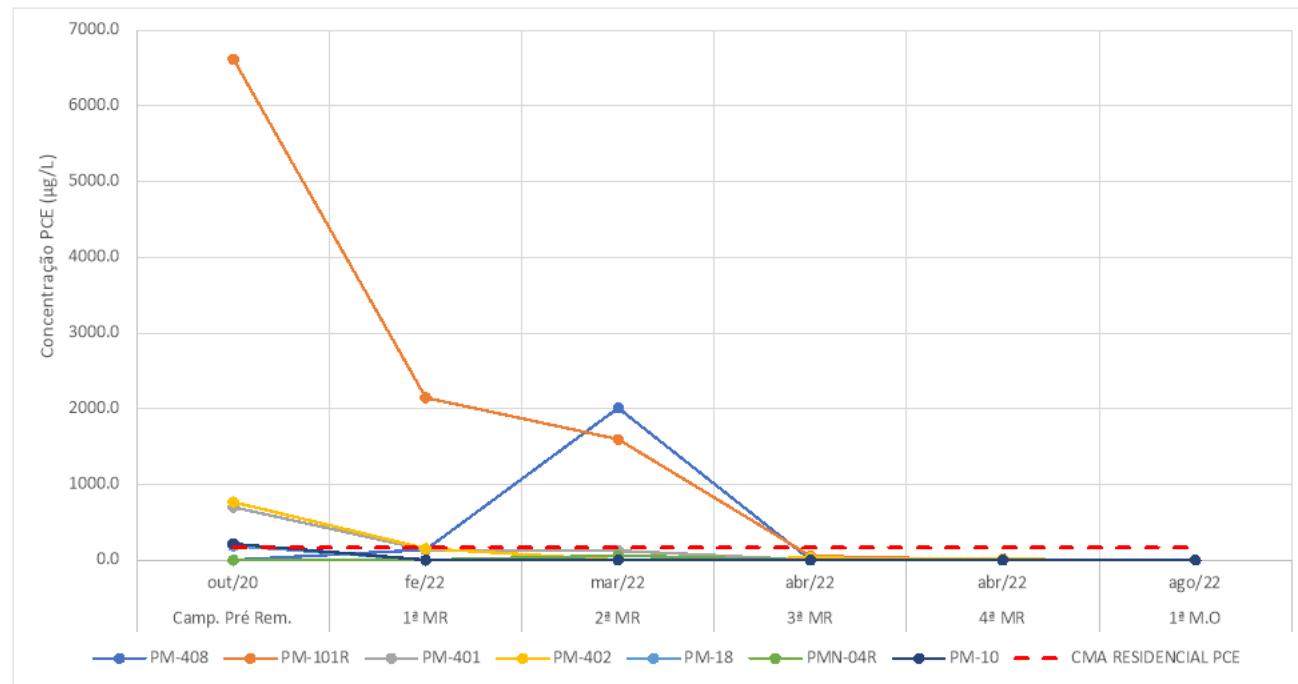
RESULTS

• PHASE 1- Intermediate Aquifer



RESULTS

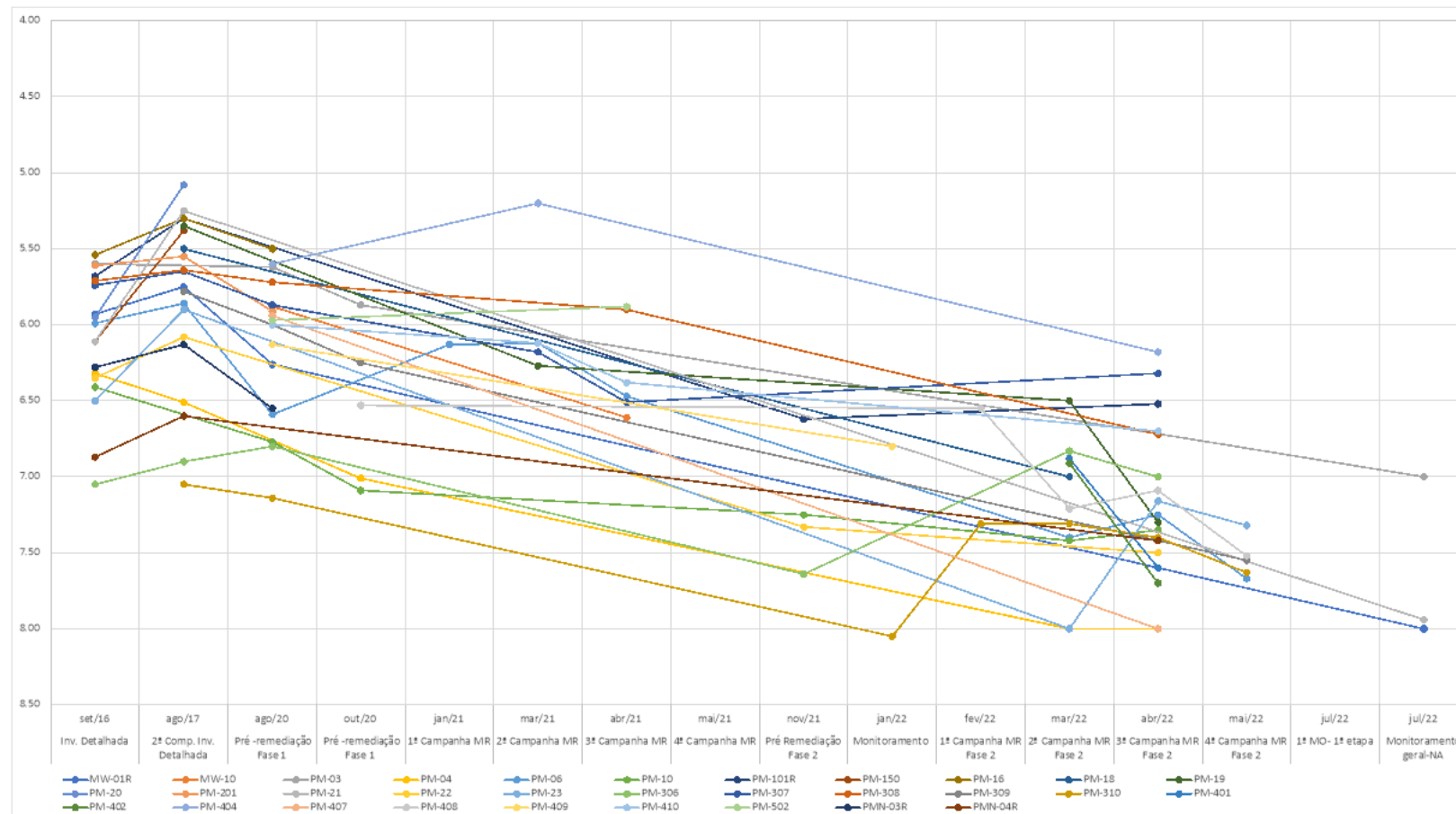
• PHASE 2



RESULTS

• Shallow Aquifer

- I. Impermeable area
- I. Clay package
- I. Recharging area
- I. Soil samples were collected at the dry points during the two stages of remediation - probes with VOC scanning and samples were collected at the same depth and lithological horizon of the screen of the respective point;
- I. Results obtained : ND



FINAL THOUGHTS

- I. Total energy consumption (Phase 1 and Phase 2): 4,160,000 kWh (98% of initial estimate)
- I. Removed approximately 4,000 kg of CVOC
- I. During operations, no concentrations indicative of risk were observed from the ambient air samples
- I. Daily monitoring indicated absence of VOCs and vacuum was always present.
- II. Site has been sampled for the past 18 months – all data show results below residential targets
- III. Existing SVE system was turned off 6 months after thermal remediation



OBRIGADO! THANK YOU!!

QUESTIONS?



Fone: +5511 3595-8100
comercial@btx.com.br
www.btx.com.br