# *Micropile Load Transfer Rates and Bond Stresses in the Puget Sound Region of Washington State, U.S.A.*

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# Background

- S&W began in-house research project in 2004
- Advance state of practice for load transfer rates and bond stresses
- Compare to soil types/densities and geologic units

# Research Process

- Collect information from S&W and partner contractor files
- Extract ultimate or maximum frictional capacities, soil types, etc.
- Assign geologic unit and soil type based on bond zone location and elevation
- Enter into database

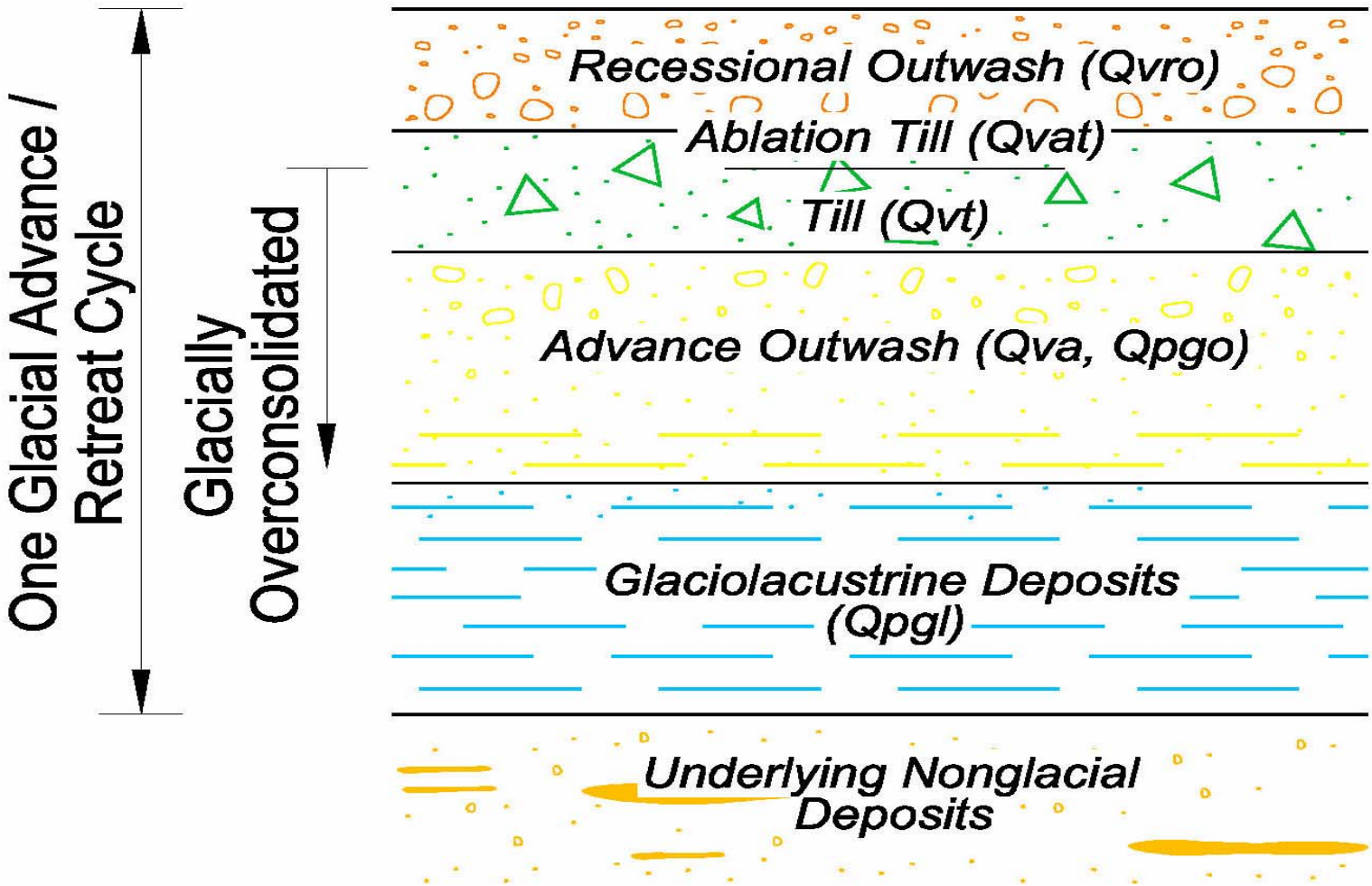
# Soil Classification

- Unified Soil Classification System, ASTM D2487
- Majority of data: silty sand with varying amounts of gravel (SM); low plasticity clay and silt (CL and ML); slightly silty sand with varying amounts of gravel (SP-SM and SW-SM)

# Major Geologic Units and Soil Types

- Deposits during glacial retreat: Recessional Outwash (Qvro) - sand and gravel
- Overridden deposits: Till (Qvt) – sand, clay, and silt; Advance Outwash (Qva) – sand and gravel
- Lean silt and clay, silty sand, and sand and gravels

# Simplified Stratigraphy



# Frictional Capacity

- Test to failure (ultimate) versus test to maximum
- Ultimate frictional capacity: engineering judgment, evaluated load/unload curves, permanent set, equipment influence, etc.
- Plotted both as load transfer rate and as bond stress

# Data

- Not in a controlled lab environment
- Some bond zones isolated, many were not
- Grout mix design not evaluated
- No instrumentation on bond zones
- No sacrificial bit, hollow-core tests

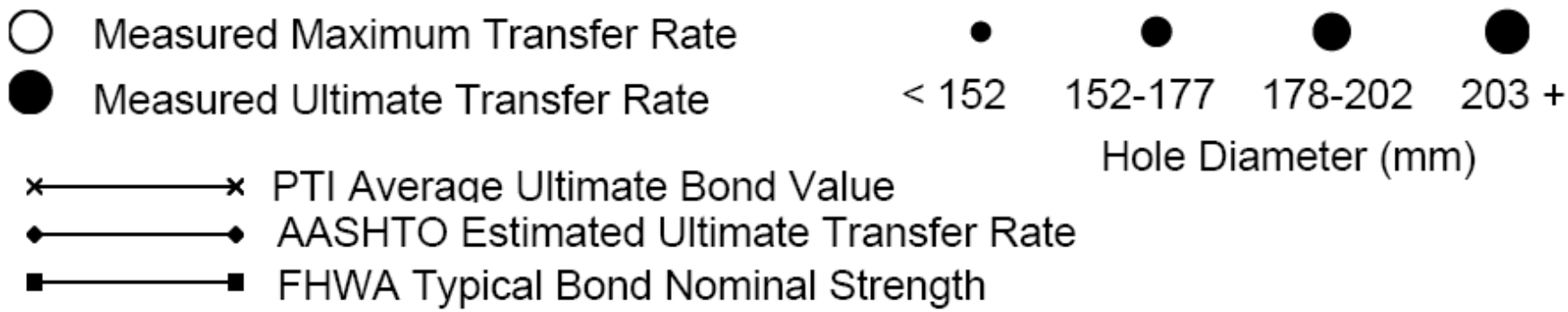
# Drilling Methods

| Method Number | Drilling Method | General Description |
|---|---|---|
| 1 | Single-tube Advancement | Casing with drill teeth, flush with air and/or water. |
| 2 | Rotary Duplex | Simultaneous rotation and advancement of casing plus internal rod, carrying flush. Rod typically has down-the-hole hammer. |
| 3 | Rotary Percussive Concentric Duplex | Same as 2, except casing and rods percussed as well as rotated. |
| 8 | Open Hole with Air Rotary Hammer | Air rotary down-the-hole hammer. Casing may or may not be used in upper no-load zone. |

# Grouting Methods

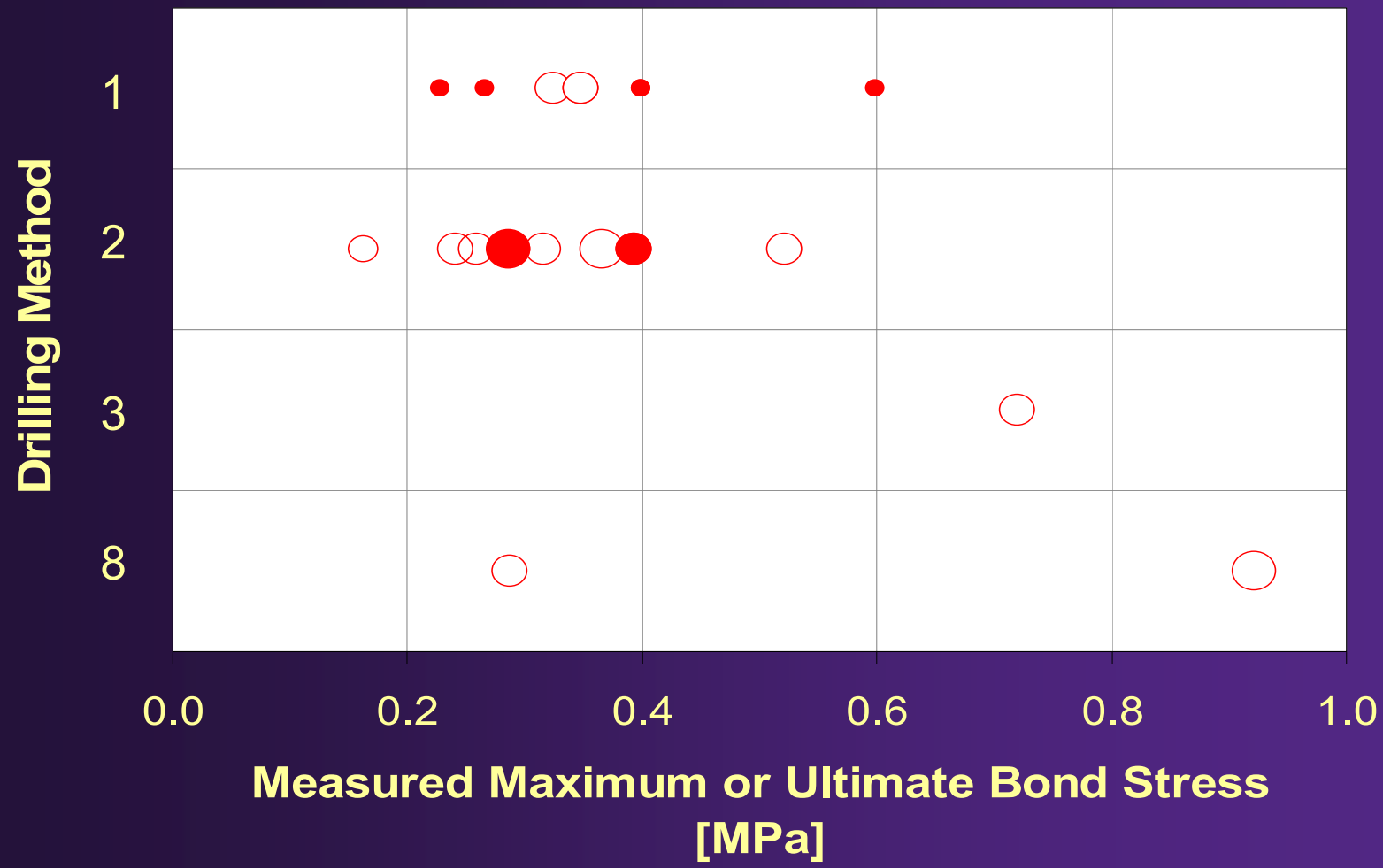
| Micropile Type | Grouting Method | Drill Casing |
|---|---|---|
| Type A | Gravity grout only | Varies from temporary casing/unlined (sub-type A1) to permanent casing in upper shaft only (sub-type A3). |
| Type B | Pressure-grouted through the casing during withdrawal | Varies from temporary casing/unlined (sub-type B1) to permanent casing in upper shaft only (sub-type B3). |
| Type D | Primary grout placed under gravity head (Type A) or under pressure (Type B), then one or more phases of secondary pressure grouting | Varies from temporary casing/unlined (sub-type D1) to permanent casing in upper shaft only (sub-type D3). |

# Plot Legend




Notes: Density or consistency of material ranges from dense to very dense or very stiff to hard.

# Drilling Method SM-SC



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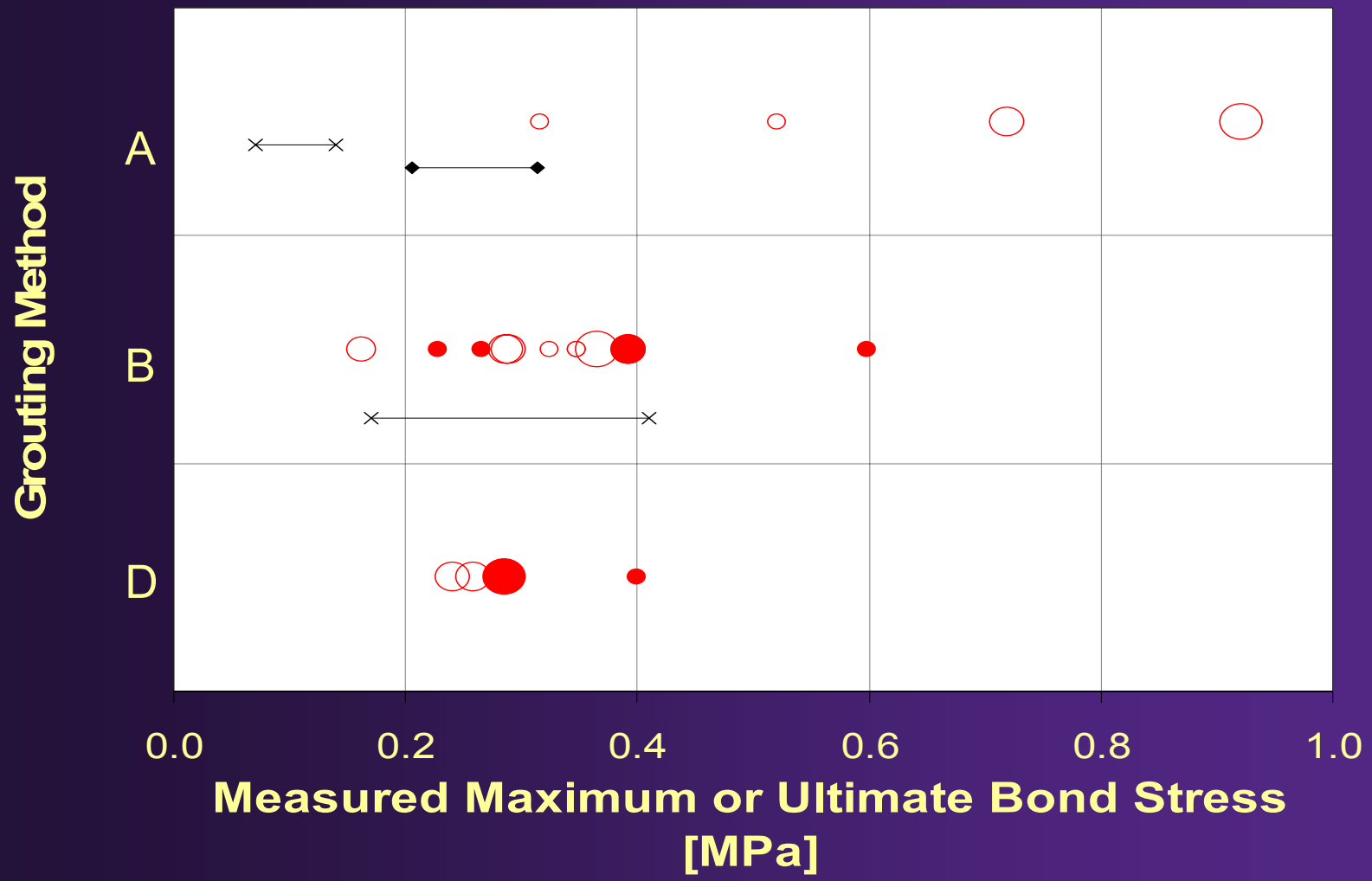
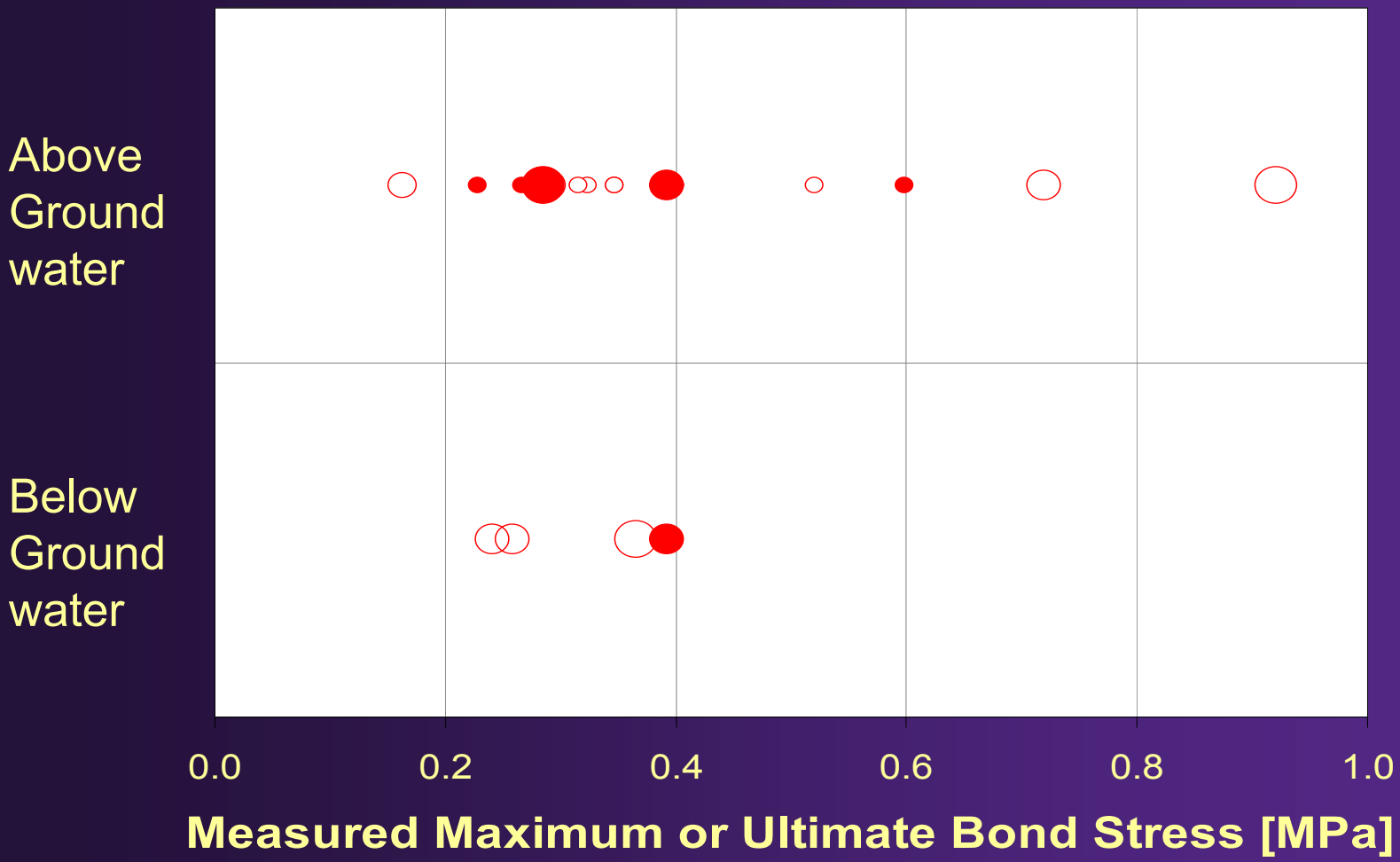


# Groundwater Presence SM-SC



# Conclusions

- Groundwater appears to lower friction for SP-SM and SW-SM, but not CL/ML or SM and SC
- Evaluate USCS classification and geologic unit
- Published values differ for same soil types

# Conclusions

- Glacially overridden soil – HIGH frictional capacity!
- Pressure/Post-grouting increase frictional capacity in non-overridden soil
- Some currently published ultimate values are conservative for soil in the Puget Sound Area

# Future Research

- Test to Failure
- Expand Database

# Acknowledgements