

## Case Analysis

# Ground Improvement For a County Road Realignment

### Market Sector

TRANSPORT INFRASTRUCTURE



### Application

IN-SITU COMPACTION



### Project Phase

CONSTRUCTION PHASE



## Site Description

Belle Ayr Mine, an operational opencast coal mine in Gillette, Wyoming, required the extraction of coal reserves located beneath the existing Bishop Road. As a result, the local authority mandated the realignment of this section of roadway to facilitate continued mining operations while maintaining public road access and continued mining operations.

## Project and Geological Review

Given the inherent heterogeneity and potential voiding within the materials, in-situ ground treatment was essential to ensure stable, uniform base for layered works and bridge abutments, mitigating post-HEIC settlement risks and enabling controlled conventional fill placements post HEIC.

The objective of the HEIC program was to densify and treat the un-documented mine backfill to the point of practical refusal (mitigate differential settlements) within the operating capability of the equipment from 10-15 feet depth.

**Up to 90% more uniform subgrade with 10x faster delivery**



## Project Details

It was initially proposed that a substantial portion of the road realignment, consisting of undocumented placed overburden materials, be treated conventionally (10 to 15 feet cut) to an average depth of 12.5 feet. This approach presented significant practical and technical challenges.

Approximately 8,568,000 ft<sup>3</sup> of material would have required excavation and replacement, resulting in considerable time and cost implications when compared to High Energy Impact Compaction (HEIC) and it's associated in-situ testing.

The overburden materials exhibited variable compaction and small to large particle size distributions, making consistent compliance with engineered fill specifications very difficult. Project impacts would have been substantial, as excavation, particle size processing, moisture conditioning, placement in controlled lifts, and layer-by-layer compaction would have significantly extended construction durations. Weather sensitivity alone posed a serious risk to already constrained completion timelines.



In addition, reliance on laboratory testing to establish density-moisture relationships, and subsequent correlation of density results to stiffness or modulus-based performance criteria, would have introduced further lag time and verification complexity. These repeated testing cycles, combined with the inherent variability of the placed overburden, created uncertainty in achieving consistent, performance-based validation hence why HEIC and it's in-situ testing was implemented.

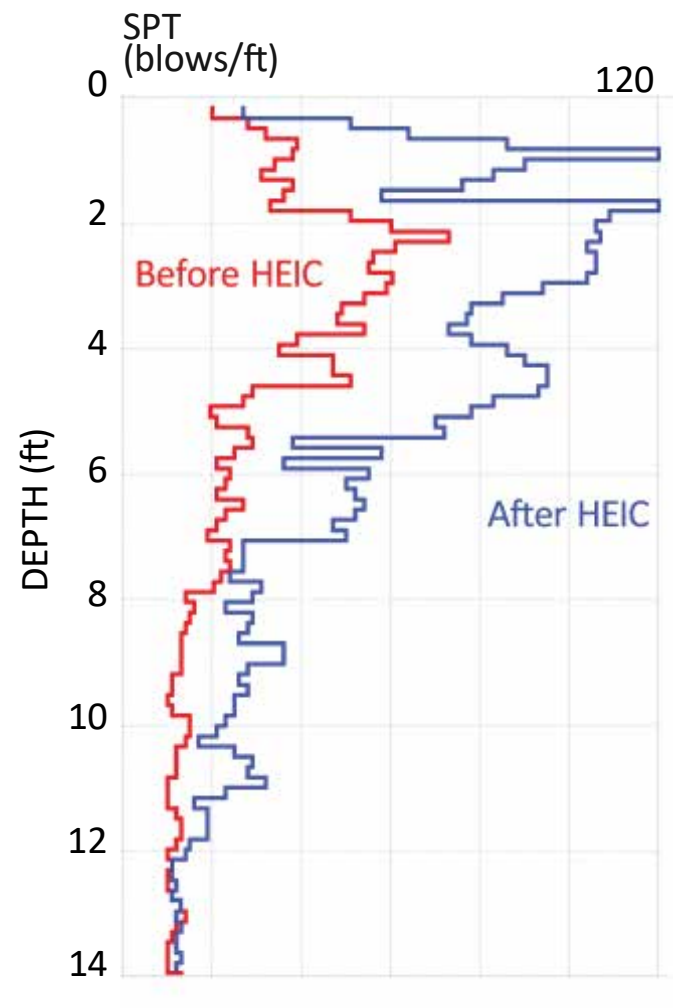
## Technical Memorandum

Overall, CPT results indicated improvements of up to an average of 31.25 % from pre-HEIC conditions to completion at 46 passes. Due to the heterogeneity of the subgrade, the depths of influence varied considerably. The most extensive improvement was observed at CPT 09, which showed 41.5 % improvement after 20 surface passes and 91.5 % improvement after 46 surface passes (shown below). Comparing this localised increase with the overall average percent improvements highlights the variability and heterogeneity inherent in the subgrade and therefore the importance of using HEIC to ensure uniformity was achieved.

Correlated SPT, Per foot averages over all				
	Pass 0	Pass 20	Pass 40	Pass 46
Average SPT Blow Counts <sup>(A)</sup>	32	36.5	40.8	42
Reduced SPT values to near refusal		4.5	4.3	1.2
Stdev <sup>(B)</sup>	17.24	11.77	6.09	1.78

(A) Mean SPT increases = ground is getting stronger.

(B) Standard deviation decreases significantly = ground is becoming more uniform.



## Summary

In-situ compaction was carried out using HEIC to densify existing ground and provide a stable, load-bearing base, ensuring that subsequent placement and compaction of engineered layers could be performed on a competent platform. This reduced variability and mitigated the risk of differential settlement.

In contrast to HEIC, conventional layered excavation and re-compaction of 10–15 ft lifts posed significant risks, including longer project durations, constructability challenges, variability in material properties, and more complex verification requirements.

Delays in accessing coal deposits directly increased the mine's operational costs. To mitigate this and accelerate production, HEIC was implemented as an alternative to conventional means, reducing complexity, time and expense.



HEIC delivers blows up to 550,000 lbs for very short durations, depending on soil type, machine setup, and operating speed. These dynamic forces don't just compact, they act as a rigorous proof roll, generating stresses and strains at depths far beyond what typical U.S. roadway traffic imposes. Observed performance shows that 40–46 surface passes ensure uniform, high-quality compaction across the treated area.

### HEIC Treatment Performance

**Variability Reduction:** Ground conditions shifted from highly heterogeneous ( $\approx 54\%$  variability) to highly uniform ( $\approx 4\%$  variability) following HEIC.

**Compaction Quality:** Achieving an SD of 1.78 against a mean of 42 blows/ft demonstrates excellent densification consistency and superior platform uniformity.

**Risk Mitigation:** The high degree of control significantly lowers the risk of differential settlement.

**Technical Benchmark:** A COV of  $\sim 4\%$  is considered exceptionally good for field-scale ground improvement.

- ✓ Up to 14 ft improvements recorded by CPT's
- ✓ Increased uniformity confirmed by PLT's and CPT's
- ✓ Up to 10X greater volume achieved
- ✓ Up to 15X cost savings versus a 12.5 foot over excavation

## Get in touch

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