

PURDUE
UNIVERSITY™

*Geotechnics and
Supplying Future Energy
Needs:*

Ground Modification Applications for Bio-Fuel Plants

Raymond J. Franz, P.E.
Roselle, IL

**HAYWARD
BAKER**
Geotechnical Construction



Bio-Fuel Facilities

- ◆ Current and future energy needs demand consideration of alternate fuel options, which in the US, include “Bio-Fuels”:
 - Bio-diesel
 - Ethanol
 - Corn
 - Grain
 - Cellulosic

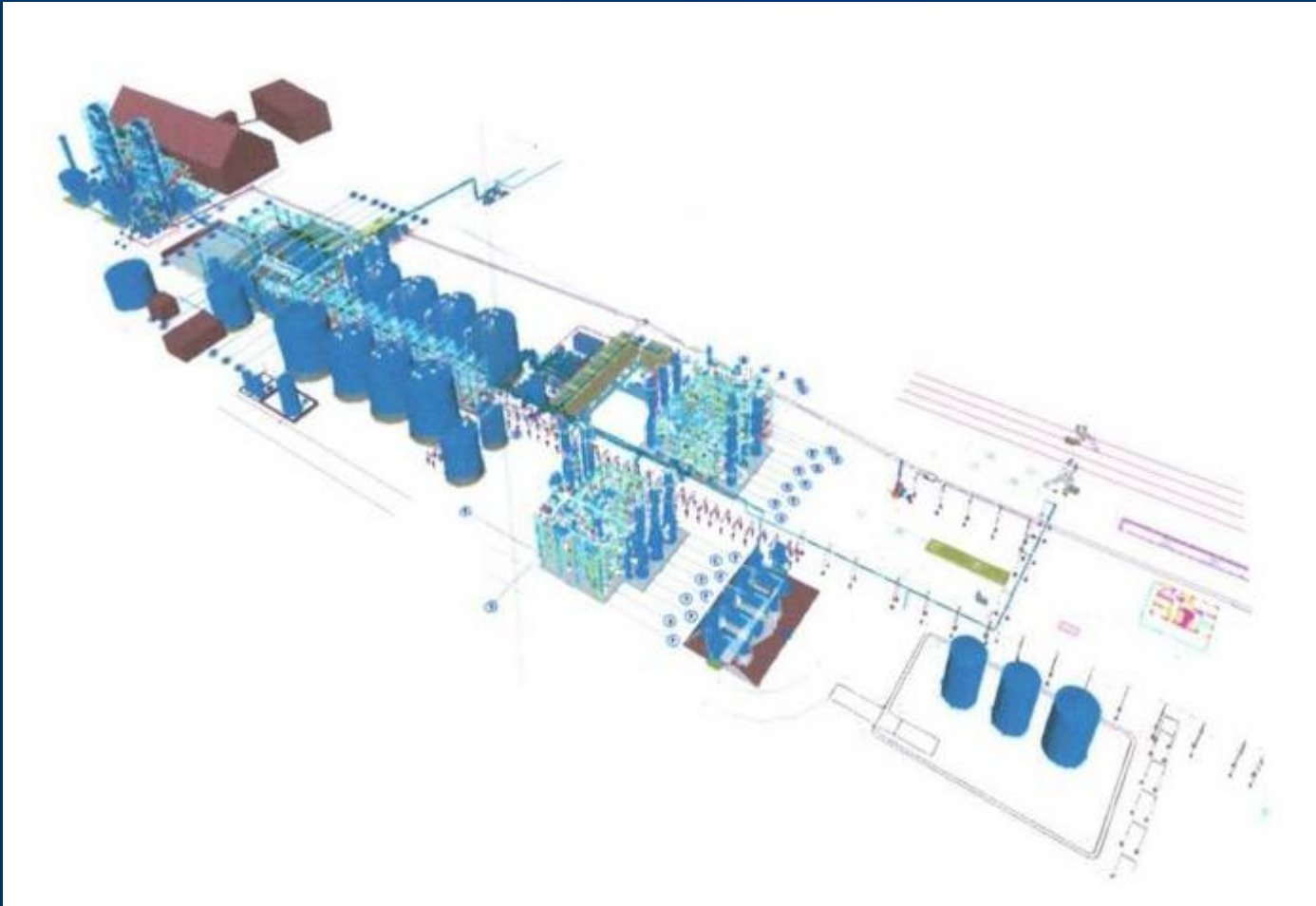
Bio-Fuel Facilities

- ◆ Geotechnical Engineers have a role in developing the processing facilities for such fuels.
- ◆ These roles include:
 - Mitigation of Geo-hazards
 - Facilitating cost-effective construction

Bio-Fuel Facilities

- ◆ **Typical Plant Components**
 - Large Diameter Liquid Storage Tanks
 - Storage Silos
 - Energy Center
 - Process Structures

Bio-Fuel Facilities



**HAYWARD
BAKER**
ARCHITECTS



Bio-Fuel Facilities

◆ Typical Requirements

- Foundation Contact Pressures
 - 3,500 psf to 7,000 psf
- Allowable Settlements
 - ¾-inch to 2½-inches
- Seismic
 - Adequate FS against Liquefaction and Lateral Spreading
 - Dynamic Settlements 1-inch

Bio-Fuel Facilities

◆ Geotechnical Challenges

- f (location, location, location)
 - » Near Source of Raw Feedstock
 - » Near Existing Transportation Infrastructure (Rail and River)
 - » Source of Process Water
- *Not Selected for Ideal Geology*

Bio-Fuel Facilities



**HAYWARD
BAKER**
CONSULTANTS



Bio-Fuel Facilities

◆ Geotechnical Challenges

- Compressible Soils
 - Glacial Lake Clays
 - Alluvium
 - Loess
 - Organics
 - Fills
- Liquefiable / Spread Susceptible Soil
 - Loose Granular
 - Very Soft Cohesives

Bio-Fuel Facilities

◆ Geotechnical Challenges

- *REAL* applied loads for tanks and silos
- Sustained load applications
- Large loaded areas/deep stress influence

These are not conventional building structures.

Geotechnical exploration and testing programs must reflect the particular requirements for these facilities:

- » *Deeper Borings?*
- » *Consolidation Testing ?*
- » *CPT?*

Ground Improvement Objectives

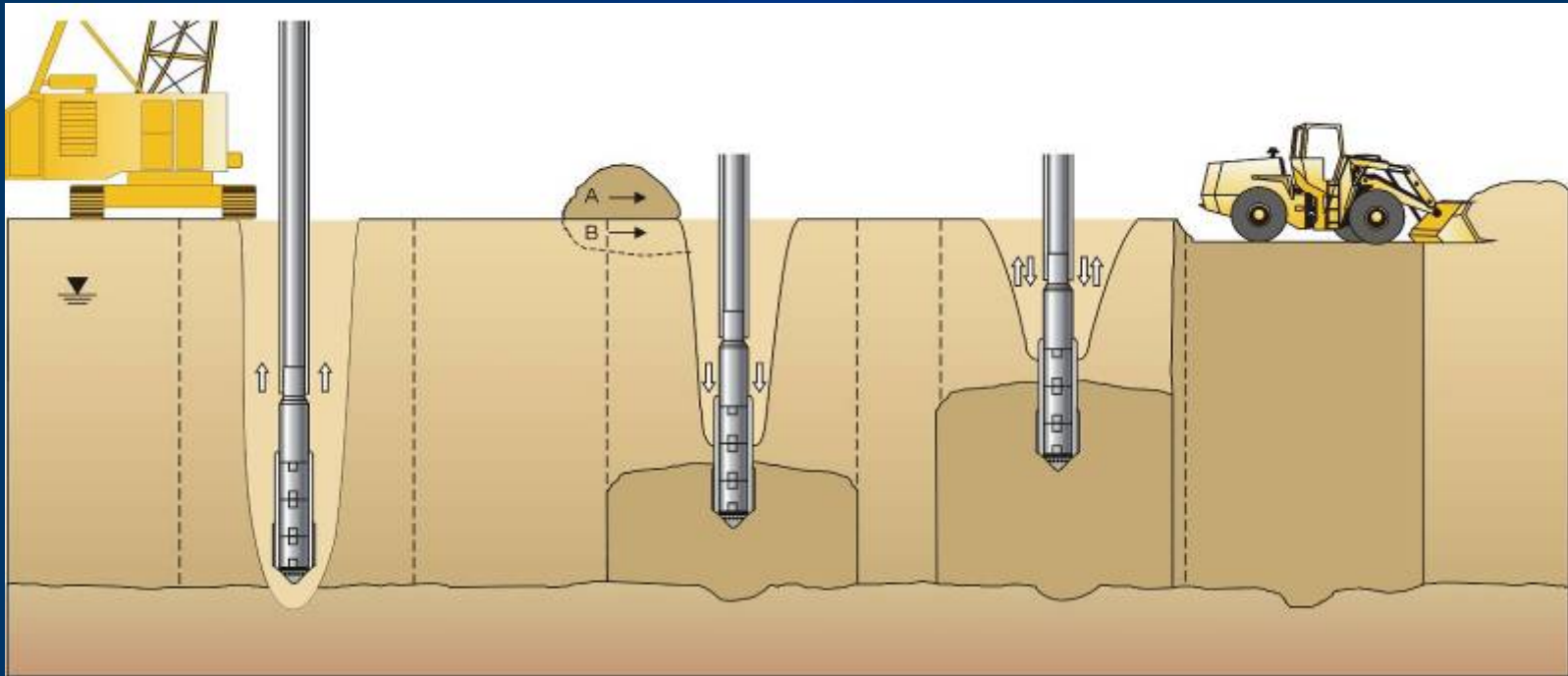
- ◆ Reduce total static settlement
- ◆ Reduce differential static settlement
- ◆ Increase allowable bearing pressure
- ◆ Improve site classification / Reduce risk of liquefaction/spreading
- ◆ Realize cost savings v. conventional alternatives:
 - Remove and Replace
 - Pile Foundations, Drilled Shafts/Caissons

Ground Modification Options

- ◆ Vibro Compaction
- ◆ Vibro Replacement (Stone Columns / Aggregate Piers)
- ◆ Soil Mixing
- ◆ Jet Grouting
- ◆ Surcharge and Drains

Ground Modification Options

The Vibro Compaction Process:



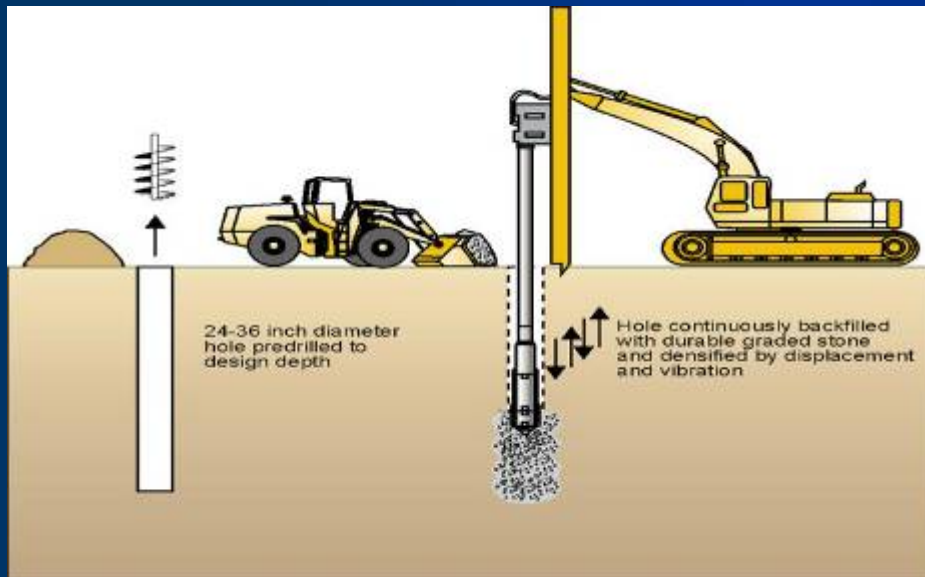
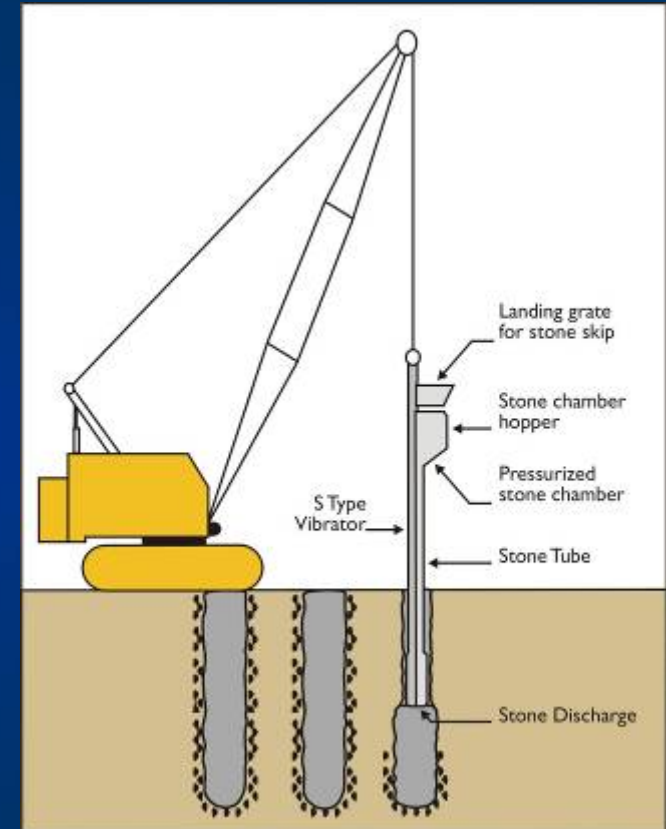
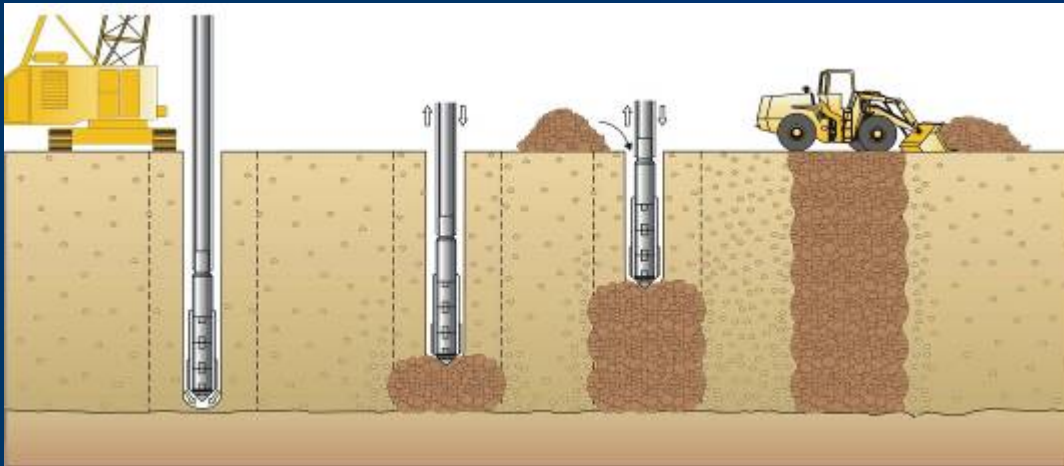
Densification

HAYWARD
BAKER
CONSTRUCTION

KELLER

Ground Modification Options

Vibro Replacement Processes:



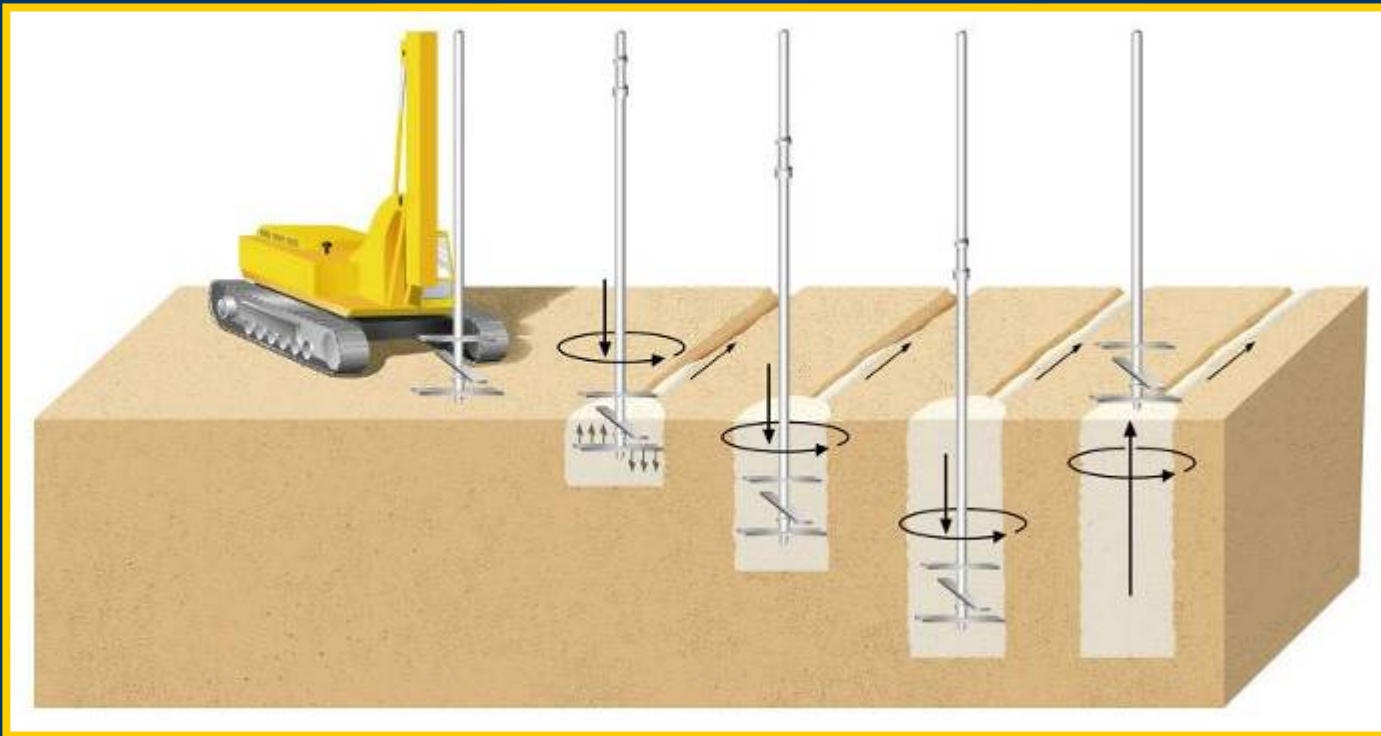
Reinforcement

HAYWARD
BAKER

KELLER

Ground Modification Options

Wet Soil Mixing Process:



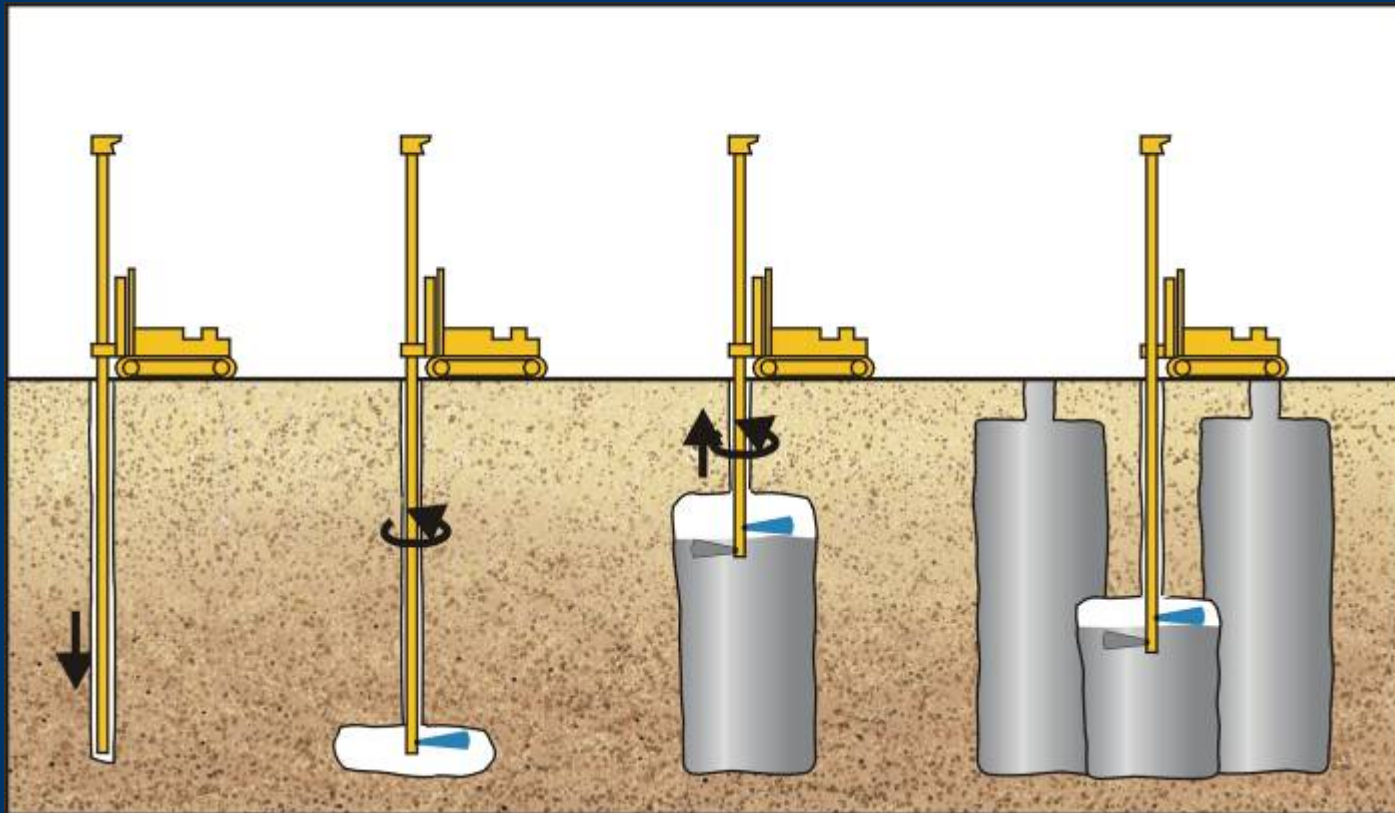
Stabilization with
Binder – Mechanical
Blending

HAYWARD
BAKER
CONSTRUCTION

KELLER

Ground Modification Options

The Jet Grouting Process:



Stabilization with
Binder – Hydraulic
Blending

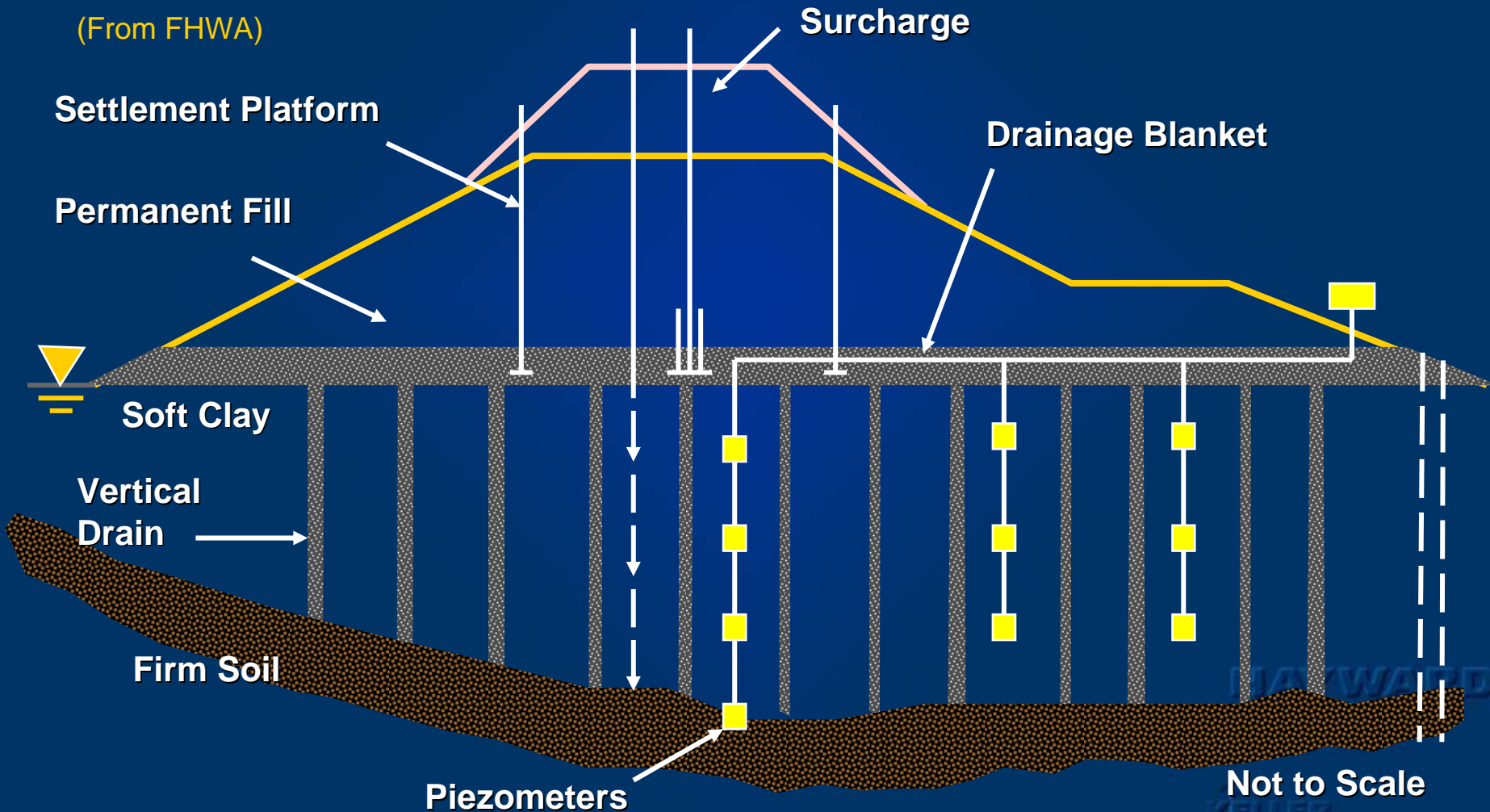
HAYWARD
BAKER
CONSULTANTS

KELLER

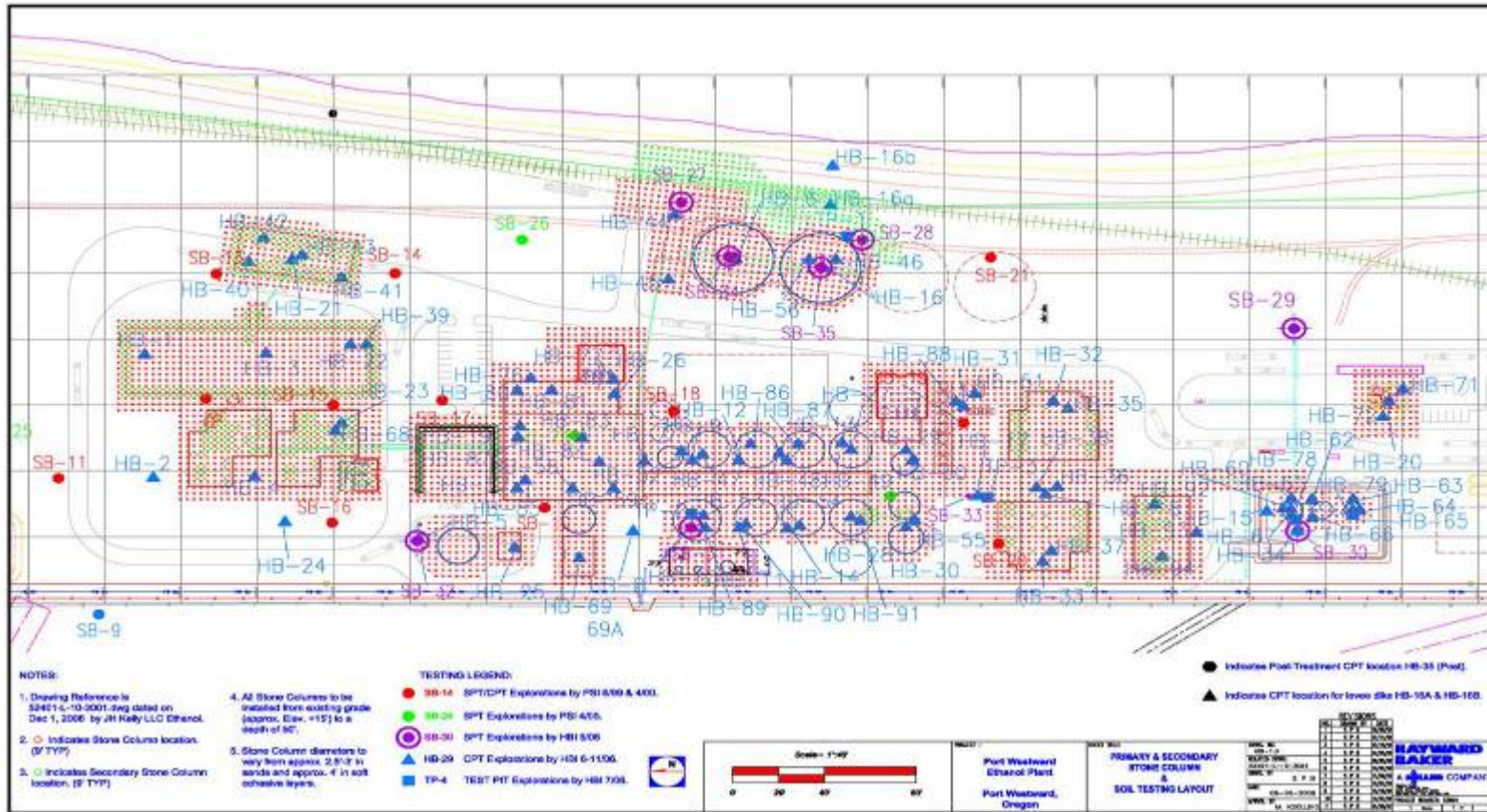
Ground Modification Options

Surcharge and Vertical Drains:

(From FHWA)



Ground Modification Installation

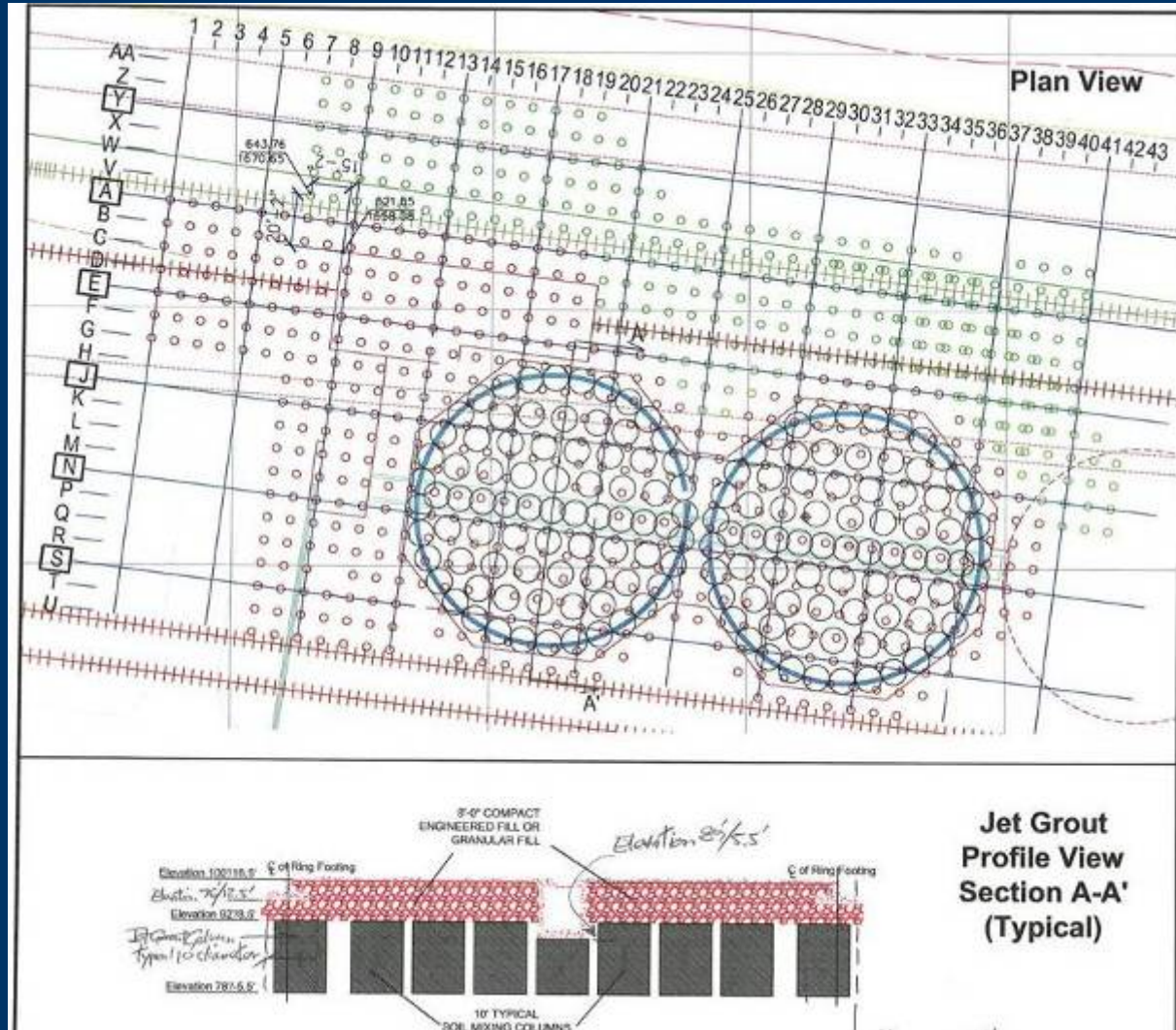


Example Treatment Program including Seismic Mitigation

HAYWARD BAKER

KELLER

Ground Modification Installation



Soil Mixing/
Jet Grouting
in Silo Area

HAYWARD
BAKER

KELLER

Ground Modification Installation



**HAYWARD
BAKER**
CONSULTANTS



Ground Modification Installation



**HAYWARD
BAKER**
CONSTRUCTION



Ground Modification Installation



**HAYWARD
BAKER**
CONSTRUCTION



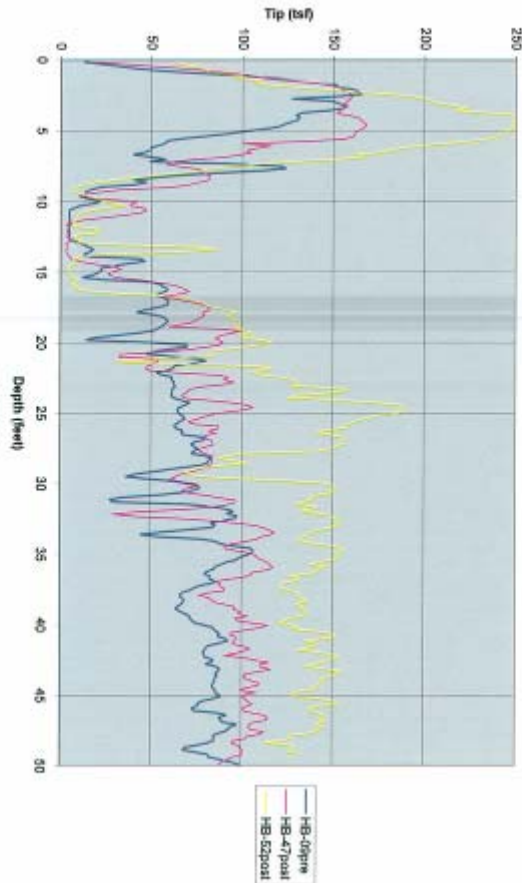
Ground Modification Installation



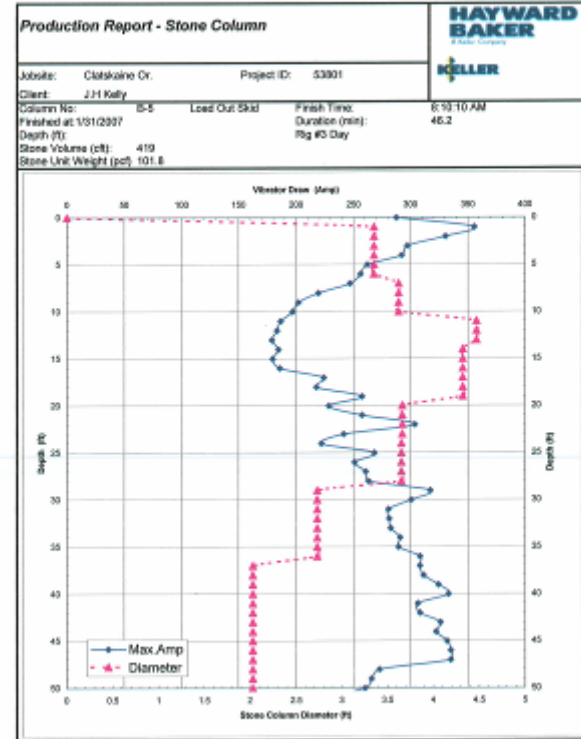
**HAYWARD
BAKER**
CONSULTANTS

KELLER

Ground Modification Installation



BH-09(pre) vs HB-47(post) & HB52(post)
Cascade Grain Ethanol Plant



HAYWARD
BAKER

KELLER

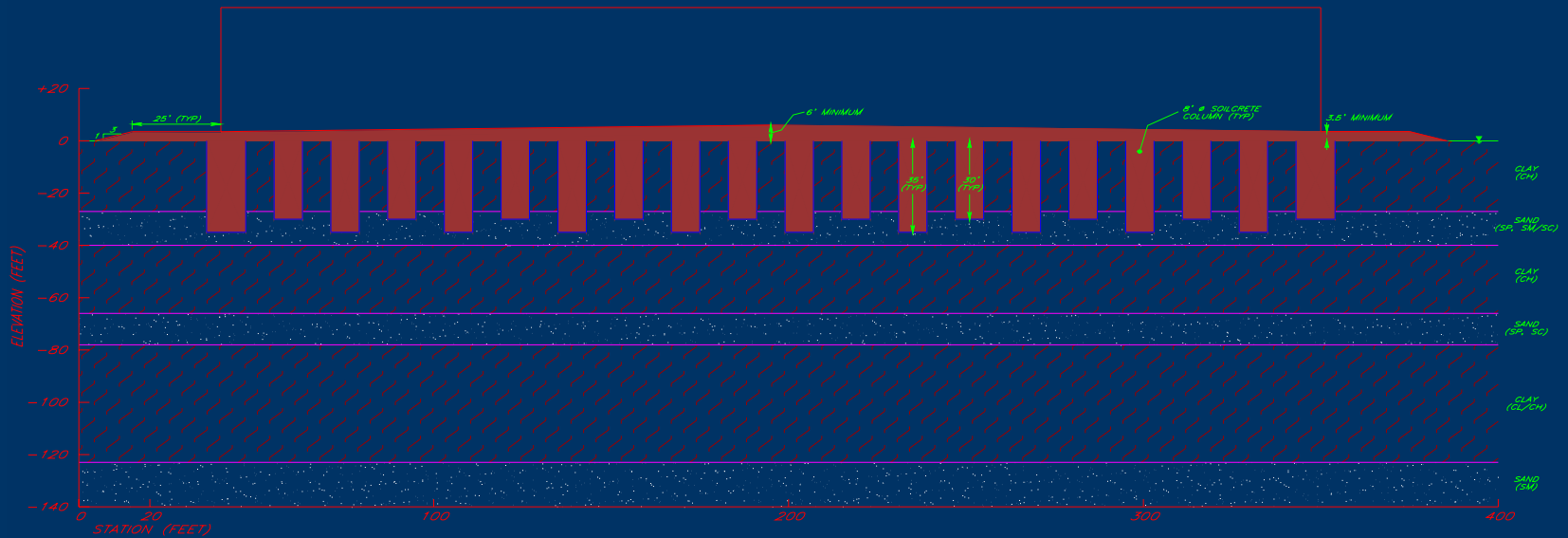
Ground Modification Installation



**HAYWARD
BAKER**
CONSTRUCTION



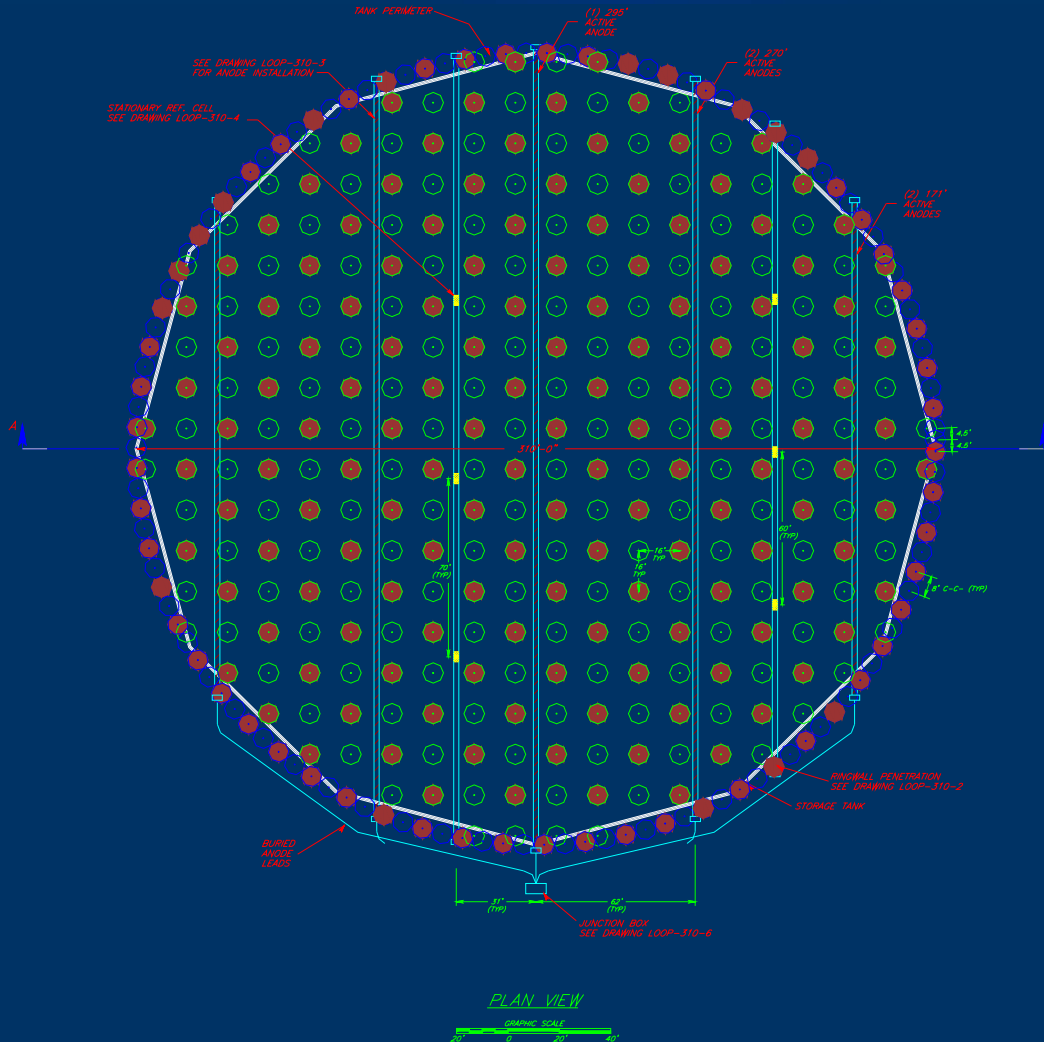
Ground Modification Installation



HAYWARD
BAKER
ENGINEERS



Ground Modification Installation



HAYWARD
BAKER
INCORPORATED



Ground Modification Installation



**HAYWARD
BAKER**
CONSULTANTS

KELLER

Ground Modification Installation



HAYWARD
BAKER
CONSULTANTS



Conclusions

- ◆ Frequently, Bio-Fuel facilities are constructed in less than ideal geologic settings.
- ◆ Sound Geotechnical Engineering for Bio-Fuel projects requires more attention to project elements.
- ◆ Appropriate Ground Modification techniques can mitigate seismic risks.
- ◆ Appropriate Ground Modification techniques can economize construction and control foundation performance.