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TRANSMITTAL (Document)

☑ Submit ☐ Resubmit

Date	Project Code/Type		Project Title	PO No.	Transmittal No.
25-Aug-2025	Code: RY63	Type: BDTS	Boulevard World-Indonesia Zone	29131	ML-RY63-BDTS-DOC-GEN-25-003-REV-00

DISCIPLINE

☑ GENRAL ☐ CI ☐ ST ☐ ME ☐ EL ☐ LC ☐ LA ☐ HS

To ☑ Project Manager ☐ Head Office ☐ Others **From :** Media Land Group

CONTRACTOR USE

Location ☑ Building ☑ External

Item No.	Division	Item Description (Name, Type, Size, Capacity, Specific Use, Etc.)	Manufature	Catalog No. Brochure No., Others	No. of Copies
1	GENRAL	GEOPHYSICAL SURVEY FOR BLVD WORLD 2025 -INDONESIA .			

تم الاستلام

25/8

RECEIVED 25 AUG 2025

Submitted by

Name :	Title : Project Manager	Signature	Enclosures :	Hard Copy / Soft Copy
Name :	Title : Sr.ME.Eng	Signature		
Name :	Title : Tech. Manager	Signature		
Name :	Title : QA/QC Manager	Signature		
Name :	Title : Project Manager	Signature		Items:

MEDIA LAND group C.R.1010565831

CONSULTANT USE

Item #														
Code														
Reviewed By														

☐ Approved ☑ Approved As Noted ☐ Amend & Resubmit ☐ Rejected ☐ No Action

Action Code

1. No Exceptions Taken
2. Make Corrections as Noted
3. Amend and Resubmit
4. Rejected

Remarks:

a) Installation shall only proceed when Action Code is 1 or 2.
b) Action Code 3, shall be resubmitted within time limit set in the contract.
c) Review does not relieved the Contractor from Responsibilty of Compliance with all requirements of Contract documents.

Special Instructions

we have no objection to adopt the (GPR) test Report, providing that Coordination must be made with electrical and mechanical Department to move services under building

Action Taken by:

Name : [illegible] Title : Rep. Engineer Signature Date: 25/8/2025

Name : ADEEB ZAEEM Title : Project Manager Signature Date: 2025/8/25

IN		OUT		Consultant Stamp
Signature Date:		Signature Date:		

دار الرياض DAR AL RIYADH CONSTRUCTION MANAGEMENT & SERVICES Supervising Works For Sela-boulevard World

GEOPHYSICAL SURVEY FOR BLVD WORLD 2025 – INDONESIABULIDLING

RIYADH-K.S.A

Report No.	25-021-111
Revision No.	1
Status	For Approval
Date	23/08/2025

PREPARED FOR

MEDIA LAND GROUP

Revision History						
1	25/08/2025	For approval	AAB	MAL	MMS	MLK
Revision No.	Date	Description	Prepared	Checked	Approved	QA Check

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7036 Saida Street
Al Suwaidi District - Riyadh

Date: 25/08/2025

To: Media Land Group.

Subject: Submission of Final Report – Underground Utility Detection Survey –BLVD WORLD 2025 – INDONESIA Project, Riyadh

Dear Sirs,

United Geophysics Solutions is pleased to submit to your esteemed office the final interpretive report for the Geophysical Survey for Subsurface Utility Detection, carried out using Ground Penetrating Radar (GPR) and Radio Detection (RD) technologies at the BLVD WORLD 2025 – INDONESIA Project, located in Boulevard Riyadh City – Al-Louloua Building, Hittin District, Riyadh, Kingdom of Saudi Arabia.

This investigation was commissioned to support the planning and execution phases of the project by identifying and verifying the presence, alignment, and depth of existing underground utilities and any potential subsurface obstructions that may pose risks to excavation or structural works.

The survey was executed using advanced geophysical instruments, including:

- **Cobra Smart WiFi GPR** system with Multi frequency 100–900 MHz operating band, offering high-resolution imaging for both shallow and deep subsurface conditions.

- RIDGID SeekTech SR-20 cable and pipe locator for detecting metallic utilities.

The enclosed report includes:

- A detailed description of the methodology and equipment used.

- Site layout and survey grid design.

- Data acquisition, signal processing, and interpretation procedures.

- Results identifying utilities such as power cables, water lines, and a sewer network, with depth estimations.

- Georeferenced CAD maps indicating the location of detected subsurface features.

- Technical recommendations to ensure excavation safety and prevent infrastructure damage.

We trust that the findings and deliverables contained in this report will support your design and planning efforts, mitigate construction risks, and enhance safety and operational efficiency on-site.

Should you require any further clarification or technical assistance, please do not hesitate to contact us. We sincerely appreciate your trust and look forward to future collaboration.

Sincerely,

United Geophysics Solutions

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EXECUTIVE SUMMARY

The site investigated is located in Riyadh, Kingdom of Saudi Arabia, within the vicinity of the proposed BLVD WORLD 2025 – INDONESIA facility. The primary objective of this geophysical survey was to detect, map, and confirm the elevation and routing of all existing underground utilities and any subsurface obstructions that may interfere with the safe execution of planned construction activities.

The survey was performed by United Company using a combination of advanced Ground Penetrating Radar (GPR) and Radio Detection (RD) techniques in accordance with ASTM D6432 standards. The GPR equipment used was the **Cobra Smart WiFi GPR**

Utility-Scan System, operating with Multi frequency 100–900 MHz operating band, providing high-resolution imaging for shallow to intermediate depths. The RIDGID SeekTech SR-20 cable and pipe locator was used to identify active metallic utilities and conductive infrastructure.

A detailed survey grid was implemented across the designated area with 1-meter spacing between longitudinal and transverse lines, covering both the perimeter and internal sections of the site. Data acquisition was completed within a single day. All acquired signals were processed using advanced filtering tools, and the results were visualized in real-time and interpreted post-survey. Detected anomalies were georeferenced using RTK GNSS positioning and plotted on a project-specific AutoCAD base map.

Key findings include the detection of multiple buried utility lines attributed to underground cables and pipelines, with estimated depths ranging from 0.20 meters to approximately 0.80 meters below ground level. Some anomalies could not be conclusively identified in terms of material or function, but were clearly distinguishable from the native soil background.

The results of this investigation provide a detailed utility reference map that serves as a safety guide for excavation works. It is highly recommended that test pits or manual trenching be conducted at critical locations to verify and validate the interpreted data before any major earthworks begin.

Introduction

This report details the results of the geophysical survey conducted at the Hittin Area, Riyadh, Saudi Arabia, as part of the development activities for Boulevard Riyadh City – Al-Louloua Building. The primary objective of the investigation was to detect, map, and verify the presence of underground utilities, cables, and any potential subsurface obstructions that might interfere with the planned excavation and construction operations.

The geophysical survey utilized Ground Penetrating Radar (GPR) technology, which is a non-invasive and high-resolution method widely used for identifying subsurface conditions. This method was selected for its effectiveness in safely mapping utilities and obstructions without disturbing the surface. Additionally, Radio Detection (RD) was employed to enhance the accuracy of utility mapping, particularly for identifying metallic infrastructure.

The findings of this investigation are integral to the safe execution of the construction works, providing essential data to prevent damage to existing utilities and avoid costly delays. The survey adhered to international geophysical standards, specifically ASTM D6432, to ensure the highest quality of data acquisition and analysis.

This report outlines the full scope of the survey, the equipment and methodology employed, the interpretation of the results, and the recommended actions based on the survey's findings.

Objectives of the Geophysical Investigation

The primary objective of this geophysical investigation was to accurately detect, locate, and map all underground utilities, cables, and any subsurface obstructions that might interfere with the proposed excavation and construction activities at the **BLVD WORLD 2025 - INDONESIA** project site.

The specific objectives of the investigation are as follows:

- **Detection and mapping of all underground utilities**, including water pipelines, electrical cables, telecom lines, and any other relevant infrastructure.
- **Identification of subsurface obstructions** such as rocks, previous foundations, or construction debris that could affect the progress of excavation and construction.
- Provide **high-resolution, non-invasive imaging** of the subsurface, facilitating detailed planning and reducing potential risks during construction.
- Offer **actionable recommendations** based on findings, including strategies for avoiding or mitigating interference with underground utilities and obstructions.
- Ensure **compliance with international standards** (such as **ASTM D6432**) to guarantee the precision, reliability, and quality of data acquisition and interpretation.

These objectives are essential to ensure the efficient, safe, and cost-effective execution of the construction works, avoiding disruptions and preventing any unforeseen challenges related to underground infrastructure.

Scope of Work

The geophysical investigation conducted for the **BLVD WORLD 2025 - INDONESIA** project, located in the **Hittin Area** of Riyadh, aimed to detect, locate, and map all underground utilities and subsurface obstructions that could interfere with the planned excavation and construction activities. The project site consists primarily of **concrete**, which presents a unique challenge in terms of data acquisition, requiring careful consideration of the equipment and survey methodology.

The investigation focused on the following primary tasks:

- **Surveying the entire site**: The area was systematically surveyed using advanced geophysical methods, with a focus on mapping underground utilities such as water pipelines, electrical cables, telecom lines, and other relevant infrastructure.
- **Use of high-resolution geophysical equipment:**
  - **SeekTech SR-20**: A utility locator used to detect and precisely locate metallic infrastructure such as pipes and cables.
  - **Cobra Smart WiFi GPR**: An additional advanced GPR system used for obtaining detailed subsurface images.
- **Data collection and processing**: Data was collected using the above-mentioned technologies and processed to generate detailed subsurface maps, providing accurate locations and depths of utilities and potential obstructions.
- **Collaboration with the project management team**: Ensured alignment with the construction schedule and minimized disruption to ongoing work.
- **Adherence to international standards**: The survey was conducted in compliance with industry standards, including **ASTM D6432**, to guarantee the reliability and quality of the data collected.

This comprehensive approach was designed to ensure the safe and efficient execution of the construction activities, providing valuable information for planning and minimizing the risk of damage to underground infrastructure.

Site Description

The project site is located within Boulevard Riyadh City – Al-Louloua Building, situated in the Hittin district of Riyadh, Saudi Arabia. The site coordinates are QJG2+JP with postal code 13516. This area represents a prominent and rapidly evolving urban development hub, characterized by a dense mix of commercial, residential, and recreational facilities.

The ground surface throughout the survey zone comprises monolithic reinforced concrete pavement, constructed to support heavy urban traffic loads and pedestrian movement. The pavement was observed to be in excellent structural condition, exhibiting uniformity across the surveyed extent and free from visible indicators of prior subsurface interventions such as saw-cutting, trench reinstatement, or patch repairs.

This uniform surface condition provided an ideal medium for Ground Penetrating Radar (GPR) data acquisition, reducing potential near-surface scattering effects and ensuring consistent signal penetration. The absence of surface irregularities and disturbance zones significantly enhanced data clarity, thereby improving the accuracy of subsurface anomaly detection and utility mapping.

In conclusion, the site conditions were considered highly conducive to advanced geophysical investigation, enabling the collection of reliable, high-resolution GPR datasets with minimal interpretive uncertainty.

Table 1: Site Information Summary

Parameter	Value
Project Name	Boulevard Riyadh City – Al-Louloua Building
Location	Hittin District, Riyadh, Saudi Arabia
Coordinates	QJG2+JP (Postal code 13516)
Ground Surface	Reinforced Concrete Pavement
Condition	Excellent (uniform surface, no cuts or patch repairs)

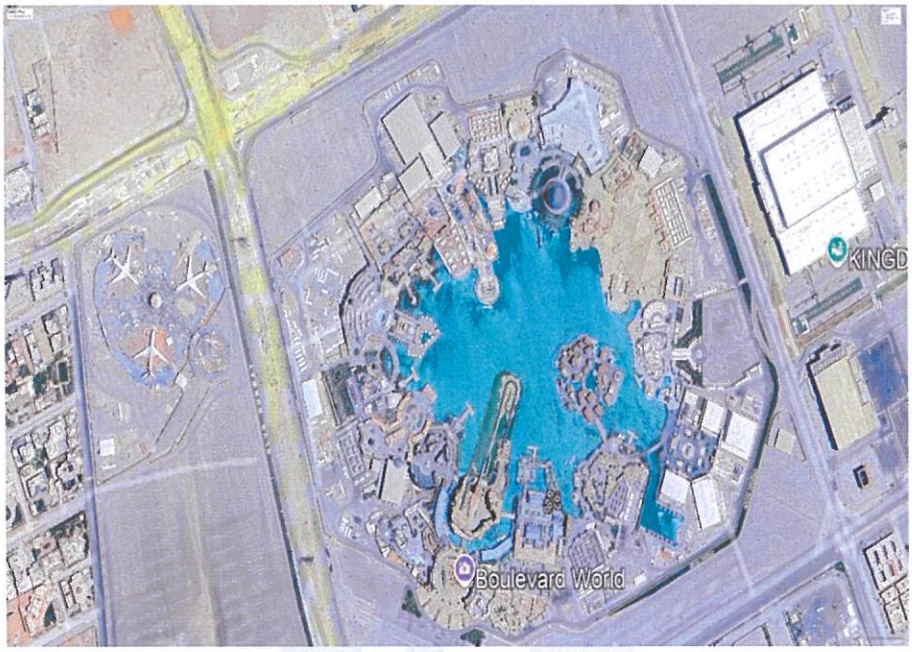


Figure 1: Site Location Map — Satellite image showing the Boulevard Riyadh City – Al-Louloua Building, Hittin District, Riyadh.

1.1 Geological Description

Geologically, the area lies within the sedimentary formations of the Arabian Shelf. The shallow subsurface typically consists of fill materials, silty sands, and calcareous soils overlaying limestone or sandstone formations. However, geological assessment in this project is limited as the focus is on detecting man-made utilities.

1.2 Survey Lines on Site

The following image illustrates the designated survey lines used during the Ground Penetrating Radar (GPR) investigation at the site. These lines were carefully planned to ensure comprehensive coverage of the area, allowing for accurate subsurface data collection.

Figure 2: Survey Layout Map — Planned GPR survey lines superimposed on the site aerial image.

This layout ensures efficient and effective mapping of the subsurface utilities and structures.

Equipment and Devices Used

UNITED GEOPHYSICS SOLUTIONS COMPANY utilized advanced technologies and globally recognized systems to ensure accurate detection of underground utilities beneath concrete surfaces. The following equipment was used for this project:

Table 2: Equipment Summary

Device	Model	Key Features	Weight
Ground Penetrating Radar	Cobra Smart WiFi (Radarteam)	Dual-channel 100–900 MHz, WiFi, cart-mounted	14–16 kg
Electromagnetic Locator	SeekTech SR-20 (RIDGID, USA)	EM detection, depth & direction display	~2.5 kg handheld

1.3Ground Penetrating Radar (GPR)

Cobra Smart WiFi by RADARTEAM

- Dual-channel, multi-frequency system (100–900 MHz) for both shallow and deep targets
- Equipped with WiFi connectivity for real-time wireless control and data transfer.
- Ideal for detecting pipes, cables, voids, ducts, and underground utility boxes beneath concrete or concrete layers.
- Total weight: approximately 14–16 kg (main unit + antenna ≈ 10–11 kg, battery and accessories ≈ 3–5 kg).
- Mounted on a lightweight cart for efficient maneuvering in field environments.

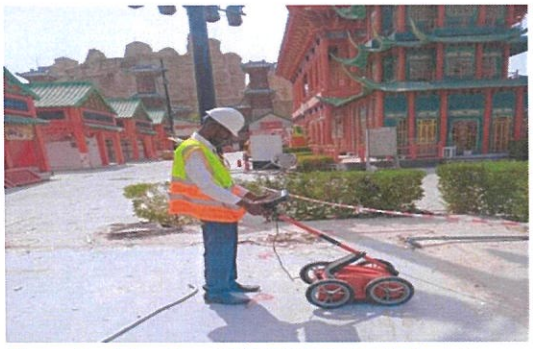


Figure 3: Cobra Smart WiFi GPR in Field Operation — Field photo showing the Cobra Smart WiFi system operated during utility detection survey.

1.4 Electromagnetic Locator – SeekTech SR-20 by RIDGID (USA)

- High-precision electromagnetic utility locator for identifying metallic pipes and energized cables.
- Operates by detecting transmitted signals or natural electromagnetic fields.
- Displays depth and direction in real time via a high-resolution digital screen.
- Serves as a complementary method to GPR, especially in areas where signal interpretation may be challenging.

Figure 4: Electromagnetic Locator (SeekTech SR-20) in Field Use — Field photo showing the SR-20 device being operated on site for underground utility detection.

The combination of GPR and EM detection enables UNITED GEOPHYSICS SOLUTIONS COMPANY to provide highly accurate and validated results, even in complex underground environments with multiple utility types and material variations.

Technical Team

All utility detection and Ground Penetrating Radar (GPR) survey operations are executed by a highly skilled and certified technical team from **United Geophysics Solution**. This team, specializing in advanced geophysical techniques and utility mapping, ensures the highest standards of precision, safety, and operational efficiency at every phase of the project.

The team assigned to this project includes the following roles:

- **Project Manager**

  Responsible for overall project management, ensuring alignment with client requirements, timelines, and budgets. Coordinates all project activities, communicates directly with the client, and ensures that all deliverables meet quality standards and compliance with international best practices.
- **Lead GPR Specialist**

  Responsible for operating the GPR equipment, ensuring calibration and data acquisition are performed with the highest level of precision. Manages on-site activities and ensures full coverage and optimal signal penetration, adapting to specific site conditions.
- **Utility Mapping Engineer**

  Analyzes GPR data to accurately identify subsurface utilities and anomalies. Prepares detailed utility maps, CAD drawings, and integrates data into GIS systems for future use and integration into infrastructure planning.
- **Health, Safety, and Environmental Officer**

  Ensures full adherence to safety protocols and environmental standards during field operations. Conducts risk assessments, oversees safety practices, and ensures safe working conditions, particularly near active utilities or high-traffic areas.

Each team member brings specialized expertise and has a proven track record in similar infrastructure and utility mapping projects. They hold certifications in GPR operation, utility

Survey Methodology

1.5 Initial Planning and Site Assessment

A pre-survey walk-through was conducted to assess access, surface type (reinforced concrete pavement), and any operational constraints (traffic, HSE). Existing records and base maps were reviewed to align survey objectives with site realities. The outcome was a clear survey plan with defined priorities and safe work boundaries.

1.6 Survey Grid Design (Lines, Spacing, Directions)

Systematic survey lines were laid out to achieve full coverage, with spacing selected to balance resolution and productivity (denser spacing in high-risk areas). Line orientations were aligned with site geometry and expected utility directions, with perpendicular "check lines" added to confirm targets. All lines were geo-referenced to enable accurate mapping in CAD.

1.7Calibration & Quality Control Plan

Calibration procedures (time-zero, velocity checks via hyperbola fitting) were performed at the start and repeated as needed. Field QA/QC included spot re-runs, live trace checks, and comparison across adjacent lines to ensure consistency. Any deviations triggered immediate corrective actions and documentation.

Data Acquisition

1.8 GPR Data Collection Procedure (Cobra Smart WiFi) –

Data was collected using the Cobra Smart WiFi GPR along the predefined grid, with overlapping passes to minimize blind spots. Acquisition settings were optimized for reinforced concrete, balancing depth window and resolution. All runs were logged with timestamps and location references for traceability.

Table 3: Scanning Parameters

Parameter	Value / Setting
Scanning Grid	Parallel transects, ~0.5 m spacing
Scanning Area	Variable per zone (refer to site map)
Frequency	400 MHz (suitable for medium depths)
Mode of Operation	Line scan and grid scan (selected areas)

1.9Real-Time Monitoring and Field Adjustments

Operators monitored signal quality in real time, adjusting speed, gain, and line spacing where conditions warranted. Suspect responses prompted immediate confirmation passes and, where needed, perpendicular "cross-lines." Weather, surface moisture, or site activity were noted and mitigated to protect data quality.

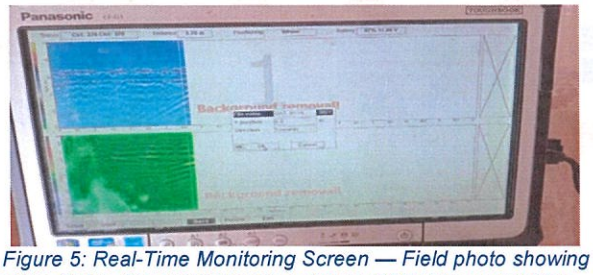


Figure 5: Real-Time Monitoring Screen — Field photo showing the live interface of the Cobra Smart WiFi system during GPR data acquisition.

1.10 Field Notes and Constraints

Structured field notes captured anomalies, surface observations, temporary obstructions, and any deviations from plan. Constraints (e.g., access restrictions or high-traffic windows) were recorded with their impact and mitigation. These notes support later interpretation and clarify confidence levels for each finding.

Data Processing and Results Interpretation

Penetrating Radar (GPR) records were imported into **PRISM2** software for systematic processing and refinement. This stage ensured that the acquired signals were enhanced and calibrated to provide a reliable foundation for interpretation.

1.11 Signal Filtering

Unwanted background noise and high-frequency interference were removed using specialized digital filters. This significantly improved signal clarity and allowed the main hyperbolic reflections to be isolated.

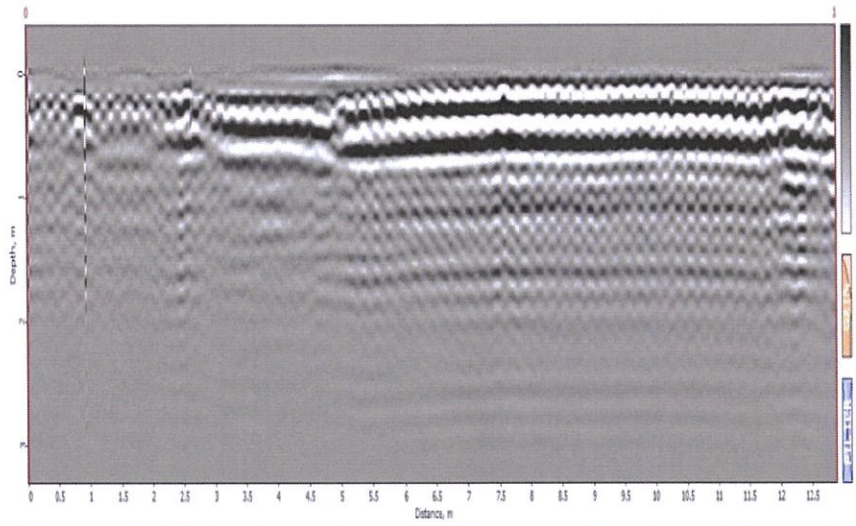


Figure 6: Raw GPR Data (Before Processing) — Radargram showing high background noise and unclear reflections prior to filtering.

1.12 Depth Calibration

Time–depth conversion was performed based on estimated dielectric properties of the surface materials. This step ensured that detected anomalies were represented at their true depths relative to the ground surface.

Figure 7. Processed GPR Data (After Processing) — Clearer hyperbolas after depth calibration and filtering.

1.13 Data Enhancement

Post-processing techniques were applied to increase contrast and visibility of subsurface anomalies. Adjustments in gain, color scales, and stacking were performed to highlight key features for interpretation.

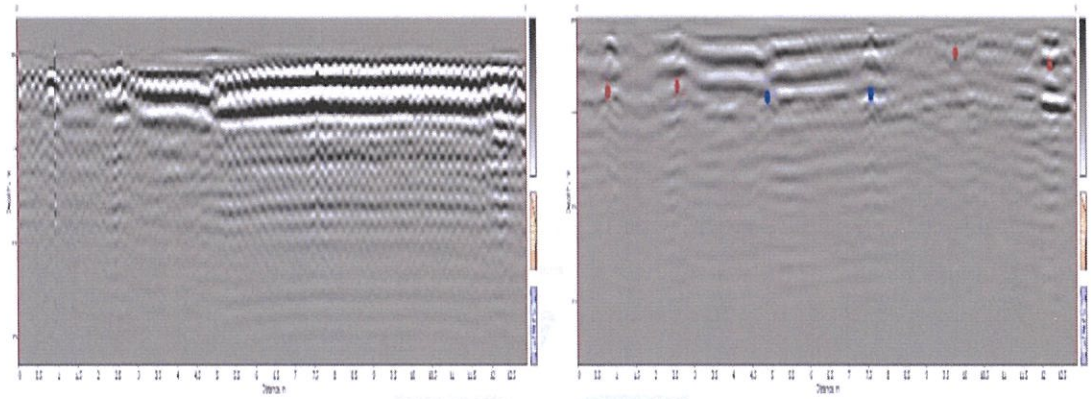


Figure 7: Comparison of Raw vs. Processed Data — Side-by-side view showing clearer hyperbolic reflections and enhanced visibility of subsurface features after processing

Results Interpretation

The processed data was analyzed by a team of GPR specialists to derive actionable insights:

- **Hyperbolic Reflections**

  Distinct hyperbolic reflections were observed:

  • A strong hyperbola interpreted as a subsurface power cable at ~0.6 m depth.

  • Multiple hyperbolas attributed to shallow pipelines at depths between 0.6–0.8 m.

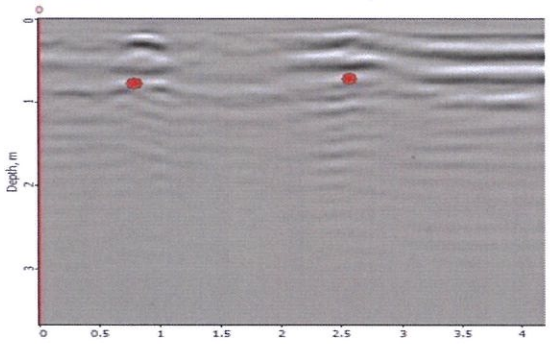


Figure 8: Typical Hyperbolic Reflection – Power Cable (~0.6 m) — Annotated radargram segment highlighting the red-marked hyperbola.

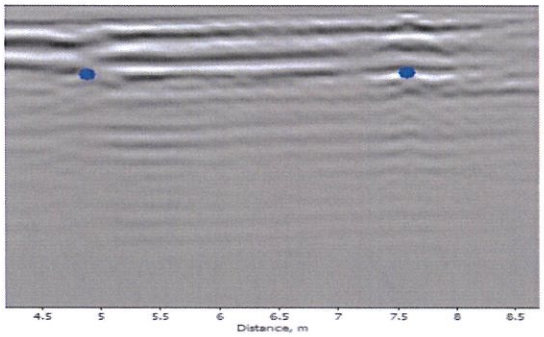


Figure 9: Multiple Hyperbolas – Shallow Pipelines (0.6–0.8 m) — Annotated radargram segment highlighting blue-marked hyperbolas.

- **Utility Mapping**
  - Integration of GPR results into CAD for accurate geospatial mapping of utility alignments and orientation.

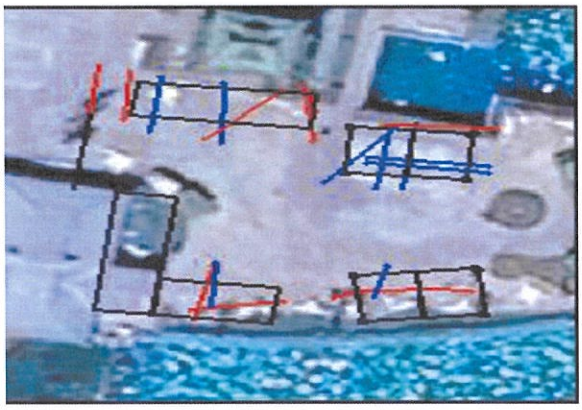


Figure 10: Utility Map (CAD Overlay) — CAD overlay map showing the detected utilities with alignment and depth annotations (red: power cables, blue: pipelines).

- **Validation & Cross-Referencing**
  - Results were cross-checked with existing utility records.
  - Anomalies validated through multiple survey lines.
  - Verification performed using supplementary techniques where feasible.
- **Key Findings**

1. Identification of shallow pipelines and one power cable.
2. No major voids or anomalies detected beyond surveyed depth.
3. Congested areas identified requiring further validation.

Limitations & Challenges

1.14 Methodological / Physical Constraints

- **Material properties:** Reinforced concrete, variable moisture, and saline content can attenuate or scatter GPR signals, reducing penetration and target contrast.
- **Electromagnetic interference (EMI):** Nearby power lines, communication cables, and site equipment may introduce noise affecting data clarity.
- **Velocity uncertainty:** Depth estimation depends on EM wave velocity; local changes in concrete/soil dielectric properties introduce depth ±10–25% uncertainty unless calibrated in situ.
- **Complex target environment:** Closely spaced/overlapping utilities (bundles, ducts) can generate compound or masking hyperbolas that are difficult to separate.

1.15 Site & Access Constraints

- **Restricted access / traffic control:** High-traffic areas limit line spacing and repeat passes; some zones may be inaccessible (fenced, landscaped, or obstructed).
- **Surface condition:** Joints, slabs, surface roughness, or level changes can affect antenna coupling and trace consistency.
- **Work windows:** Night work or limited time slots reduce the opportunity for re-runs and perpendicular confirmation lines.

1.16 Data Quality & Interpretation Risks

- **Ambiguity of signatures:** Certain non-utility features (e.g., reinforcement mesh, construction debris, voids) may mimic utility hyperbolas.
- **Partial detections:** Utilities at greater depths, small diameters, or non-conductive materials may yield weak/absent responses under specific conditions.
- **Registration / geo-referencing:** GNSS multipath or limited satellite visibility near buildings may impact positional accuracy of mapped features.

1.17 Mitigations Applied in This Survey

- **Calibration & QA/QC:** Time-zero checks, hyperbola velocity fitting, and selective re-runs on suspect lines to stabilize depth conversion.
- **Cross-line confirmation:** Perpendicular transects and correlation across adjacent lines to verify continuity and orientation.
- **Multi-source correlation:** Comparison with available utility records, site drawings, and field observations to increase confidence.
- **Targeted follow-up:** Recommendations for vacuum excavation or hand-digging at high-risk crossings before intrusive works.

1.18 Residual Uncertainty (Client Advisory)

Despite best practices and controls, GPR is a non-destructive, probabilistic method. Findings represent the best interpretation of the acquired data under prevailing conditions and do not constitute a guarantee of the presence or absence of all subsurface utilities. Intrusive verification is advised at critical locations before excavation.

Table 4: Constraints, Impacts, and Mitigations

Constraint	Impact on Data	Mitigation
Reinforced concrete / moisture variability	Lower penetration, blurred targets	Velocity fitting, gain tuning, selective re-runs
EMI (power/comm lines)	Noise, reduced SNR	Shielding where feasible, time windows, repeat passes
Dense/overlapping utilities	Compound hyperbolas, ambiguity	Cross-lines, correlation, targeted follow-up
Limited access / traffic	Reduced coverage or spacing	Night shifts, phased work, priority zones
GNSS limitations near buildings	Positional accuracy	Control points, manual referencing, CAD alignment

Recommendations

Following the interpretation of the GPR data and on-site observations conducted at the Hittin Project, the following recommendations are provided to ensure safe excavation practices and protect existing underground utilities:

1. **Manual Excavation Required**
   All excavation activities within identified utility zones must be performed manually to avoid unintended damage to subsurface infrastructure.
2. **Strict Adherence to Marked Alignments**
   Construction personnel must follow the utility paths as marked on-site and illustrated in the provided utility overlay maps with precision.
3. **Maintain Safety Clearance**
   A minimum horizontal clearance of 0.5 meters should be maintained on both sides of each identified utility unless additional verification confirms otherwise.
4. **Additional Verification in Congested Areas**
   In regions where multiple signals overlap or utility congestion is observed, supplementary validation methods—such as vacuum excavation—are strongly recommended prior to proceeding.
5. **Integration with Utility Records**
   The outcomes of this survey should be incorporated into the project's as-built documentation to maintain accurate and updated utility records.
6. **Qualified Supervision During Excavation**
   A certified utility detection specialist should be present during excavation activities to ensure compliance with safety protocols and to address any unexpected findings.
7. **Acknowledgement of Survey Limitations**

   The limitations of GPR technology must be considered (e.g., depth penetration, signal attenuation, interference in reinforced areas). Complementary detection methods should be employed when deeper or uncertain anomalies are suspected.

Table 5: Recommendation at Glance

Recommendation	Where to Apply	Rationale
Manual excavation in utility zones	Along detected alignments	Minimize damage risk
Keep ≥0.5 m horizontal clearance	Both sides of utilities	Safety buffer
Supplementary verification in congestion	Overlapping signals area	Reduce uncertainty
Specialist supervision during excavation	All excavation near utilities	Ensure protocol compliance

Quality Assurance (QA/QC)

1.19 Policy & Standards

All activities were executed under the project QA/QC plan in alignment with applicable standards and best practices (e.g., ASTM D6432 for surface GPR). Documentation, calibration logs, and field records were maintained to ensure full traceability.

1.20 Instrument Calibration & Verification

- **Pre-survey:** Time-zero check, antenna coupling check on concrete, and system self-tests.
- **During survey:** Periodic velocity calibration via **hyperbola fitting**, repeat passes on control targets, and gain verification.
- **Post-survey:** End-of-day checks and reconciliation against start-up values; variance outside tolerance triggered re-review.

1.21 Data Acquisition Controls

- Use of predefined **survey grid** and **overlapping passes** to minimize blind spots.
- **Real-time QA:** Live trace review for noise/clip, speed control, and immediate re-runs on suspect lines.
- **Field notes:** Structured logging of anomalies, constraints, weather/surface conditions, and any deviations from plan.

1.22 Processing QA

- Controlled workflow in **Prism 2** (dewow, band-pass, background removal, gain), with versioned project files.

8. **Depth/velocity checks** documented prior to time-to-depth conversion.
9. Peer review of processing parameters to ensure consistency across lines/sectors.

1.23 Interpretation QA

- Independent **cross-line confirmation** and correlation between adjacent lines.

- Distinction between utilities, stratigraphy, and reinforcement using pattern recognition and context.
- **Confidence grading** (High/Medium/Low) with rationale recorded (signal clarity, cross-checks, records).

1.24 Deliverables QA

- CAD/GIS outputs validated against control points and site basemaps.
- Figure captions include **Line ID, depth range, processing steps**.
- Final report undergoes technical review and compliance check (QA checklist) before issue.

1.25 Non-Conformance & Corrective Actions

- Any deviation (equipment, data quality, safety constraint) documented as **NCR** with root-cause and corrective action.
- Re-survey or targeted verification performed where material impact is identified.

Table 6: QA/QC Summary Table

Control Point	Method	Acceptance / Action
Time-zero & coupling	Pre-survey check on concrete	Stable baseline; re-tune if drift observed
Velocity calibration	Hyperbola fitting (known targets)	Δdepth within ±10–25% (context-dependent)
Signal quality	Live trace SNR review	Re-run if clipping/noise persists
Coverage	Overlapping passes, grid audit	Fill gaps; add cross-lines on key targets
Processing params	Prism 2 workflow, peer review	Consistent filters/gain across lines
Mapping accuracy	CAD/GIS vs control points	Adjust alignment; document residuals
Interpretation	Cross-line confirmation & grading	Assign confidence; flag for verification
Deliverables	QA checklist before issue	Correct and re-export if non-compliant

Health, Safety, and Environmental (HSE)

1.26 Policy & Roles

All works were executed under the project HSE plan and client/site rules. A designated HSE lead oversaw daily briefings, permit compliance, and incident reporting.

1.27 Risk Assessment (Task-Specific)

Pre-task risk assessments (PTRAs) covered: live utilities, traffic interaction, trip/slip hazards, manual handling, heat stress, and electromagnetic interference (EMI). Controls followed the hierarchy of controls.

1.28 Permits & Authorizations

Where required, work permits (hot/cold work, road occupancy, night work) and utility clearances were obtained and displayed on site. Exclusion zones were established around critical assets.

1.29 Traffic & Public Interface

Temporary traffic management (TTM) and pedestrian control were implemented per site rules: cones, barriers, spotters, and signage. Survey lines were sequenced to minimize live-lane exposure.

1.30 Utility Proximity Controls

No intrusive works were performed. GPR and locator activities maintained safe offsets from suspected high-risk corridors; any intrusive verification will be by vacuum excavation/hand-dig only under separate permit.

1.31 PPE & Ergonomics

Minimum PPE: hard hat, high-vis, safety boots, cut-resistant gloves, safety glasses, hearing protection as needed. Manual-handling limits observed; cart height/handle adjusted to reduce strain.

1.32 Environmental Protection

No ground disturbance or waste generation from GPR. Spill kits available for fueling/vehicles. Noise and light minimized for night operations; works paused during heavy rain to protect data and safety.

1.33 Emergency Preparedness

Site induction covered muster points, first-aid resources, emergency contacts, and nearest clinic/hospital. A first-aid kit and fire extinguisher were available on site; incidents are logged and reported within 24 hours.

1.34 Training & Competency

Operators were briefed on GPR equipment, TTM procedures, and client HSE rules. Authorizations and equipment inspections were verified prior to shift.

Documentation

Daily toolbox talks, PTRA forms, permit copies, and inspection checklists were filed with the project records and are available upon request.

Table 7: HSE checklist

Item	Control / Evidence
PTRA completed & signed	Daily pre-task form on file
Permits/TTM in place	Valid permits; cones/barriers/signage
PPE compliance	Observed; spares available
Utility risk controls	No intrusive works; safe offsets
Environmental controls	No disturbance; spill kit present
Emergency readiness	First-aid, contacts, muster points briefed
Incident reporting	24-hr notification procedure

Standards & References

1.35 Standards Followed

- **ASTM D6432** – *Standard Guide for Using the Surface Ground Penetrating Radar (GPR) Method.*
- **PAS 128** – *Specification for underground utility detection, verification and location* (UK).
- **BS 5930 / BS 10175 (where applicable)** – Ground investigation / site investigation practice.
- **Project HSE rules & client specifications** – Site-specific health, safety and environmental requirements.

1.36 Technical References

- **GPR manufacturer documentation** (Cobra Smart WiFi) – Operating manuals and recommended acquisition/processing settings.
- **Software user guides** – *Prism 2* processing workflows and *CAD* mapping procedures.
- **Utility records and as-built drawings** supplied by the client (if available).
- **Site aerials/basemaps** (orthophotos or GIS basemaps) used for geo-referencing and visualization.

1.37 Application in This Survey

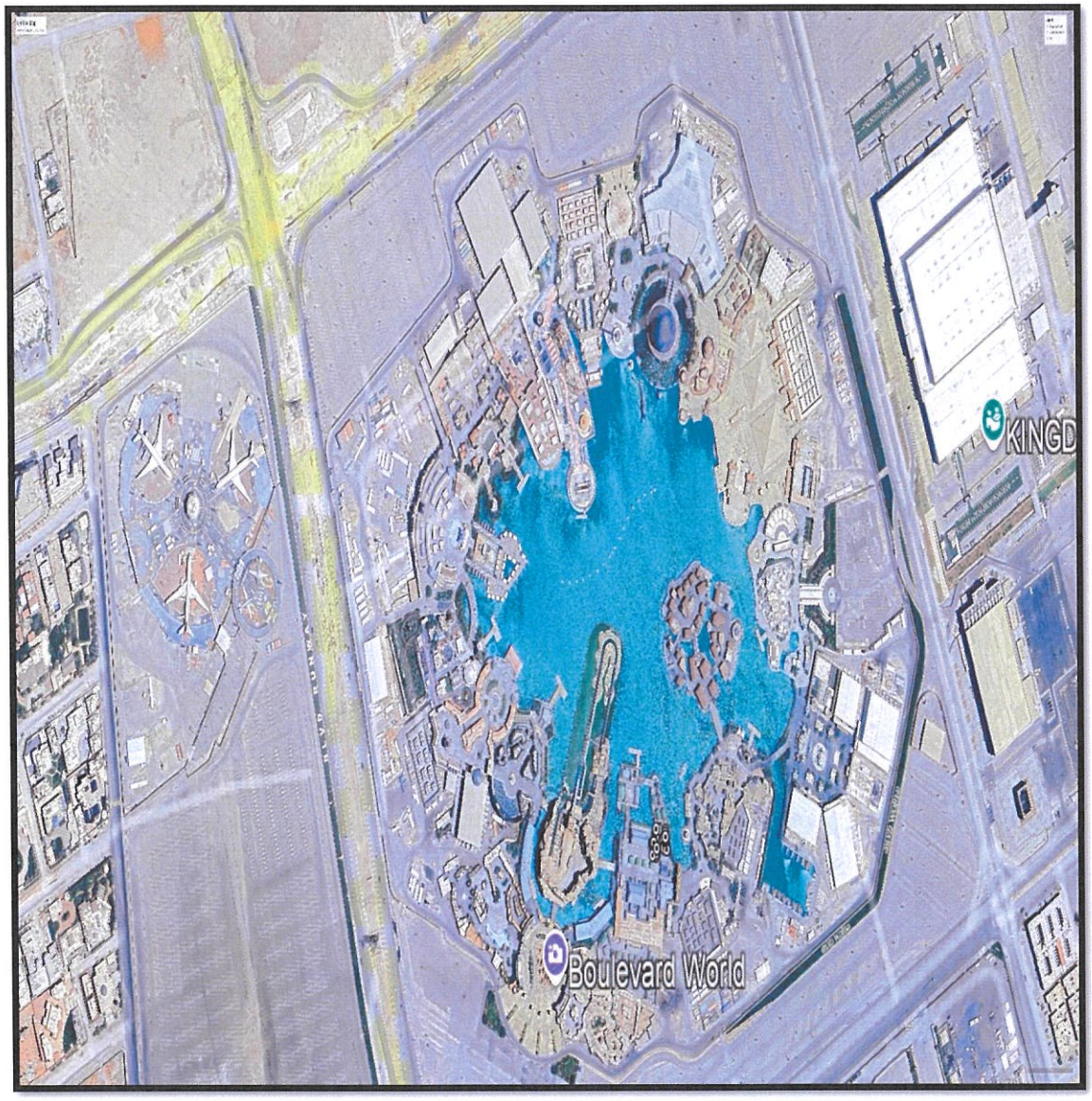
- Survey planning, acquisition, and processing were aligned with **ASTM D6432** guidance (antenna coupling, time-zero, velocity calibration, filtering).
- Utility detection and classification were documented consistent with **PAS 128** principles (confidence attribution, positional accuracy, verification).
- Mapping outputs were prepared in **CAD** with appropriate metadata, projection, and figure captions.

General Notes

To ensure the success and accuracy of the utility detection process using Ground Penetrating Radar (GPR), the following general notes must be taken into consideration:

- The GPR method is most effective in areas free of heavy surface reinforcement or metallic interference. Detection in highly congested or reinforced zones may yield reduced clarity.
- Environmental and surface conditions (e.g., wet surfaces, concrete thickness, surface clutter) may influence the quality of radar signals and the interpretability of subsurface features.
- Depth estimations provided in the report are approximate and based on assumptions of average subsurface dielectric constants. Actual depths may vary slightly depending on local material properties.
- This report presents a non-invasive geophysical assessment and does not constitute a guarantee of the complete presence or absence of utilities.
- It is recommended that findings be validated through safe excavation methods prior to any intrusive work or construction.
- All interpretations are based on GPR data collected at the time and date specified; subsurface conditions may change over time due to external factors.

APPENDIX A : SITE PLAN



The map displays the georeferenced location of the GPR and RD survey conducted at *Boulevard Riyadh City – Al-Louloua Building, Hittin District, Riyadh, Saudi Arabia.*
The survey zone is clearly marked within the context of surrounding infrastructure to support utility planning and interpretation.

APPENDIX B: Site Work Images

Appendix B – Field Photos

This appendix presents selected field photographs taken during the survey, including surveying works, GPR operation, and electromagnetic detection activities. Each figure is captioned for clarity.

Figure B-1. Surveying Works on Site — GNSS-based surveying to support GPR mapping.

Figure B-2. Surveying Operation — Site positioning and layout prior to GPR scanning.

Figure B-3. Electromagnetic Locator (SeekTech SR-20) — Field operation to detect shallow metallic utilities.

Figure B-4. Electromagnetic Survey in Progress — Operator scanning paved surfaces for buried cables.

Figure B-5. Ground Penetrating Radar (Cobra Smart WiFi) — High-resolution scanning for subsurface anomalies.

Figure B-6. GPR Survey During Evening Session — Continuous survey conducted with minimal site interference.

APPENDIX C: Final Utility Map

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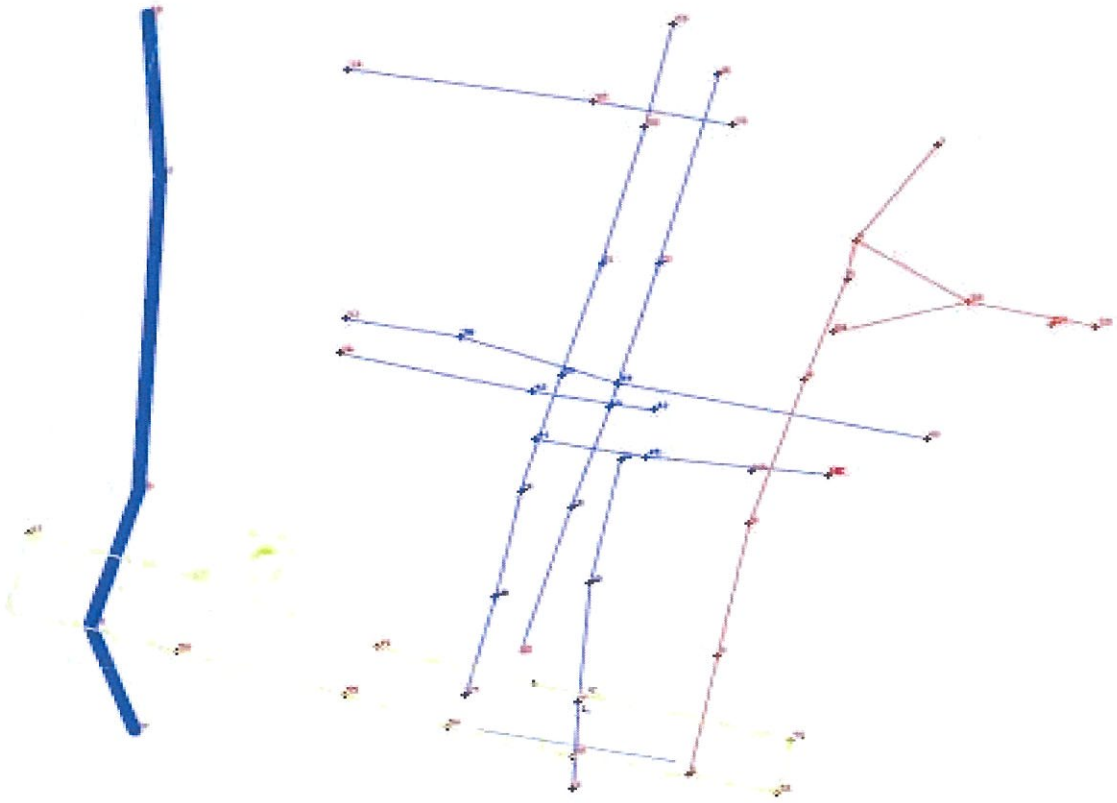

The map presents the interpreted underground utilities detected during the GPR and RD survey, with color-coded representation for clarity:

- **Blue lines** represent identified **underground pipelines** (e.g., water or drainage).
- **Red lines** indicate **electrical conduits** or cables.
- **Yellow lines** mark the positions of **trenches** or backfilled utility paths.
- **Cyan boundary** outlines the **general site limits** as referenced in the base map.

This visualization supports accurate utility mapping and provides essential spatial context for planning and excavation safety.

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APPENDIX D: Coordinates of Detected tilities

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Coordinates of Detected Underground Utilities

The following table summarizes the georeferenced positions and estimated depths of key underground utilities identified during the GPR and RD survey. The coordinates were derived using total station measurements and are intended to support excavation planning and utility avoidance procedures.

Utility Type	From (X, Y)	To (X, Y)
Power Cable-01	661900.407, 2740953.732	661905.605, 2740953.179
Power Cable-02	661900.898, 2740955.351	661905.006, 2740955.010
Power Cable-03	661902.467, 2740963.033	661906.662, 2740959.066
Power Cable-04	661902.301, 2740964.141	661906.877, 2740964.508
Power Cable-05	661902.404, 2740964.093	661904.323, 2740964.598
Power Cable-06	661905.477, 2740968.083	661905.829, 2740973.874
Power Cable-07	661919.587, 2740972.584	661920.158, 2740965.559
Power Cable-08	661920.422, 2740963.069	661921.130, 2740958.360
Power Cable-09	661917.387, 2740959.410	661921.934, 2740958.511
Pipe Line-01	661901.403, 2740956.885	661906.028, 2740956.353
Pipe Line-02	661901.895, 2740960.008	661906.955, 2740959.957
Pipe Line-03	661905.625, 2740968.653	661910.304, 2740965.075
Pipe Line-04	661905.662, 2740968.346	661910.819, 2740967.688
Pipe Line-05	661905.245, 2740969.661	661910.837, 2740969.053
Pipe Line-06	661908.972, 2740973.466	661908.303, 2740967.292
Pipe Line-07	661909.571, 2740973.517	661908.770, 2740967.275
Pipe Line-08	661917.353, 2740968.252	661920.028, 2740967.611
Pipe Line-09	661917.092, 2740959.617	661920.811, 2740959.372
Pipe Line-10	661902.3136, 2740953.2611	661902.9329, 2740964.717
Pipe Line-11	661904.3351, 2740952.8920	661905.8541, 2740964.241

Note:

- All coordinates are presented in the local grid system (WGS 84 / UTM Zone 38N) unless otherwise stated.

APPENDIX E: Raw & Processed Radargrams

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Appendix A – Raw & Processed Radargrams

This appendix presents side-by-side comparisons of Ground Penetrating Radar (GPR) radargrams. The raw radargram (left) is shown next to the processed radargram (right). Processing included filtering, gain adjustment, and depth calibration to improve clarity of subsurface reflections. Borders have been applied for clarity; shadow effects can be added in Word via Format Picture → Effects → Shadow.

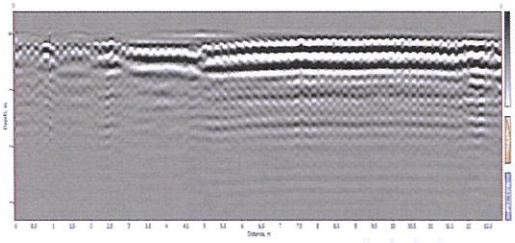

Figure A-1a. Raw radargram — background noise obscuring shallow reflections.

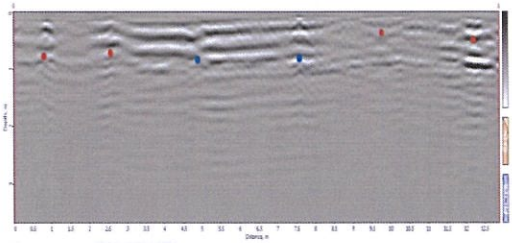
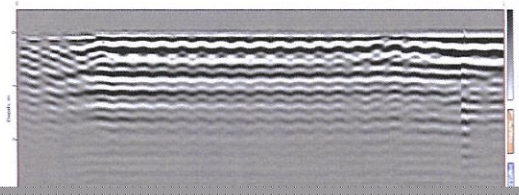
Figure A-1b. Processed radargram - clear hyperbola showing power cable at ~0.6 m depth.