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# Rolling Impact Compaction for Ground Improvement in Florida


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# Outline

- Overview of Florida's karst terrain
- Site background
- Site investigation - Geophysical, Standard Penetration Test (SPT) and Cone Penetration Test (CPT) programs
- Ground improvement objectives and method selection
- Implementation of Rolling Impact Compaction
    - Rolling impact compaction trial
    - Post-compaction CPT verification
- Conclusions and recommendations

# Florida’s Unique Geology

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- Predominately comprised of “karst” terrain, a landscape formed by the dissolution of underlying carbonate rocks (e.g., limestone).
  - This is the reason for the numerous lakes, springs, and sinkholes found in Florida.
- Sinkholes are formed by the carbonate (or water-soluble) rocks dissolving and the resulting voids collapsing.

# Site Background

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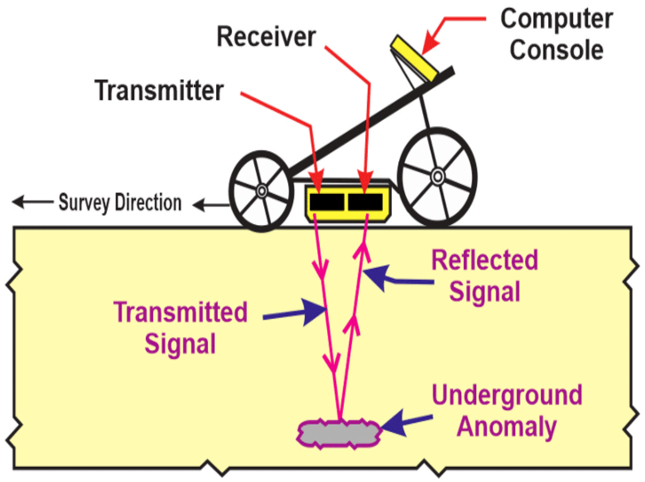
- Geosyntec provided design and permitting services for expansion of a facility in Florida spanning approximately 220 acres.
- Lithologic framework generally consists of (from top to bottom):
  - Surficial deposit of undifferentiated sands and variably silty sands
  - Interbedded clayey sands, sandy clays and/or silty clays
  - Limestone bedrock of the Ocala Limestone Formation
    - Depth to limestone ranges from 25 to 85 ft

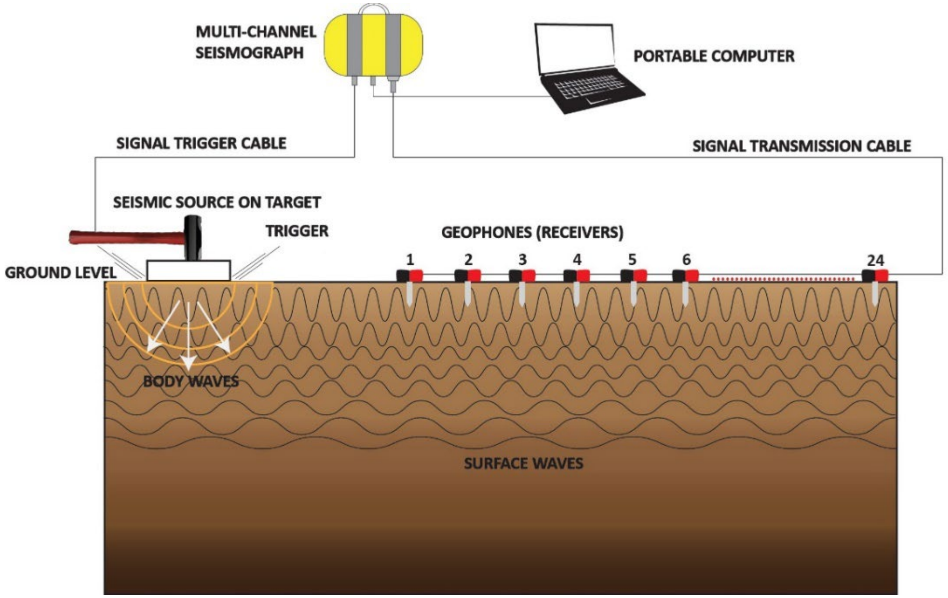
# Geophysical Evaluations

- Geophysical methods, such as ground penetrating radar (GPR), Multi-channel Analysis of Surface Waves (MASW), and microgravity were used to identify possible loose zones or voids in subsurface materials (soils or bedrock) in the expansion area.

GPR




MASW




MICROGRAVITY

# SPT Boring and CPT Sounding Programs

- SPT borings and CPTs were advanced in the expansion area to correlate with the GPR, MASW, and microgravity results.
- Additional objective of the investigations was to identify the physical top of competent limestone.


# Microgravity and SPT Results

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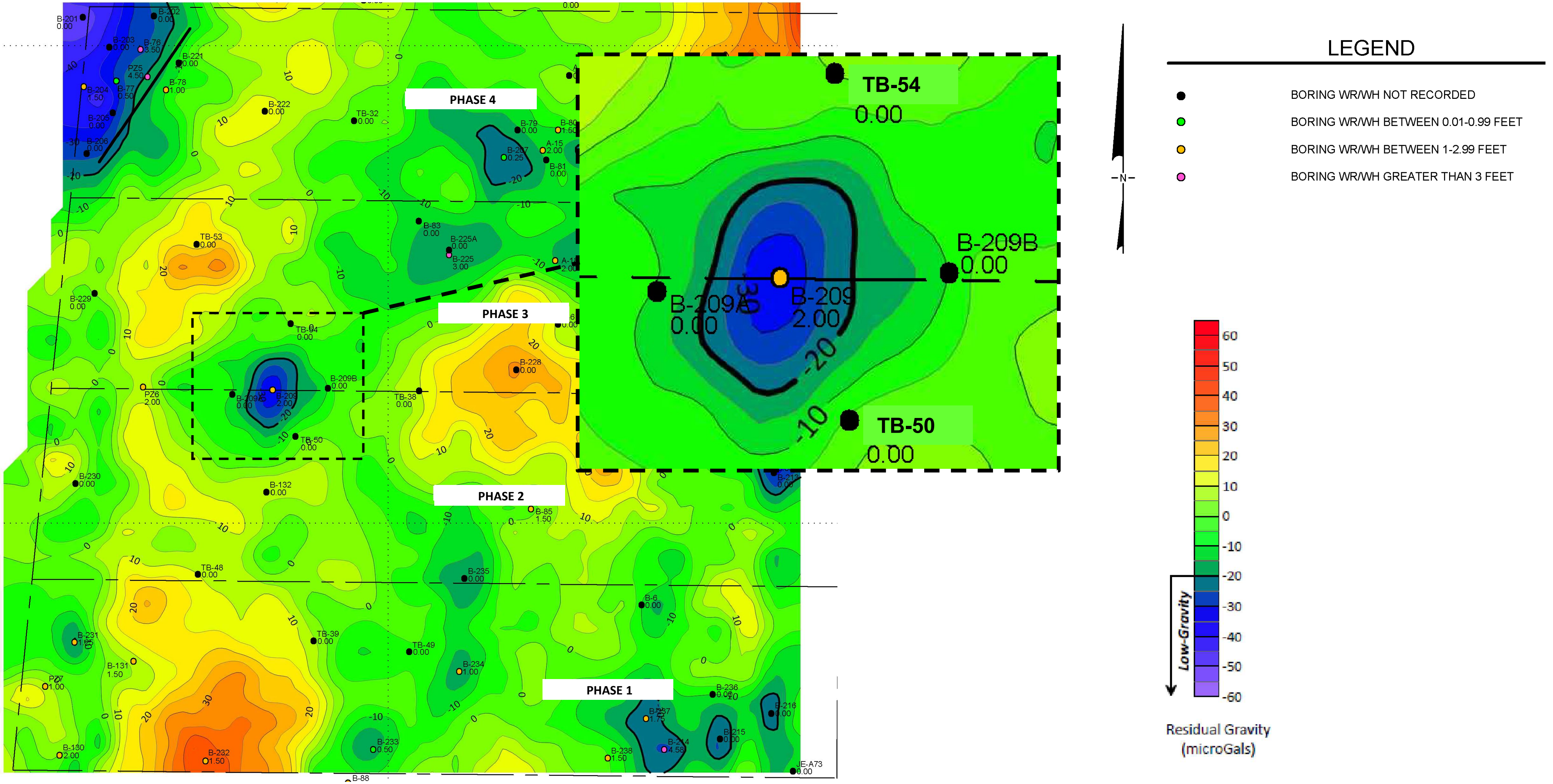

# Soil Arching Analyses

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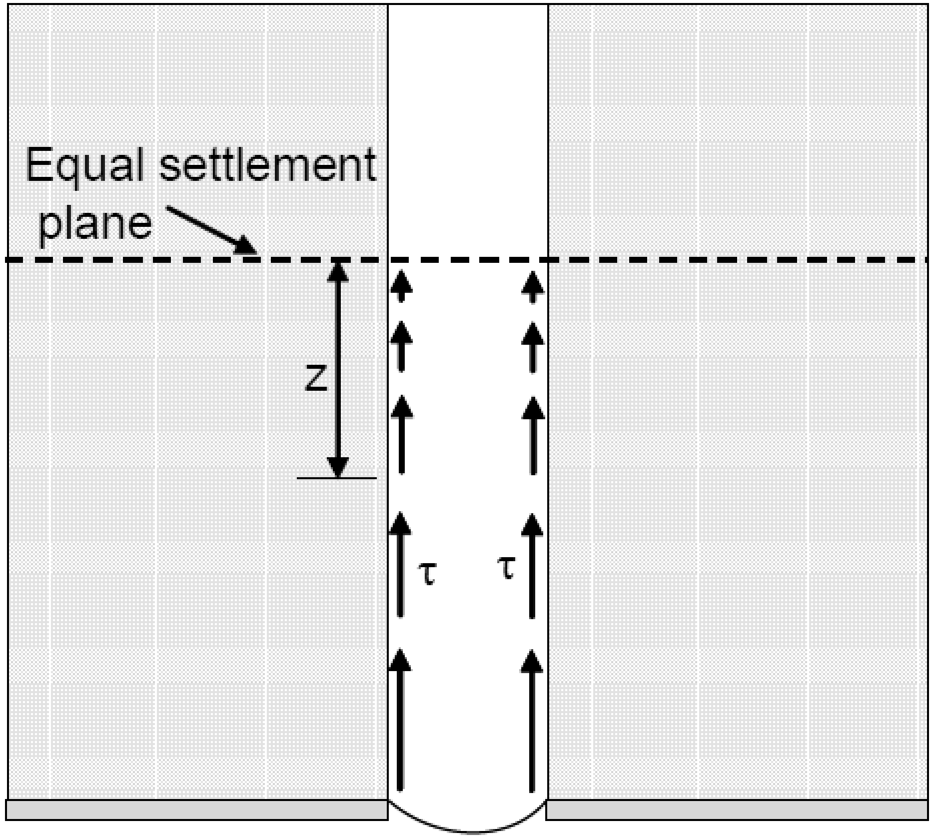
- The low-density zones (i.e., WR/WH conditions) noted in the soil borings were analyzed to evaluate the stability and geometry of potential anomalies.
- Soil arching analyses, using Terzaghi (1943) theory, were performed to assess the maximum stable widths of theoretical voids.
    - The collapse of a void could occur if a vertical applied stress exceeds the shear strength of the soil arch.
- Potential unstable areas within the relative high microgravity zones (greater than -15 µgals) were generally shallow, within approximately 5 to 10 ft of design subgrade elevations.
    - Not practical to pinpoint and remediate specific areas of concern, so "blanket" approaches were considered.



# Rolling Impact Compaction for Ground Improvement of Shallow Features



- Depth of influence reported for impact rollers of about 2 to 8 ft in cohesive soils (e.g., clayey soils), while in non-cohesive soils (e.g., sandy soils), the depth of influence has been observed at 10 to 13 ft and sometimes deeper.
- Rolling impact compaction method appeared suitable to remediate features at a depth of 5 to 10 ft below design subgrade elevations.

# Rolling Impact Compaction Trial

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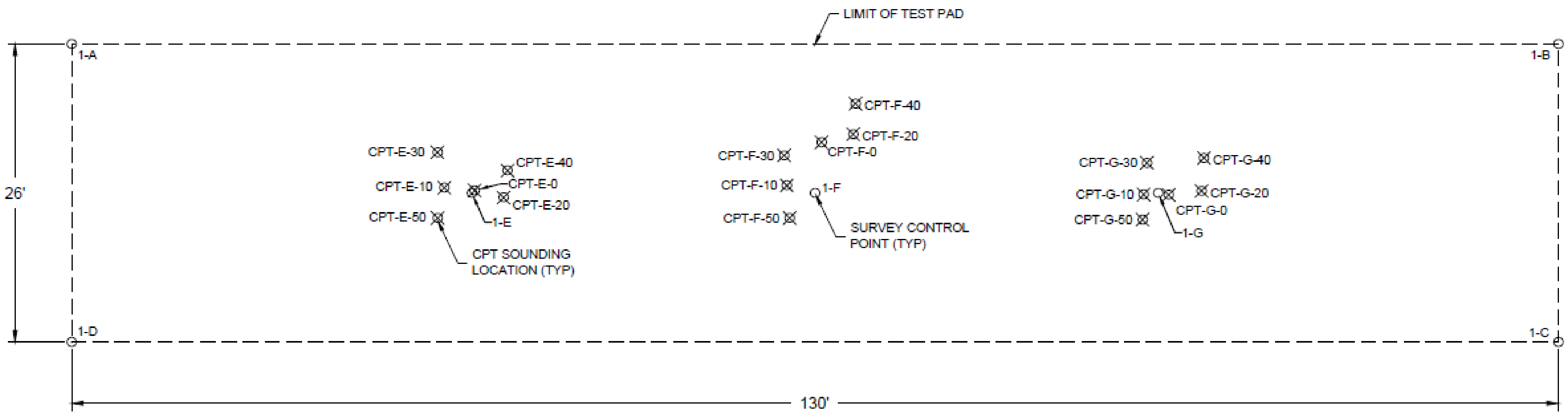


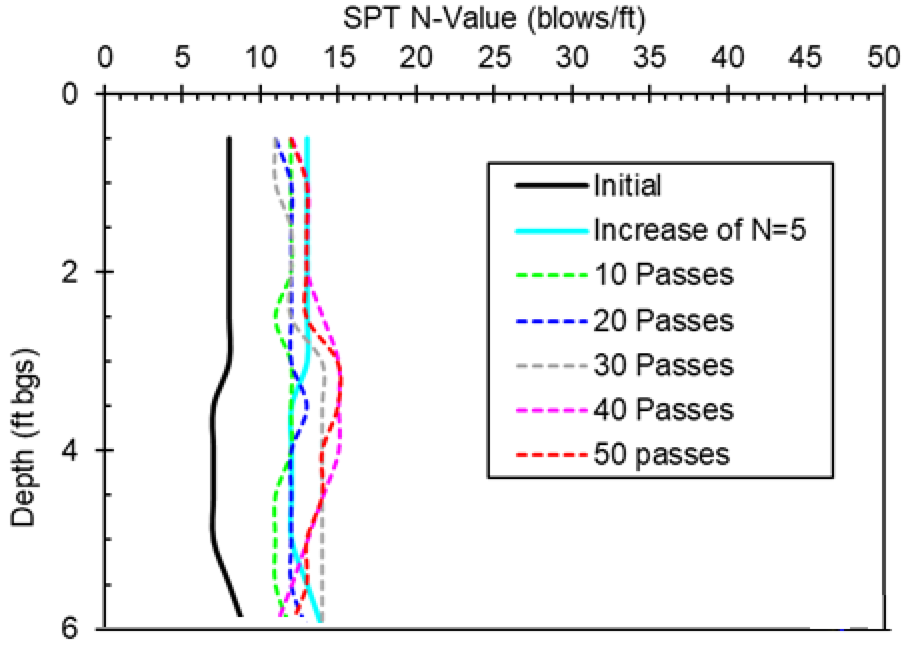

- 26 ft x130 ft test pad area with test locations spaced at 30 ft intervals.
- CPTs were performed prior to rolling impact compaction, and then after every ten passes of impact compaction were completed.
- Objective was to identify the minimum number of passes to increase the equivalent SPT N-value by 5. For example, weight of rod or weight of hammer intervals (i.e., N=0) would be improved to an N value of at least 5.

# Rolling Impact Compaction Trial

# Rolling Impact Compaction Trial Results

- Generally, an increase in N-value of 5 or more was achieved after 20 or more passes.
- At one test location (denoted 1-G), this improvement was only observed after 40 passes.
- A minimum of 40 passes was conservatively recommended across the proposed full-scale impact compaction areas.

CPT 1-G



# Lessons Learned from Compaction Trials

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- Impact compactor was towed by a John Deere 310 tractor, which often lost traction due to loose soil conditions.  This could have been mitigated by more frequent moisture conditioning.
- The tractor periodically became lodged in the soil. Using either a track-mounted tractor or a high-speed dozer for towing may have increased the mobility and effectiveness of the impact compactor.

# Full-scale Rolling Impact Compaction

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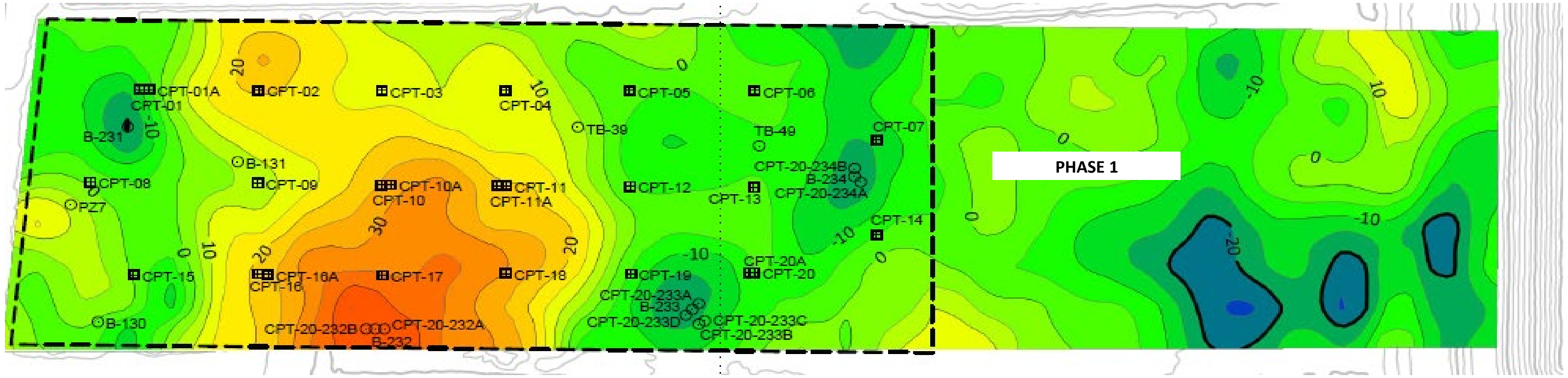
- Performed based on test pad trial data and observations.
- Forty (40) passes were performed in the facility expansion footprint.
- High-speed, tracked towing equipment was used for one of the two construction phases.
  - Achieved consistent compaction speed and optimum efficiency

# Phase 1 Results




- Performed 20 CPTs in 10-acre impact compaction area.
- Step-out CPTs were performed after the primary location encountered an equivalent N-value less than 5 within 10 ft below the design subgrade elevations.
- CPT logs indicate clayey soil was encountered at the six locations where an equivalent N-value less than 5 was encountered, generally at a depth of 9 ft.
- SPT N-values of at least 2 were achieved at the 9-10 ft depth that corresponded to clayey soils.

# Phase 2 Results

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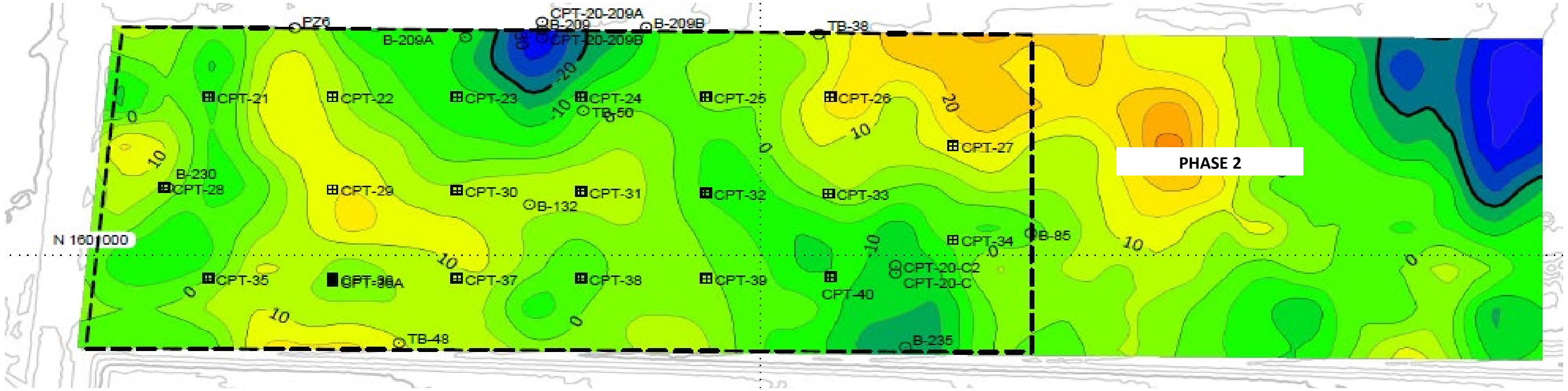


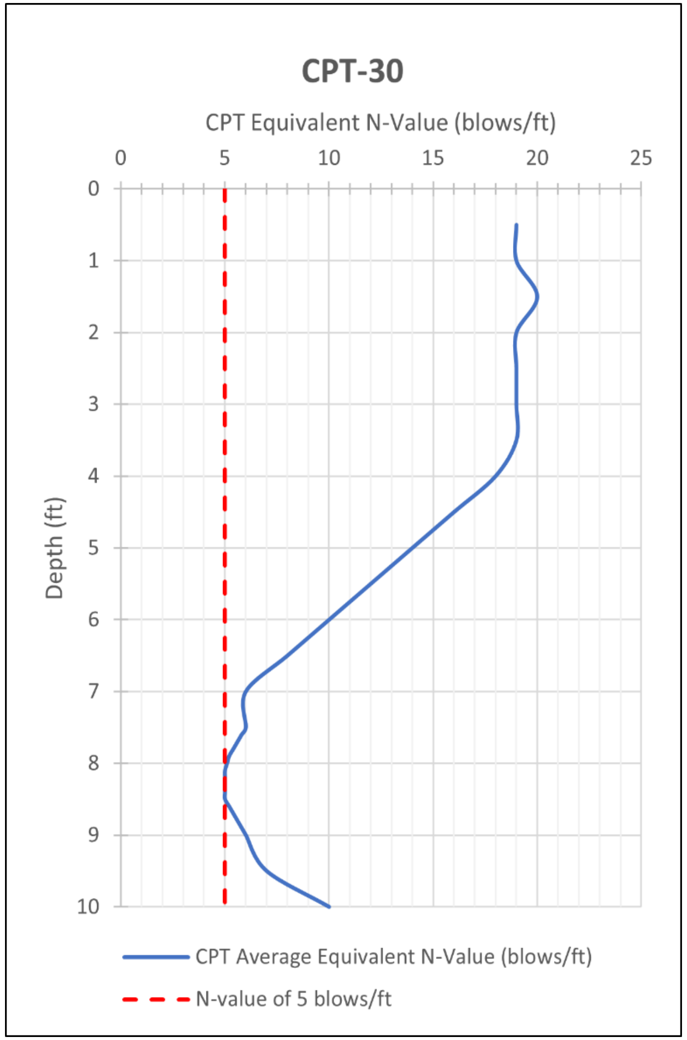


- Performed 20 CPTs for 10-acre impact compaction area.
- No equivalent CPT values less than 5 were encountered for the 20 locations performed in this area.
- CPT logs indicate sandy soils were generally encountered.
- Cohesive soil was encountered at one location, CPT-30, and an N-value of 5 was observed at the corresponding depth.

# CONCLUSIONS AND RECOMMENDATIONS

- Depth of soil improvement depends on equipment, methodology, and soil type.
- Test pad trial is critical to evaluate adequacy of contractor's equipment and methodology to achieve a relative improvement in soil characteristics.
- Selection of towing equipment is critical to achieve consistent, optimal speed recommended by the manufacturer.
- Deepest improvement achieved for sandy soils (>10 ft in some cases).

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THANK YOU