

Next-Generation Liquefaction Project

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Liquefaction Workshop
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Project Co-Director: Steven L. Kramer

Students and Post-Doctoral Scholars: Allan Ng, Michael W. Greenfield, Christine Beyzaei, Tadahiro Kishida, Dong Youp Kwak

Principal Collaborators (to date):

US: Steven Bartlett, Ross W. Boulanger, Yousef Bozorgnia, Jonathan D. Bray, Brady Cox, Russell Green, Robert E. Kayen, Tom Shantz, T. Leslie Youd

Japan: Kohji Tokimatsu, Toru Sekiguchi, Shoichi Nakai

NZ: Misko Cubrinovski

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Outline

- Project introduction and motivation
- Research philosophy and approach
- Opportunities and priorities for site characterization
- Example preliminary results
- Next steps

Introduction and Motivation

Analysis techniques for ground failure are empirical or semi-empirical

Small data sets – a few sites are especially consequential

Existing data sets are necessarily incomplete

Introduction and Motivation

Alternate liquefaction models can provide different outcomes. Why?:

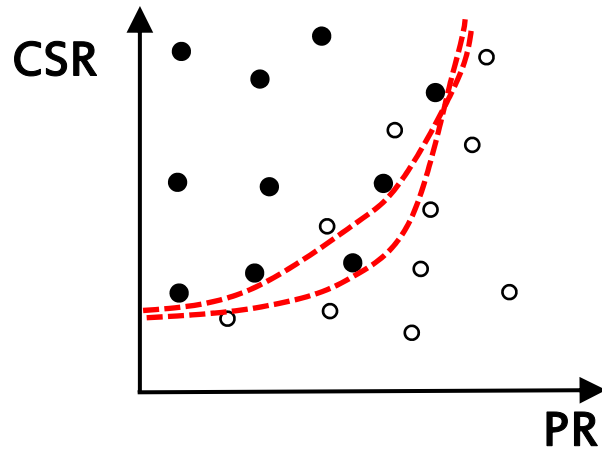
1. Different philosophies on some key points
2. Data sets not always consistent
3. Minimal between-developer interaction

Introduction and Motivation

Outcomes:

1. Model-to-model uncertainty large.
2. May reflect more than the epistemic uncertainty inherent to model building.
3. 'Right' and 'wrong' arguments between developers.
4. Substantial confusion regarding best practices

Introduction and Motivation



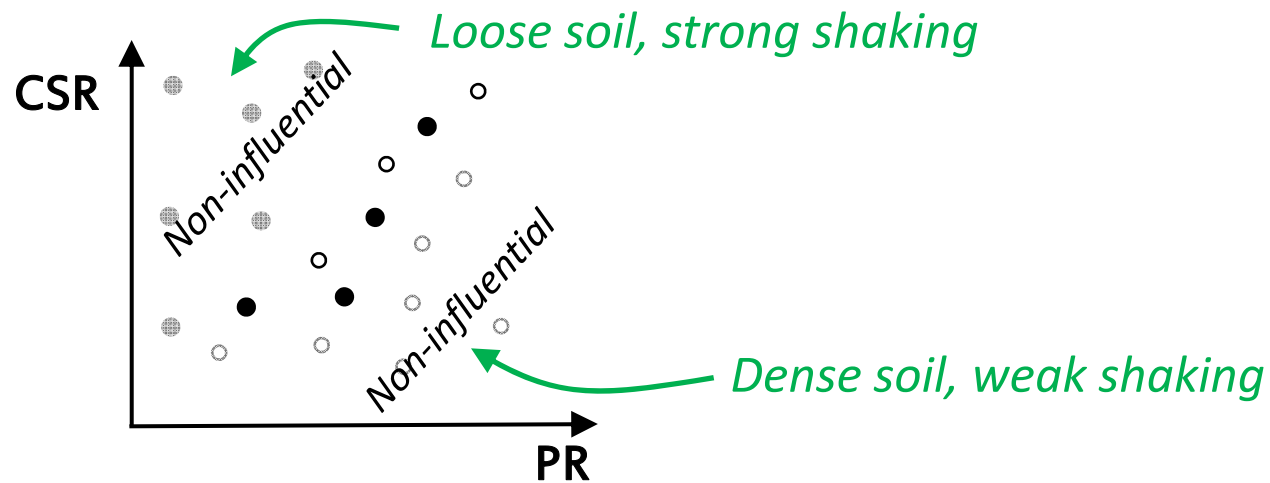
- Liquefaction
- No Ground Failure

Model deviations result in part from differences in data interpretation

Some may be due to errors in interpretation

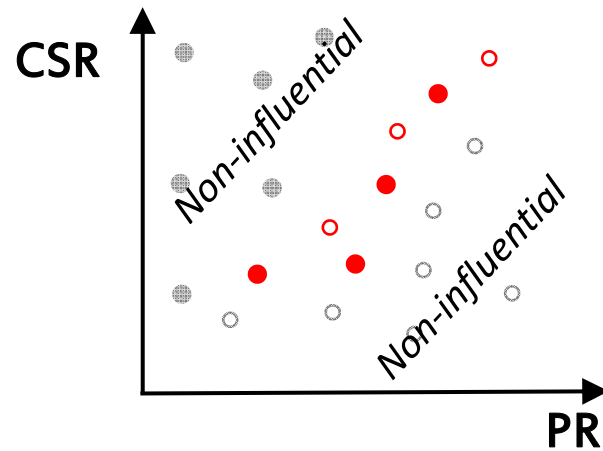
Graphic: Kramer

Introduction and Motivation



Graphic: Kramer

Introduction and Motivation



***Attention should be focused on
potentially influential, high-
value case histories***

Graphic: Kramer

Introduction and Motivation

NRC committee: summarizing problem but not providing recommendations on use of current analysis procedures

NGL conceived as a research approach to:

- Improve the resources available for model development
- Improve transparency in model building process
- Provide ‘vetted’ models having rapid impact.

Research Philosophy and Approach

- NGA as prototype
- Expand database
- Project organization/plan
- Anticipated products

NGA as prototype

Community database – many contributors

Supporting studies of critical effects poorly constrained by empirical data

Model development teams drawing upon common database.

Coordination between modeling teams.

Data not used in model development requires justification.

NGA as prototype

Addresses root causes of the current predicament:

1. Non-uniform data access and interpretation
2. Lack of transparency in data inclusion/exclusion
3. Lack of interaction during model development potentially leading to bugs in models and misunderstandings between modelers.

Expand database

Recent earthquakes enable database expansion, including:

1. High-consequence sites. Near threshold
2. Non-liquefaction sites poorly explained by current methods
3. Sites with measured deformations
4. Sites near ground motion stations.
5. Ground improvement sites

Expand database

Relevant events include:

1. 2011 NZ and Japan
2. 2010 El Mayor-Cucapah
3. 2010 Chile
4. 2004 and 2007 Japan
5. 1999 Turkey, Taiwan

Project organization/plan

Establish institutional partnerships: PEER, CUEE, UCQC, NCREE

Project Management Committee at PEER

Post docs at PEER to develop database under direction of PMC.

Funded researchers to develop case histories

Model development teams (later)

Community workshops (results dissemination, input)

Anticipated products

Community database for use by practitioners and non-affiliated researchers

Models for ground failure phenomena:

1. Multiple models by distinct developer teams, or
2. Consensus median models with defined aleatory variability and epistemic uncertainty

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- **Opportunities and priorities for site characterization**
- Example preliminary results
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Opportunities/Priorities

- Numerous workshops held with Japan and NZ researchers to establish initial priorities
- Work began April 2014
- Initial emphasis is on site characterization for high-value sites

Opportunities/Priorities

New Zealand

Extensive CPT soundings already available

Virtually no SPT blow counts or laboratory test data

9 sites selected based on field performance not matching expectation. Not near accelerometers.

Additional sites (from R. Green) to be included

Opportunities/Priorities

Japan

Sites with measured ground deformations

Chiba sites (details below)

Various sites near ground motion stations:

1. Some site have vertical arrays (e.g., PARI)
2. Liquefaction and no ground failure
3. Borehole data often already available
4. Adding V_s and CPT soundings. Checking N-values

Opportunities/Priorities

Japan

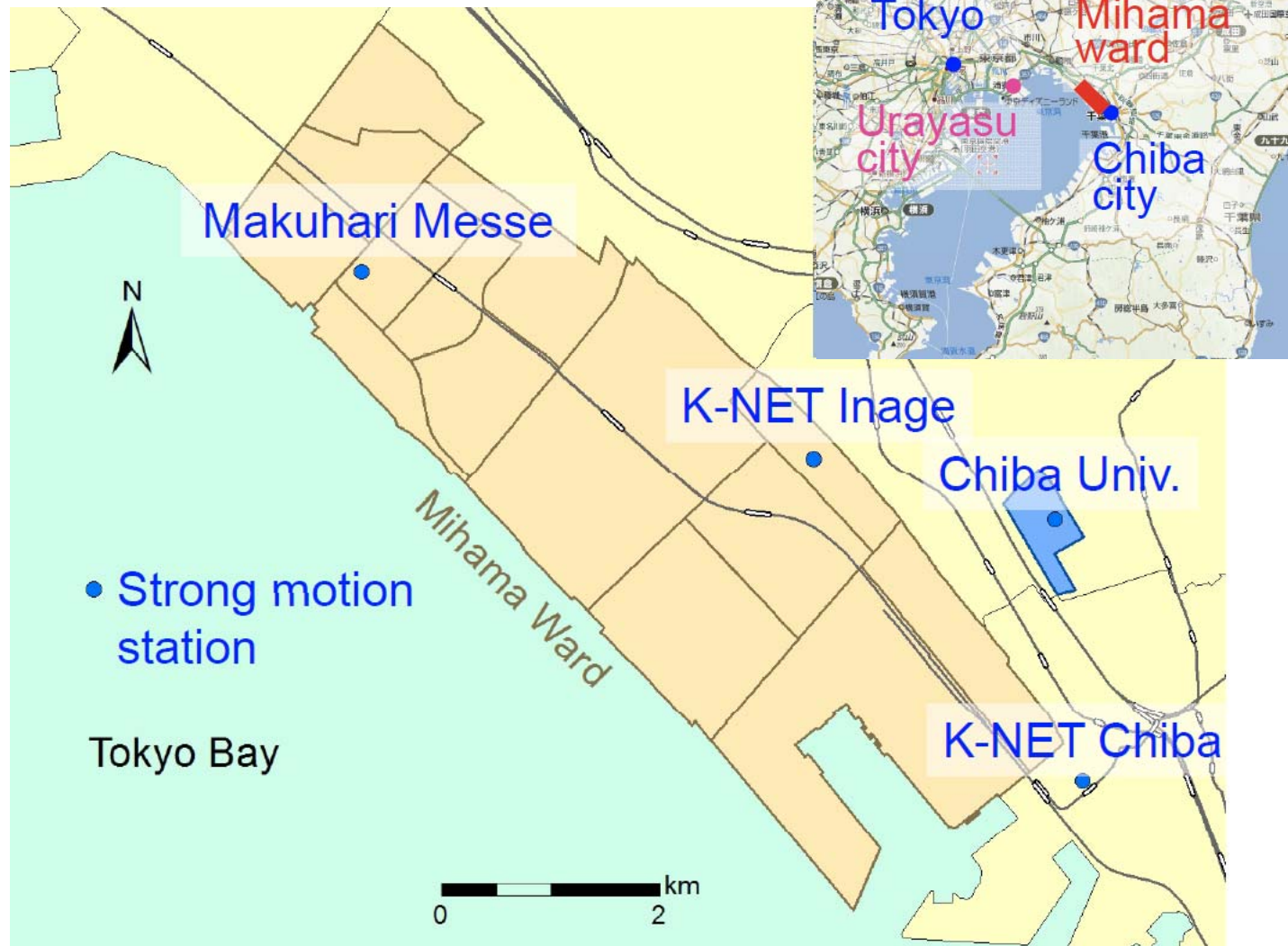
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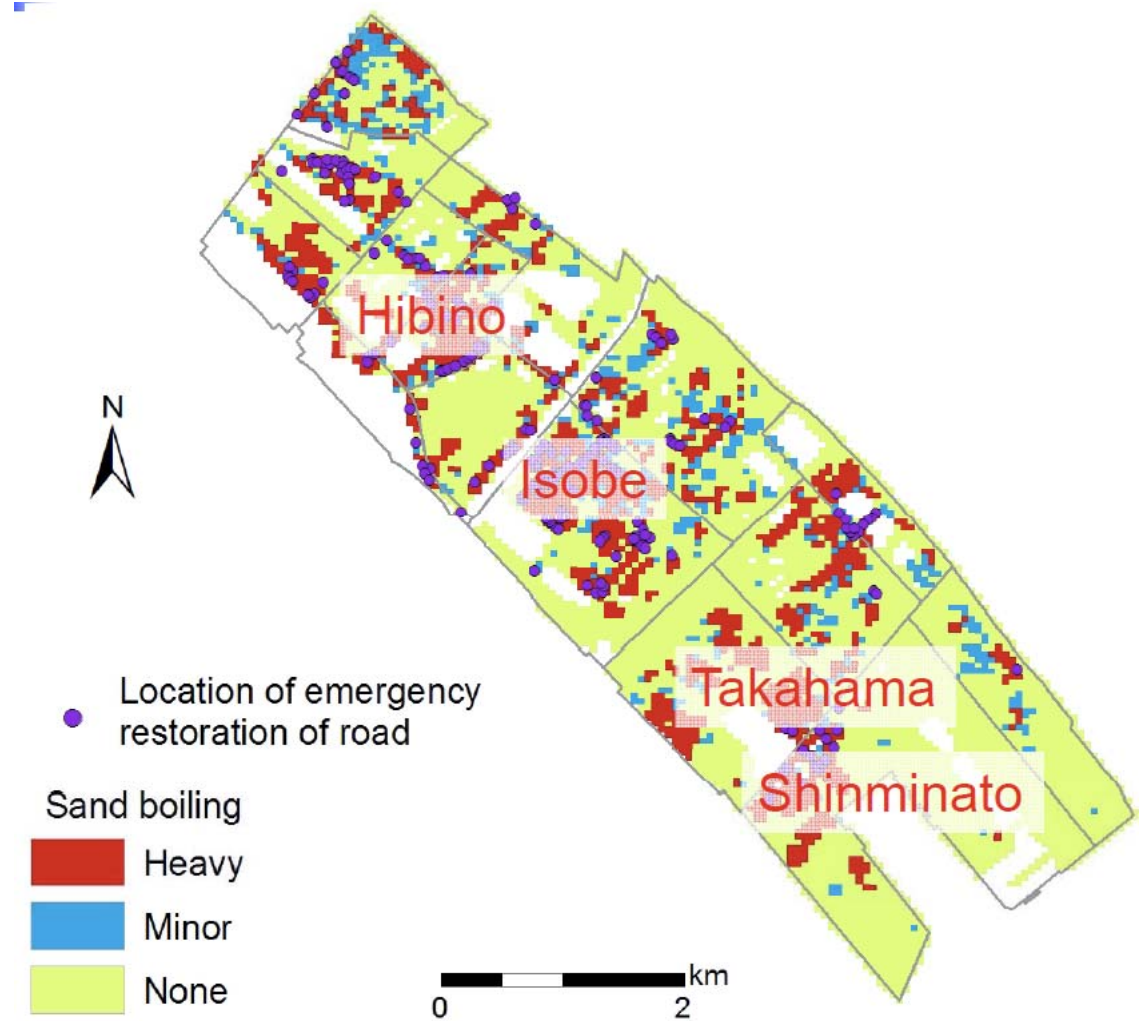
Mihama Ward, Chiba



Images: Sekiguchi and Nakai

Mihama Ward, Chiba

Field performance
characterized

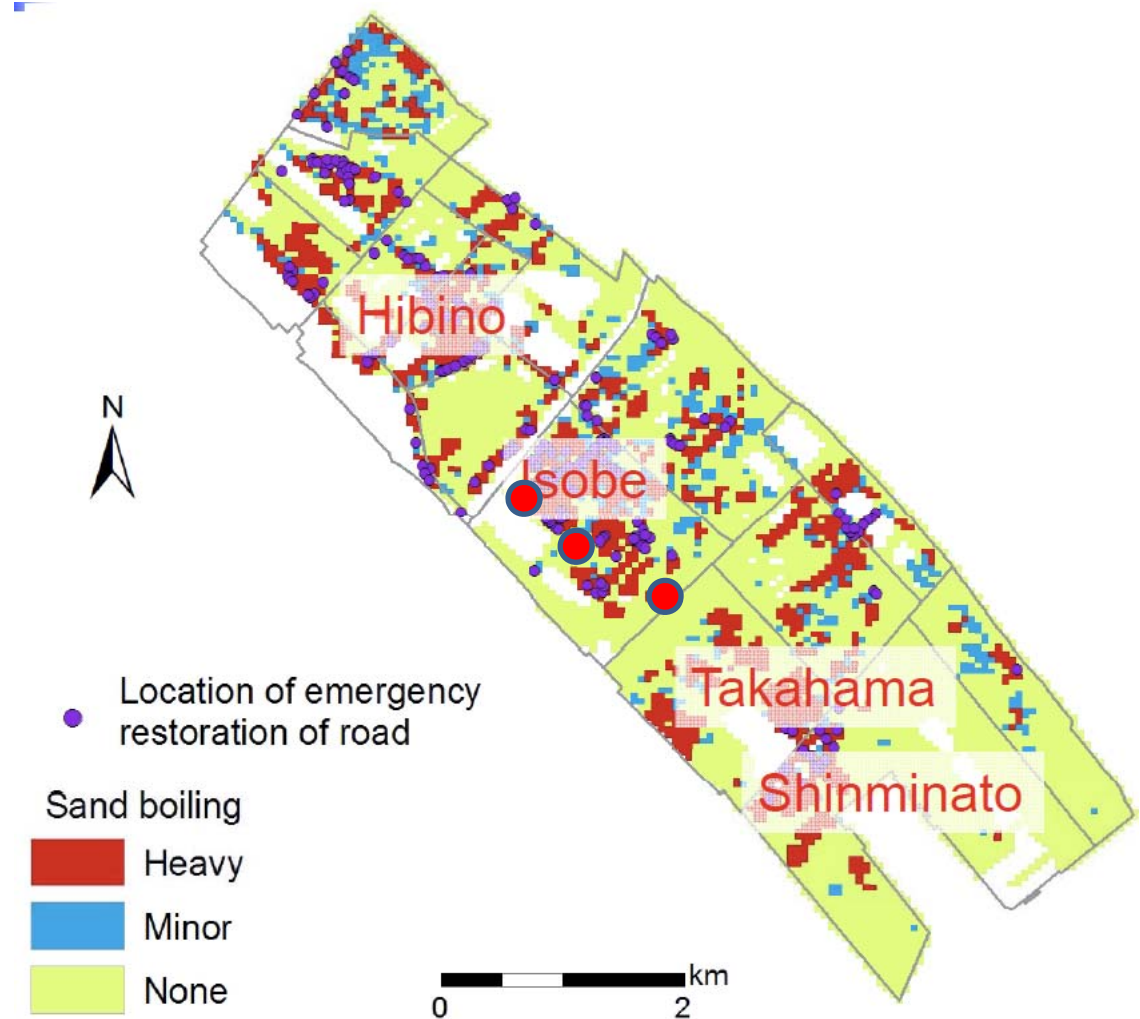


Images: Sekiguchi and Nakai

Mihama Ward, Chiba

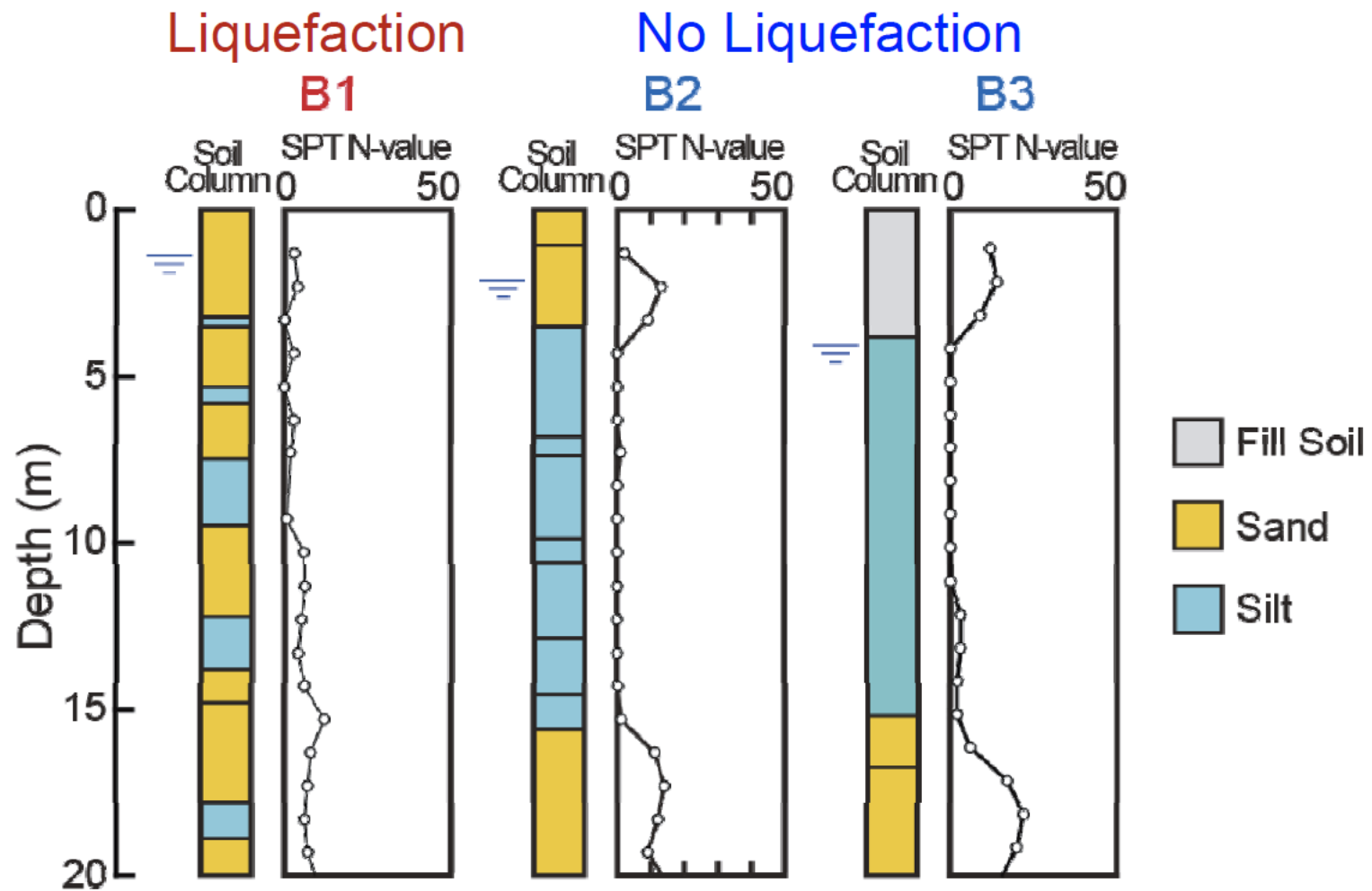
Field performance
characterized

Few boreholes in L
and non-ground
failure areas



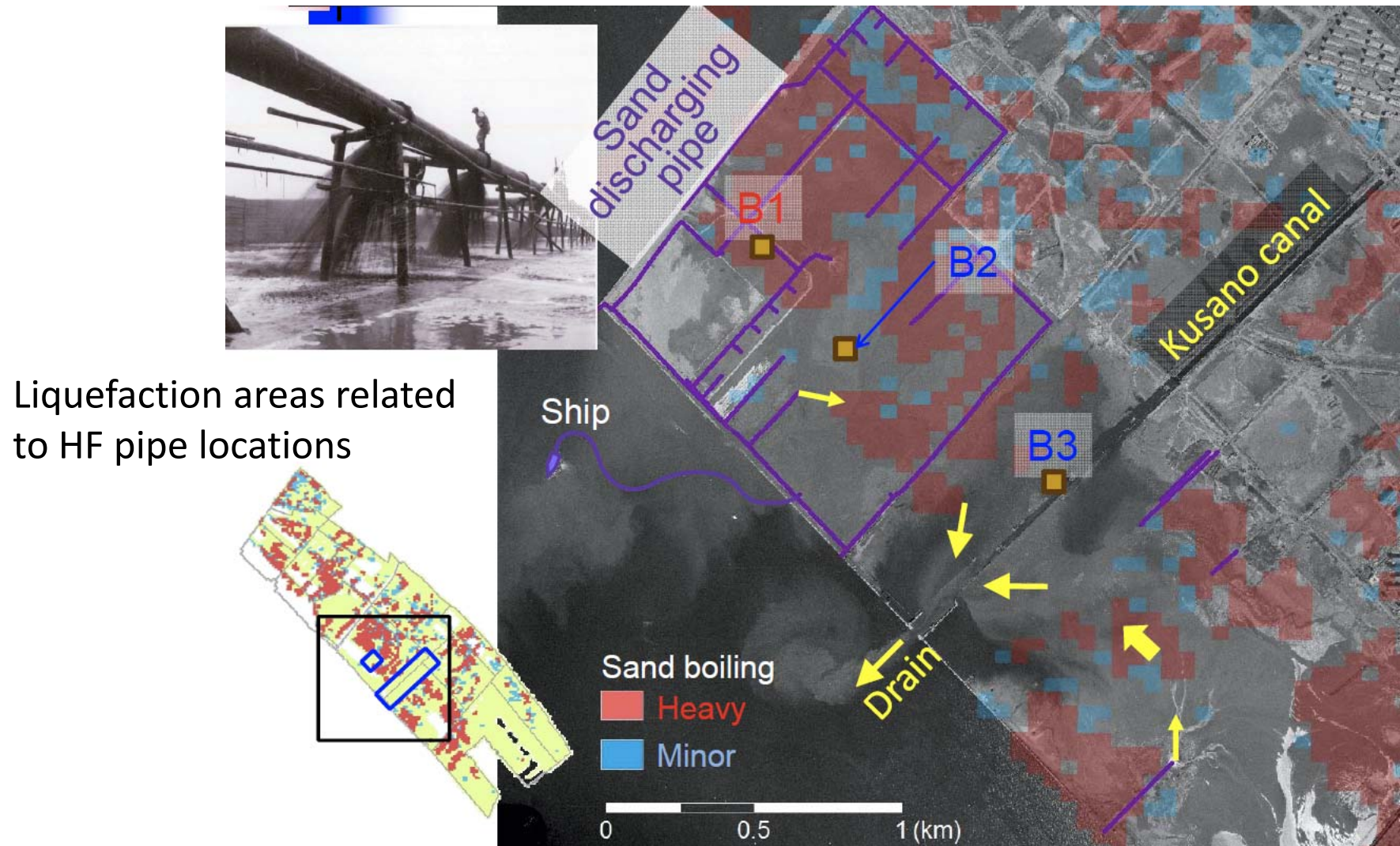
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Images: Sekiguchi and Nakai

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Summary:

Available now:

1. Field performance data
2. Historical knowledge of hydraulic fill placement
3. Boring and CPT logs in liquefaction and no-ground failure areas

Pending:

1. Laboratory testing (index, more advanced) of materials in different performance areas.
2. Limited additional CPTs and borings

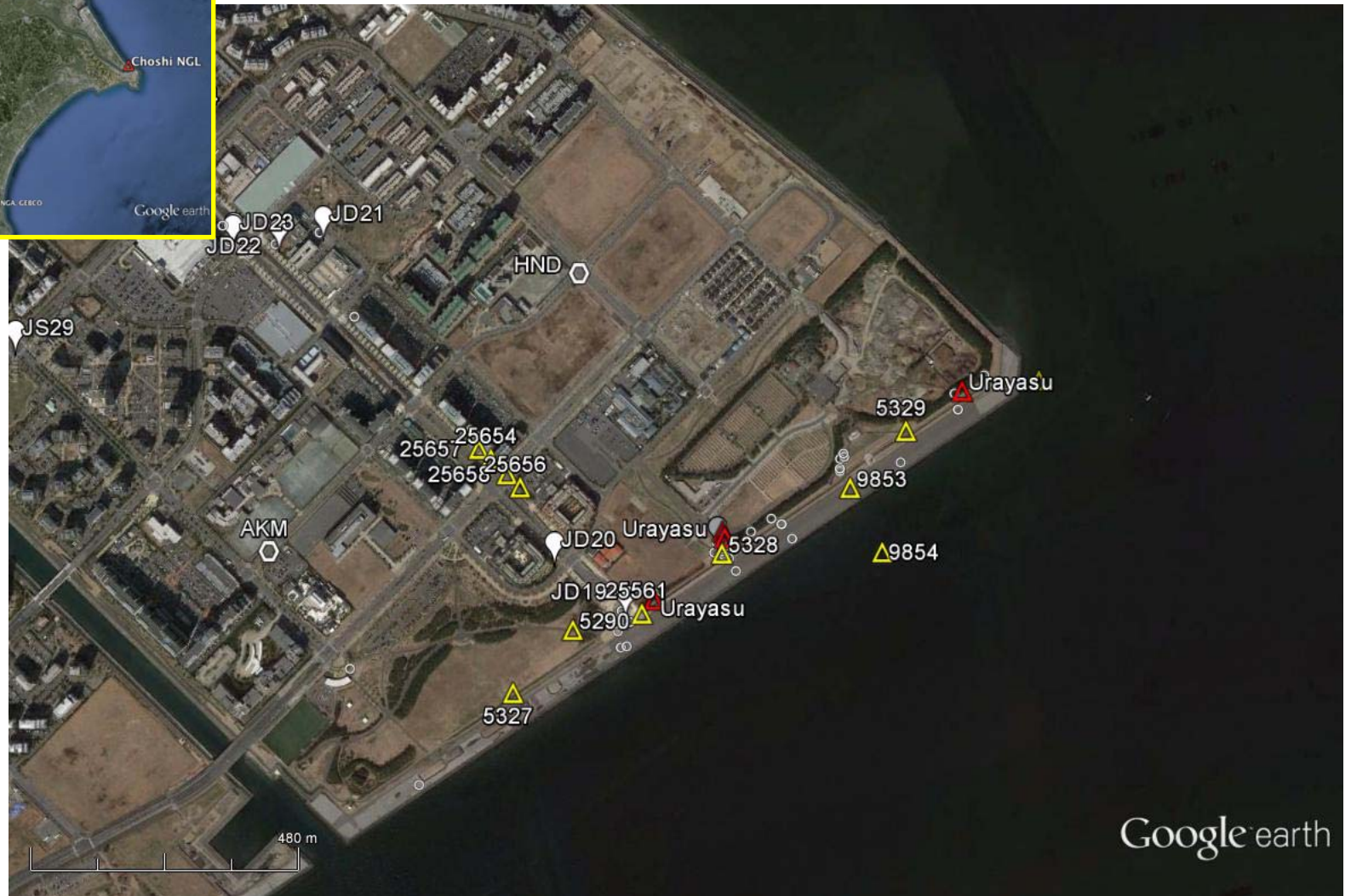
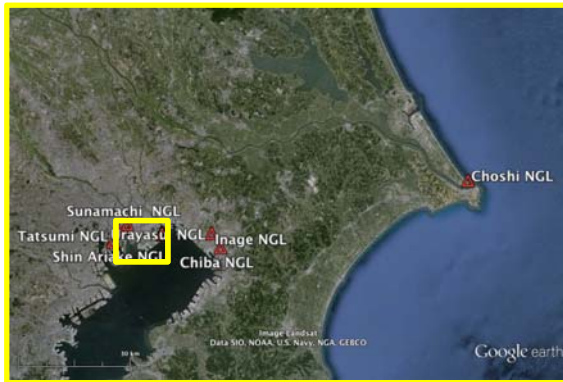
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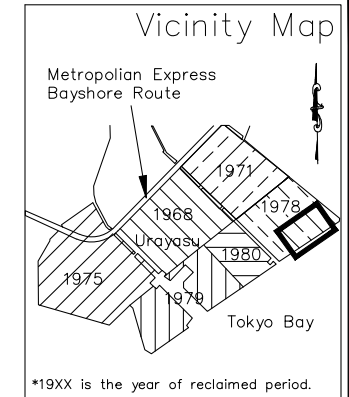
Example Results

- Lateral spread site in Urayasu
- Accelerograph sites with liquefaction and without ground failure

Urayasu Lateral Spread



Urayasu Lateral Spread

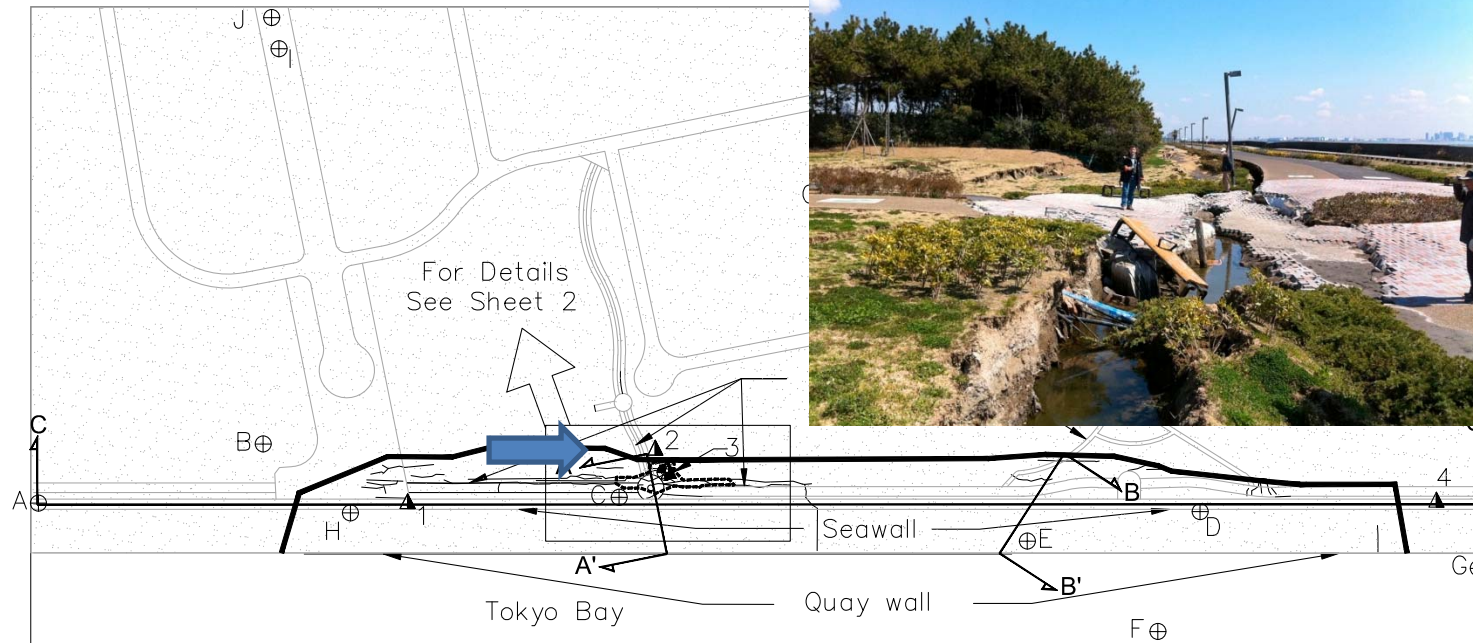


Legend

- ▲ CPT
- ⊕ SPT ⊕ SPT by others
- Landslide headscarp
- ~ Spread features
- LiDAR image region

Geomorphology

- Filled Land



NGL Point	Type	Lat. (N)	Long. (E)	TSN
1	CPT	35.636922	139.932152	120007
2	CPT	35.638020	139.933517	120008
3	CPT/SPT	35.637925	139.933560	120009/110003
4	CPT	35.640294	139.938279	120010

Existing Point	Type	Lat. (N)	Long. (E)	Source	Name
A	SPT	35.635416	139.929354	Chiba	cjz05237
B	SPT	35.636436	139.930544	Chiba	cjz05290
C	SPT	35.637666	139.933504	Chiba	cjz05328
D	SPT	35.639646	139.937164	Chiba	cjz05329
E	SPT	35.638726	139.936054	Chiba	cjz09853
F	SPT	35.637686	139.936694	Chiba	cjz09854
G	SPT	35.640466	139.939813	Chiba	cjz25416
H	SPT	35.636696	139.931914	Chiba	cjz25561
I	SPT	35.638736	139.929494	Chiba	cjz25656
J	SPT	35.638946	139.929234	Chiba	cjz25658

NGL Project

Preliminary Site Characterization

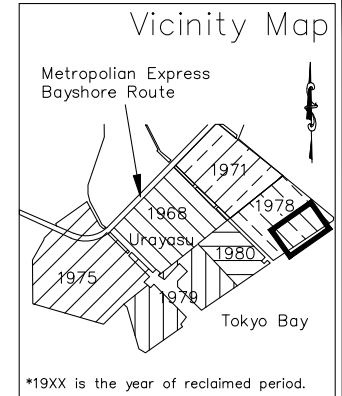
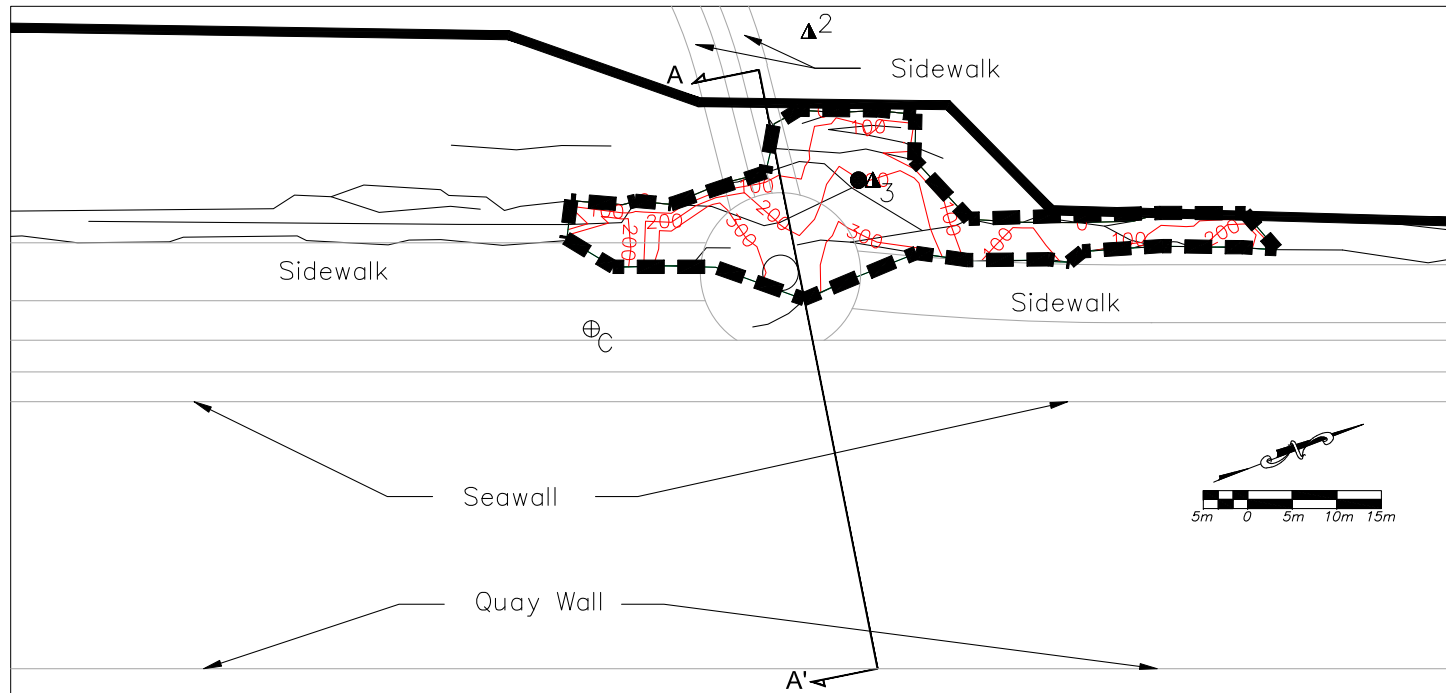
Urayasu Lateral Spread

NGL 1.4; GEER JS27

Ground Motion Station: CHB008

PREPARED BY	DATE	SCALE	REVIEWED BY	PRJ. NO. xxxxxxx
AYN	9/8/14	1cm = 30m	JPS, RK	SHEET 01 OF XX

Urayasu Lateral Spread



Legend

- ▲ CPT
- SPT ⊕ SPT by others
- ▬ Landslide headscarp
- ~ Spread features
- Displacement Contours
- LiDAR image region

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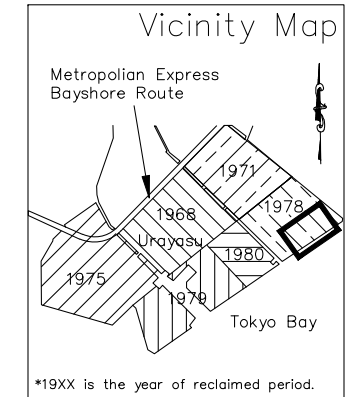
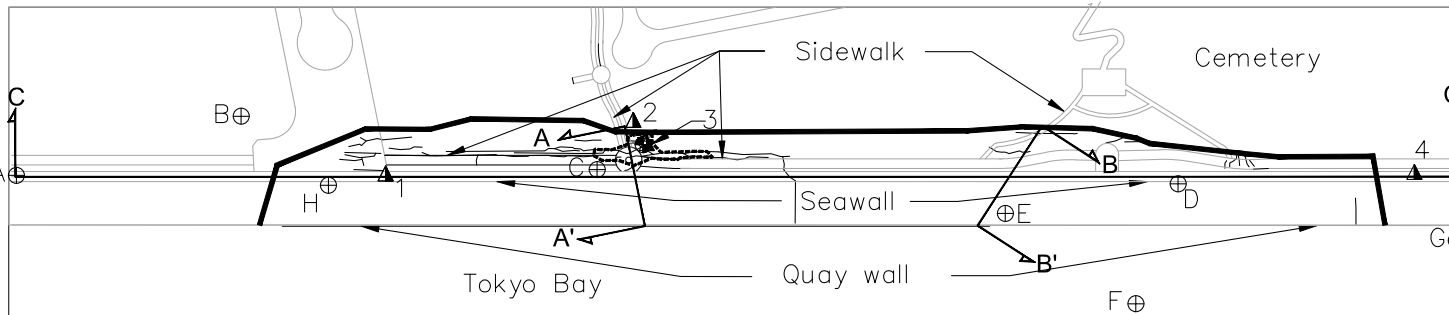
NGL Project

Preliminary Site Characterization

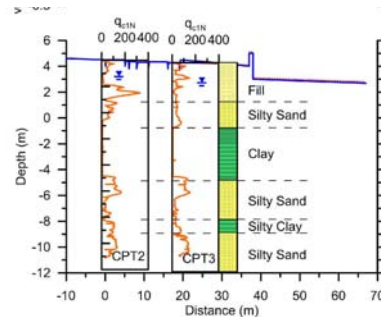
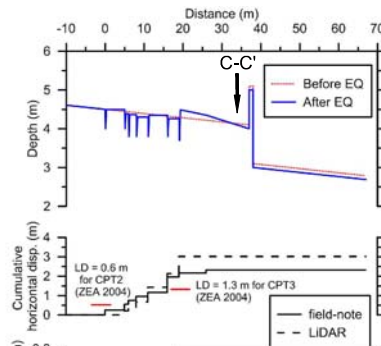
Urayasu Lateral Spread

NGL 1.4; GEER JS27
Ground Motion Station: CHB008

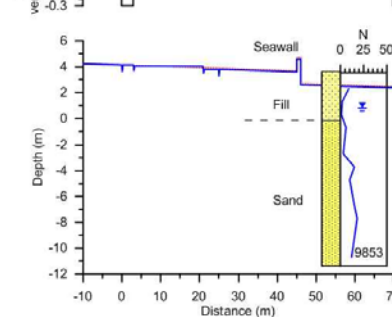
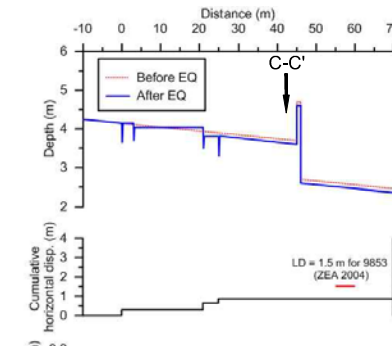
PREPARED BY	DATE	SCALE	REVIEWED BY	PRJ. NO. xxxxxxxx
AYN	9/8/14	1cm= 5m	JPS, RK	SHEET 02 OF XX



X-Section A-A'

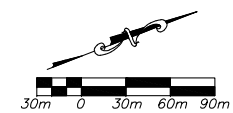


X-Section B-B'



Legend

- ▲ CPT
- ⊕ SPT ⊕ SPT by others
- Landslide headscarp
- ~ Spread features
- LiDAR image region



NGL Project

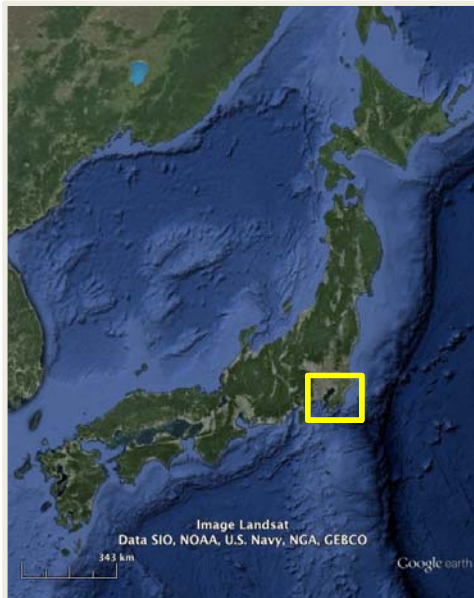
Preliminary Site Characterization

Urayasu Lateral Spread X-Sections

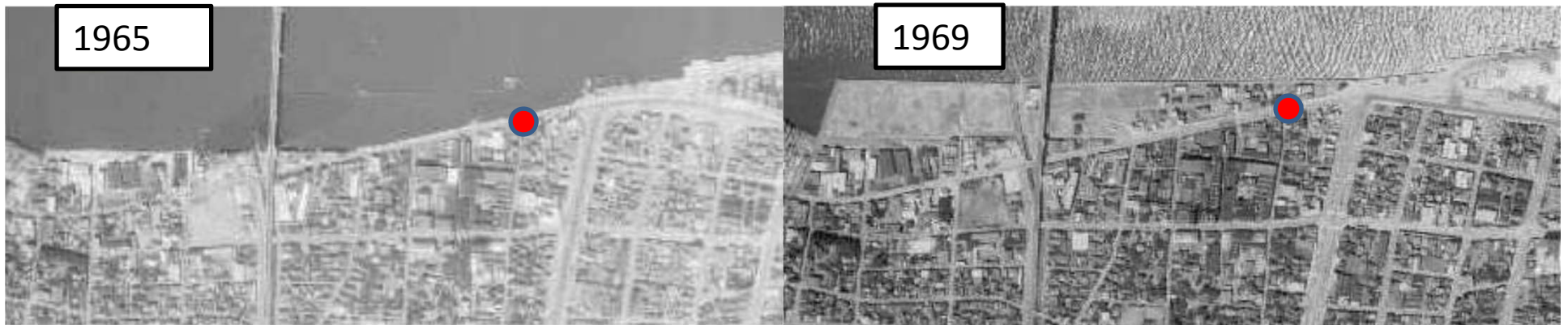
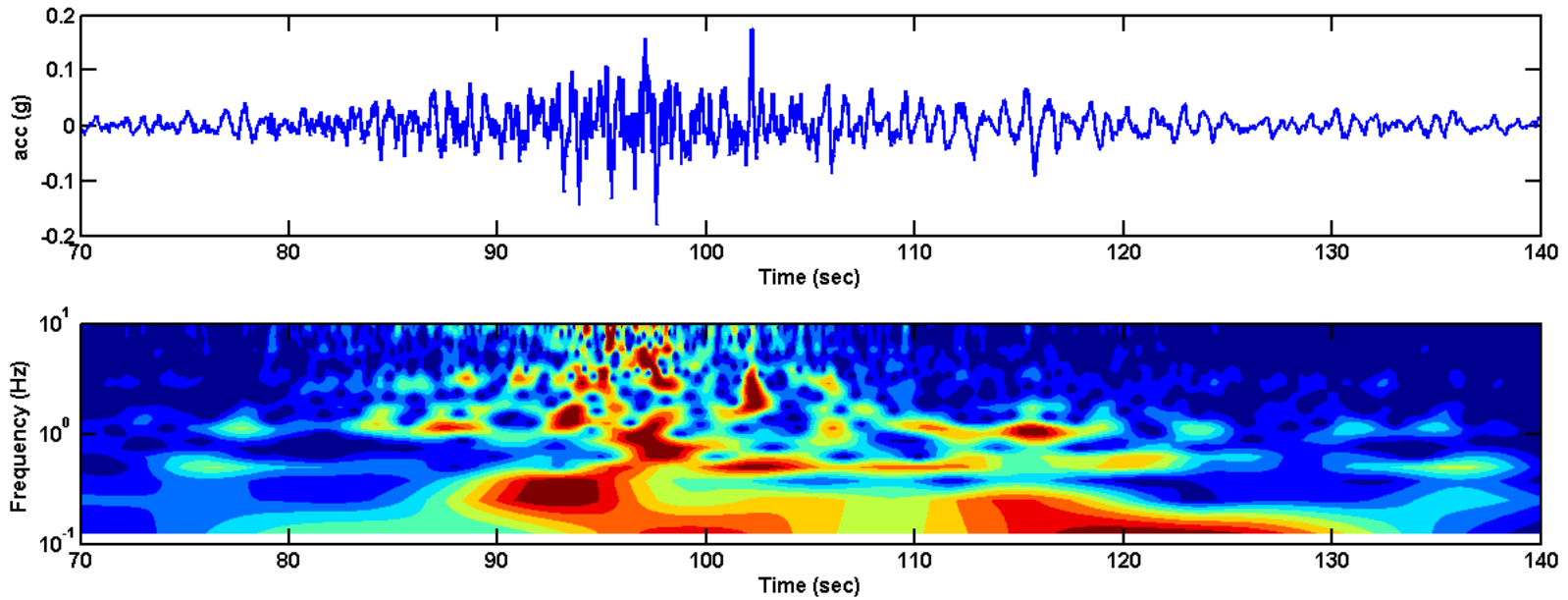
NGL 1.4; GEER JS27
Ground Motion Station: CHB008

PREPARED BY	DATE	SCALE	REVIEWED BY	PRJ. NO. xxxxxxx
AYN	9/8/14	1cm = 30m	JPS, RK	SHEET 03 OF XX

SMA Sites



Choshi Site (Knet CHB005): No ground failure



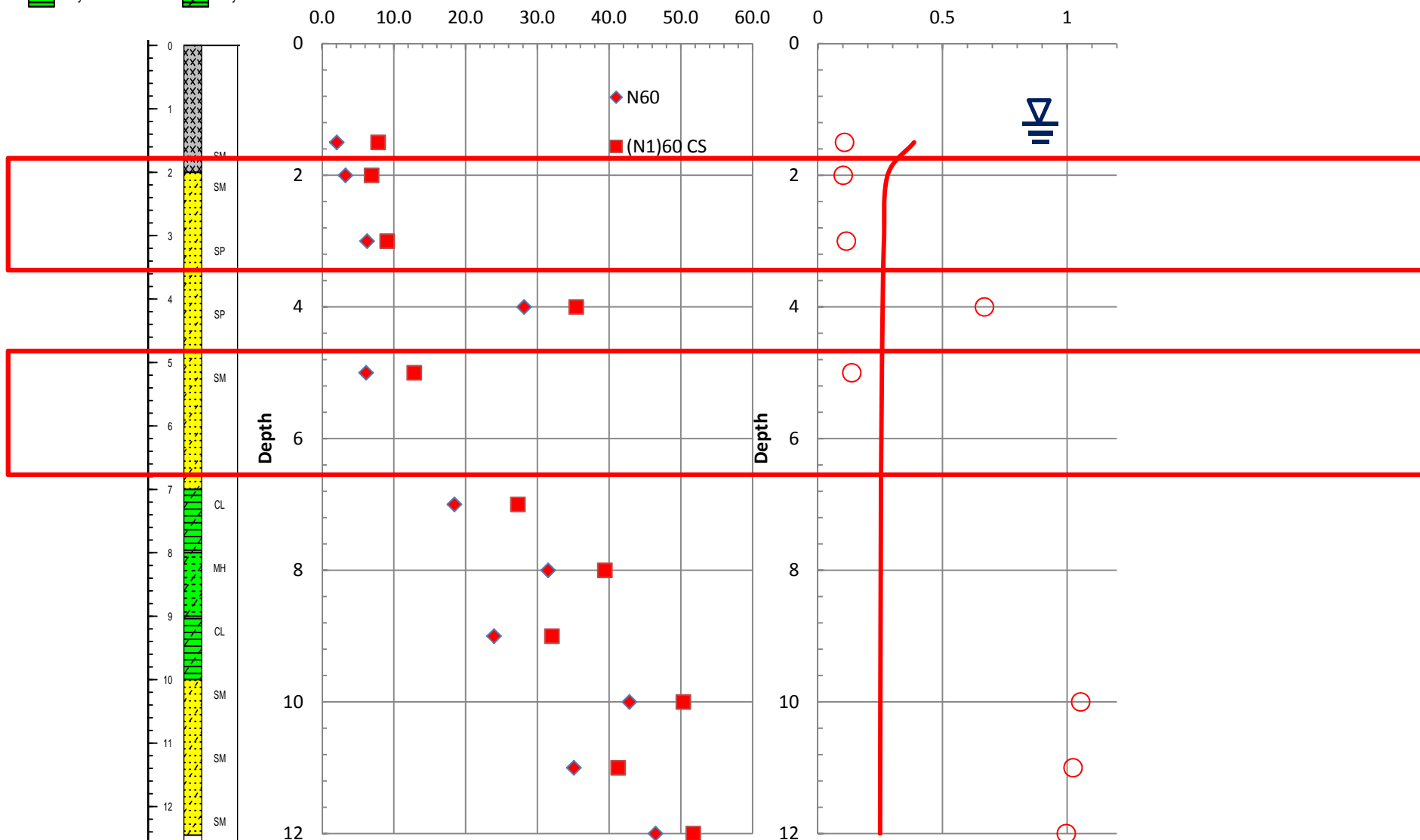
Reconnaissance by JSCE

Lithology Legend

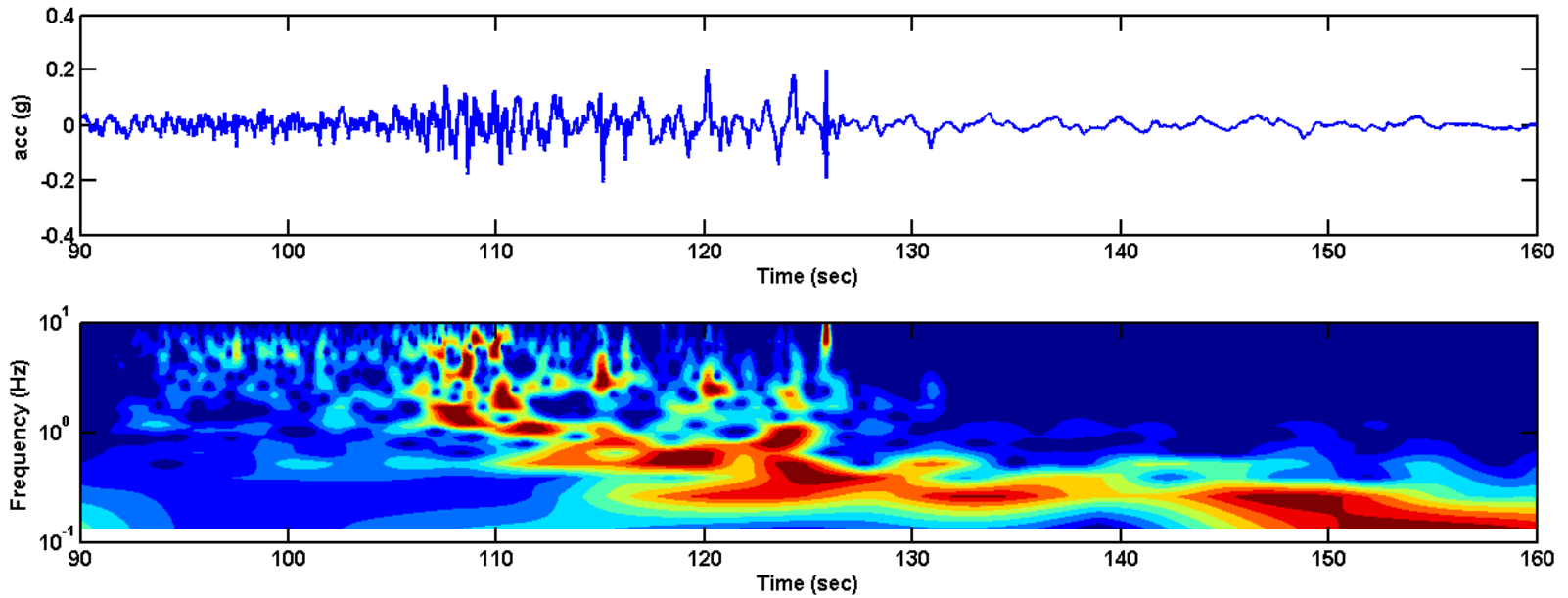


N_{60} & $(N_1)_{60CS}$

CSR & CRR

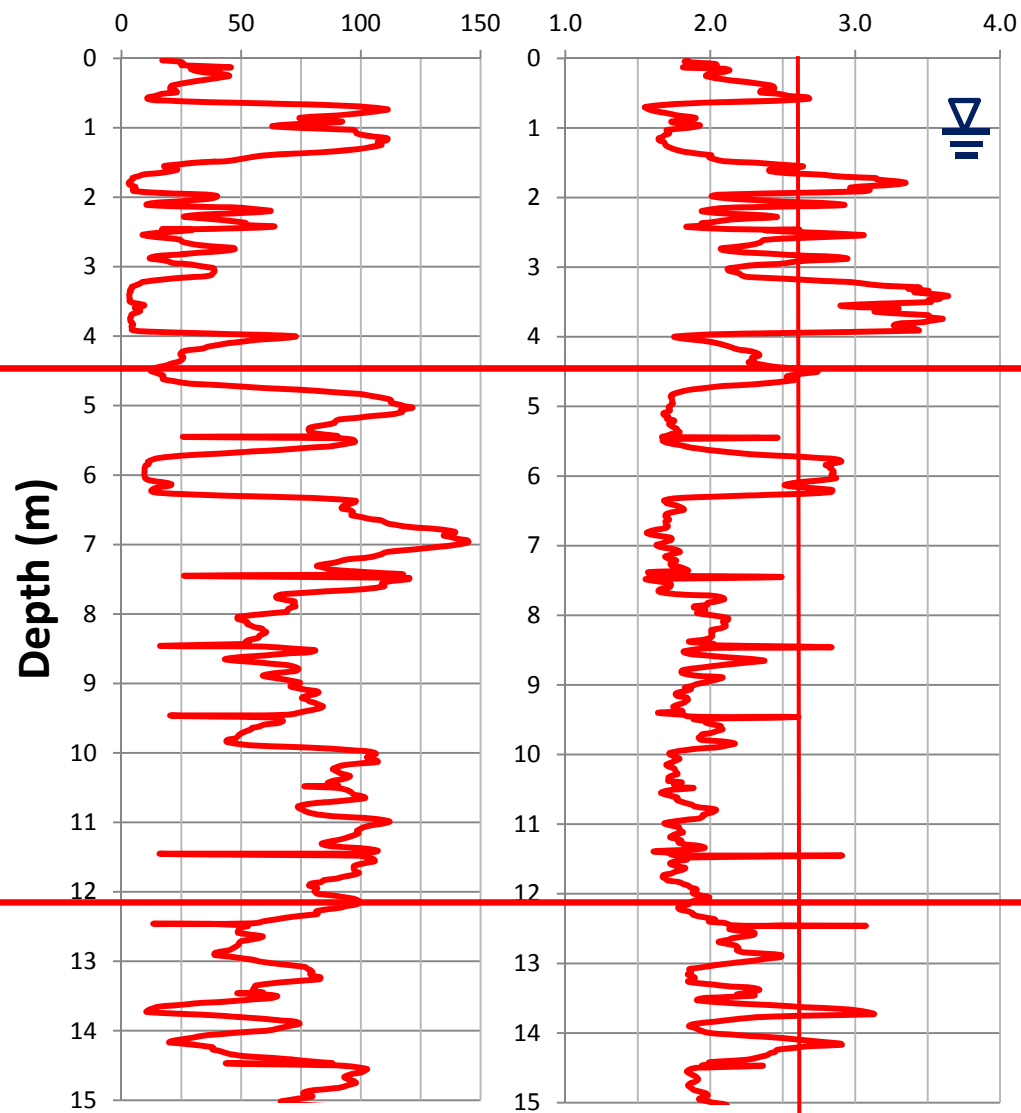


Inage Site (CHB024): Liquefaction

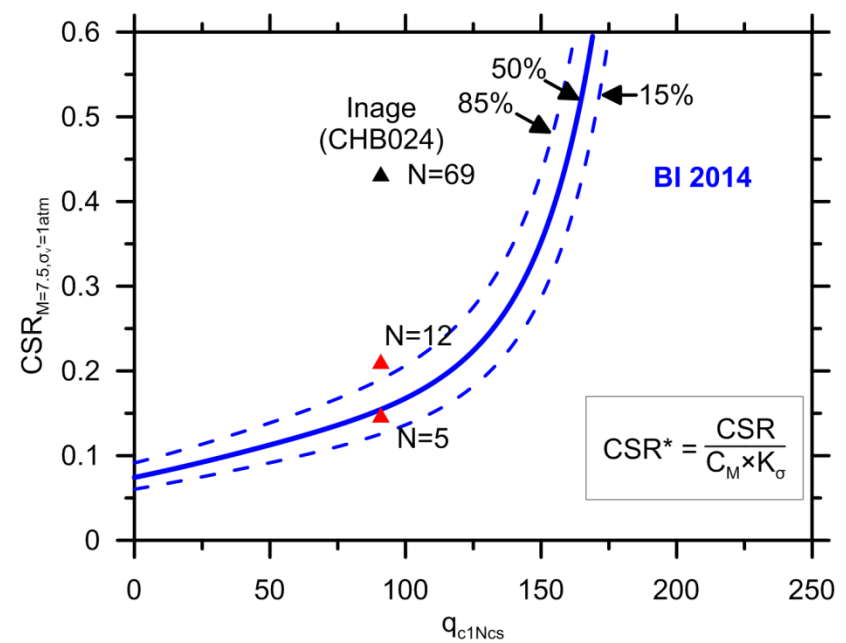
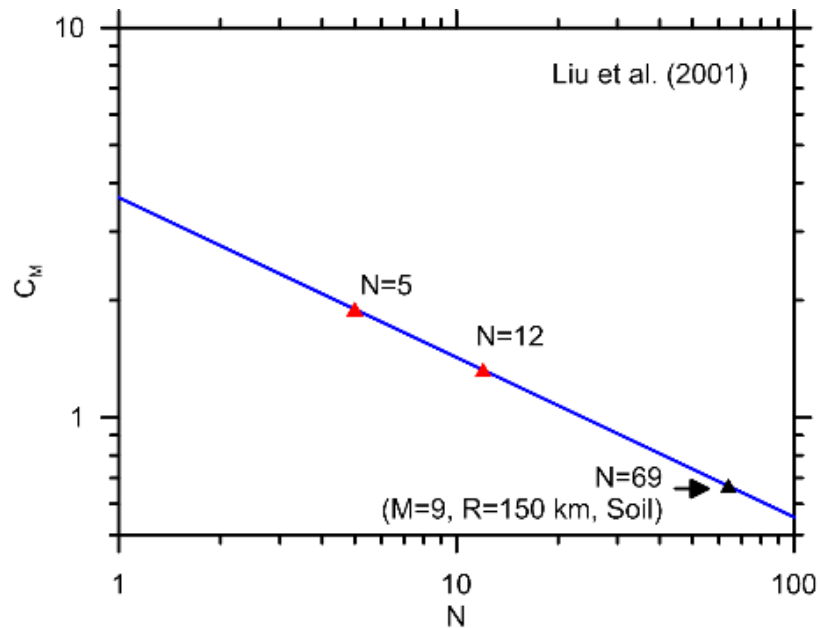
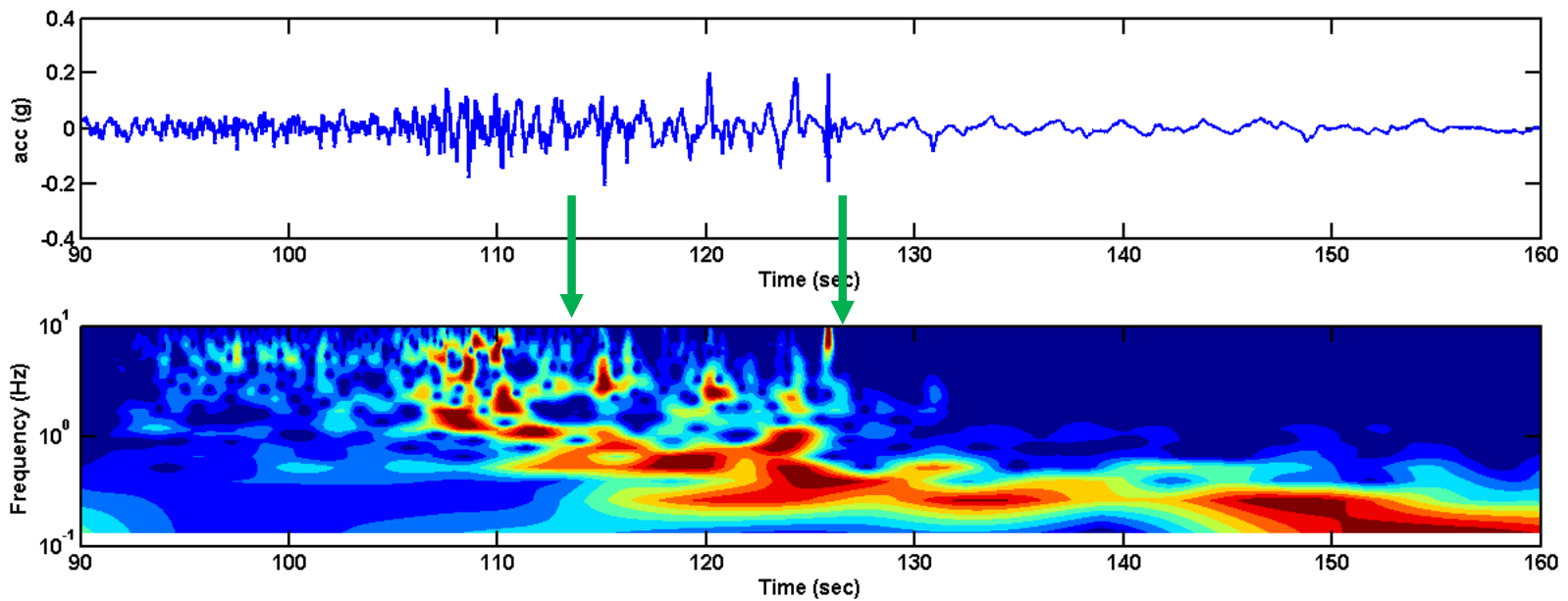


qc1n

lc



Attempt to locate (CSR-PR) on triggering curve



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Next Steps for NGL

- NRC report will endorse NGL
- Continue to gather information for impactful sites (Japan, NZ earthquakes). Planned for 2014-2015
- Need to secure long-term funding
- Establish data archival tools
- Longer term: supporting studies, modeling teams, dissemination, etc.